Toward the Great Divergence: Economic Growth in the Yangzi Delta, 1393-1953



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Dissertation submitted for the Degree of Doctor of Philosophy

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Michaelmas 2022

ABSTRACT

Short Abstract (300 words)

This dissertation examines the economic growth process of the Yangzi Delta, one of China's most developed sub-regions, from 1393 to 1953. For the first time in the literature, an annual frequency GDP series based on an output-based approach is constructed. The dissertation is split into two sections: measuring economic growth and analysing economic growth. As part of measuring economic growth, I discuss local population and land, agriculture, and industry and services in Chapters Two, Three, and Four, respectively. Chapter Five in the section on analysing economic growth briefly reviews the process of local economic growth over several centuries using constructed GDP data. The Great Divergence Debate is then discussed in Chapter Six, which places the Yangzi Delta's economic growth in an international comparative framework.

From the perspective of Chinese economic growth history, the nine Taihu Lake-centered prefectures in this study had a GDP per capita well above the China average for a long time. However, prior to the mid-nineteenth century, the local economy appeared to be stuck in what Mark Elvin refers to as the "high-level equilibrium trap". It displayed a Malthusian-style pattern of per capita GDP growth, but numerous technological or managerial innovations allowed per capita GDP to maintain at a high level. In terms of global growth history, the Yangzi Delta maintained the same level of income per capita as the most developed European economies since the late 14th century (a series consisting of the highest GDP per capita in Italy, the Netherlands, and Britain). This neck-and-neck growth race came to an end at the end of the 17th century. Since then, the leading European economies surpassed the Yangzi Delta in terms of GDP per capita, and the gap widened irreversibly. In short, the Great Divergence began at the end of the 17th century.

Extended Abstract (2500 words)

This dissertation examines the economic growth of the Yangzi Delta, one of China's most developed sub-regions, from 1393 to 1953. For the first time in the literature, an annual frequency GDP series based on an output-based approach is constructed. The new GDP data sheds light on how the Yangzi Delta's economy evolved over seven centuries, particularly in reconciling the two tit-for-tat views in Chinese economic history with "Involution" and "Development". Prior to 1865, Yangzi economic growth in terms of GDP per capita was more in line with the predictions of the Involutionary model, in which economic aggregates grew but per capita income stagnated or even fell. The dominant model of local economic development remained in what Mark Elvin refers to as the "high-level equilibrium trap". It displayed a Malthusian-style pattern of per capita GDP growth, but numerous technological or managerial innovations allowed per capita GDP to maintain at a high level. It was not until after 1865 that a new, vaguely similar pattern of modern economic growth began to emerge. According to scholars with a development perspective, under population pressure, the spread of double cropping and cash crops as well as the change in the economic structure towards the non-agricultural sector did in fact exist. These new changes simply did not translate well into increased input-output efficiency (TFP) and labour productivity. While aspects of Boserupian agricultural growth and Smithian economic growth were evident, these growth patterns had not fully transformed the fact of diminishing per capita output, but had rather alleviated it to some level. As a result, both the Involution and California Schools are correct in their respective narratives. However, given the long-term tendency of per capita GDP growth in the Yangzi region, the former may be more accurate. This "high-level equilibrium trap" pattern could be interpreted as a reconciliation of these two opposed schools of thought.

In the context of global economic growth history, this dissertation includes for the first time the Yangzi Delta's directly calculated GDP in the global GDP comparison. Since

the late 14th century, the Yangzi Delta maintained the same level of per capita income in comparison to the most developed European economies, which include those with the highest GDPs per capita in Italy, the Netherlands, and Britain. At the end of the 17th century, this neck-and-neck growth race ended. Since then, the leading European economies surpassed the Yangzi Delta in terms of GDP per capita, and the gap widened irreversibly. In short, the Great Divergence is thought to have begun at the end of the 17th century.

This study is divided into two parts: measuring economic growth and analysing economic growth. The former is the most important task of this dissertation. The Yangzi Delta's historical economic development has been extensively discussed in the literature, but a complete macro picture has not been painted until now. For a long time, most pre-modern economies were mired in some form of low per capita income stagnation. Small regions with modern economic growth potential may help break this large-scale stagnation, as seen in Britain and the Netherlands. The Yangzi Delta is to China what Northwest Europe is to Europe. Qualitative evidence suggests this region was distinct from other Chinese regions. The Yangzi Delta stands out in China for its productive agriculture, well-developed commerce, nearly the highest human capital, dense private libraries, etc. How did this region's economic growth, which might break China's growth model, fare over the centuries? Clarifying this question will not only add a region to the database of historical GDP studies, but it will also help explain the logic of the region's economic development and even China's. The Yangzi Delta may hold the key to understanding why China did not experience the Industrial Revolution.

In order to measure economic growth in the Yangzi Delta, I first go over the local population and cultivated land situation in Chapter Two. Although there are many macro population and cultivated land figures in Chinese historical publications and literature, as Ho Pingti pointed out in 1959, these figures cannot be used directly. I therefore attempt to see through these raw figures to the real world behind them. The main focus of Chapter Two is to talk about local population and cultivated land in terms of

institutions and data construction. On the institutional front, I examine the traditions and customs of the Chinese statistical system in depth, explaining when these raw numbers are unavailable and when they are. I was eventually able to construct complete benchmark data on population and cultivated land in the Yangzi Delta after fully understanding the boundaries of the numbers present in the Chinese literature. During most of the peacetime, declines in cultivated land per capita were the norm. Varying degrees of change in cultivated land per capita may result from war. Decreasing cultivated land per capita was the dominant feature of the local population and cultivated land in the long run.

The third chapter examines the Yangzi Delta's historical agricultural economy. The primary goal of this chapter is to create long-term agricultural output data. This chapter commences with the calculation of grain yields per plot. I collect nearly three thousand samples from the Yangzi Delta and surrounding areas in order to build grain yield series for the Yangzi Delta in the long run. To capture short-term fluctuations in annual frequencies, I collect over 20,000 descriptive records from gazetteers and translated these textual records into rank series by content using standard methods used in historical climate studies. The combination of short- and long-term data eventually enables me to generate annual frequency grain yields data. Following that, I investigate and construct crop types and cultivation data for the Yangzi Delta. Double cropping and cash crops were significant changes in local agricultural crops. Finally, I construct a series of agricultural outputs for the Yangzi Delta from 1393 to 1953 using the various value-added information.

Chapter Three is not solely concerned with data construction. In the final section, I use the constructed agricultural output data to discuss a long-debated issue in the literature, namely, whether local agriculture was involuting or developing. According to my calculations, both seemingly contradictory narratives appear to be right, implying a potential reconciliation between them. First, agricultural labour productivity in the Yangzi region stagnated or declined over time. Similarly, agricultural Total Factor Productivity

(TFP) estimations show almost no positive growth over nearly six centuries. This essentially means that agricultural development in the Yangzi Delta did not exhibit modern economic growth features such as continuous growth in labour productivity and TFP. This supports the Involution School's assessment of Yangzi agriculture's input-output efficiency and productivity. However, this does not imply that Yangzi agriculture was completely stagnant, with no remarkable elements. Intensive production methods, such as double cropping and extended cash crop farming, as well as more fertiliser use, have proven to be helpful in mitigating the reduction in per capita output caused by population growth. Without these "new things", Yangzi agriculture's per capita output and income of peasant farmers would surely be lower. The labour-intensive innovations caused by population pressure show that the local development pattern was not stationary, resembling the Boserupian agricultural growth model. So the "development" narrative portrayed by the California School is likewise true. When comparing the Yangzi agricultural economy to modern economies with persistent rise in labour productivity, however, the "development" aspect should not be overstated. Thus, the Yangzi agricultural economy may be better described using Mark Elvin's "high-level equilibrium trap" notion.

Chapter Four on industry and services begins with the question, namely, how did the economic structure of the Yangzi Delta change? This question is largely motivated by the fact that agricultural output per capita decreased over time. In this context, GDP per capita in the Yangzi Delta must have declined in the long run if non-agricultural output per capita did not improve significantly. In other words, rescuing the Yangzi Delta's economic growth requires a very visible positive structural change in the economy. First, I look at qualitative evidence. The majority of the Yangzi Delta's non-agricultural sector did not appear to have grown significantly faster than the population. Indeed, the urbanisation rate, which is often used as an indirect measure of economic structural change, also reflects similar results, indicating that urban population growth had not surpassed overall population growth. If these industries only expanded at a rate equal to the population, then the non-agricultural production per capita was not likely to

increase and, at most, would remain unchanged. When agricultural output per capita fell while non-agriculture remained constant, the economic structure inevitably improved, resulting in what appears to be proto-industrialisation. This improvement, however, was insufficient to prevent a further decline in GDP per capita as long as non-agricultural output growth did not appear to outpace population growth significantly in the long run.

To test the above inference, I estimate industry and services output. The results show that, while non-agricultural output per capita outperformed agriculture, overall income per capita in the economy fell. The finding, to some extent, reconciles the contradictions between the Involution and Development Schools of thought. As with proto-industrialisation, there is no doubt that structural changes in the economy occurred, the so-called "Development" of the economic process; however, input-output efficiency gains were not so substantial that per capita income did not rise, i.e. the "Involution" of the economic outcome.

The second section of the analysing economic growth begins in Chapter Five with a discussion of the growth process in the Yangzi Delta over several centuries. I use the previously constructed GDP data to investigate several important macroeconomic questions: (1) Was the Yangzi Delta China's most developed region? (2) What were the trend and breaks in economic growth in the Yangzi Delta over the centuries? (3) Was the Yangzi Delta subject to the Malthusian trap? (4) Can Boserupian or Smithian growth be used to describe the Yangzi Delta's economic growth process?

The first thing that can be confirmed is that the Yangzi Delta's economic standing in China is unquestionable. Even though Beijing, the other challenger, may have experienced a similar boom at times, the Yangzi Delta can be considered China's most developed region. Second, the Yangzi Delta's economic development trajectory might be separated into two phases: GDP per capita stagnation before 1865 and the initial efforts to embrace the path of modern economic growth after 1865. This reversal may be

explained by the fact that the local economic shrinkage became more moderate after the nineteenth century. The main reason for this could be the arrival of Western technology, institutions, and investment. However, economic growth during this period should not be overstated: TFP growth was in fact negligible. Traditional factors, particularly capital, were the primary drivers of economic growth. The answers to the third and fourth questions are actually the same. In terms of per capita GDP growth, the Yangzi Delta's economic growth pattern appeared to be more in line with the predictions of the Malthusian model. However, the persistence of technological and managerial innovations, as well as the maintenance of a high level of per capita GDP, are also features of Boserupian or Smithian growth. None of these labels are appropriate for describing the Yangzi Delta. The Yangzi Delta's economic pattern falls in between the gloomy Malthusian model and the optimistic Boserupian or Smithian growth models. In other words, it may resemble Mark Elvin's concept of the "high-level equilibrium trap".

The sixth chapter then attempts to place the Yangzi Delta's economic growth in a global context. The focus of this chapter is on responding to the Great Divergence Debate. Based on directly estimated GDP data for the Yangzi Delta, I conclude that the Great Divergence occurred at the end of the 17th century in comparison to the most developed European economies. I also run some robustness tests on the Great Divergence dating. A few counterfactual scenarios of what might have happened if the Great Divergence at the end of the 17th century had not occurred have been considered. All of these evidences point to the Great Divergence occurring at the end of the 17th century. Looking beyond the Great Divergence debate, I compare the economies of most of Europe and the Yangzi Delta and find that the greatest tragedy of the Yangzi Delta's fate may not have been the Great Divergence but rather the failure to capitalise on a general economic growth wave in Eurasia during the 19th century. This oversight directly contributed to the Yangzi Delta lagging far behind almost all of Europe's poorest economies.

ACKNOWLEDGEMENTS

As this four-year project nears completion, I would like to thank everyone who has helped, advised, and encouraged me. First, I would like to thank my supervisor, Professor Stephen Broadberry. During the past four years, I have learned so much from you that has been invaluable. Your guidance, encouragement, and patience enabled me to complete my project. When I first started working on GDP research, I never imagined that it would not be an easy project. Investigating historical economic growth is a fascinating but difficult task. Unintentional new questions and new material frequently disrupted my plans. When I have been frustrated by this, your patience and kindness have been a great comfort to me. Thanks to your patience and understanding, I have been able to try out ambitious new projects that would otherwise have been too daunting or time-consuming to consider. I have always benefited from talking to you. In any event, I would like to offer my most heartfelt gratitude to you. You were the one who led me into the vast field of historical economic growth. I hope to continue along this path and investigate every beautiful moment in the history of economic growth, beginning in Oxford.

I would like to express my gratitude to my family. I would like to thank Lei, my wife. Your unwavering support has enabled me to focus solely on my research. The happy times we have shared are what keep me feeling connected to you even when I am on the other side of the world, thousands of miles away. Just thinking about you makes me feel as if all my worries, fatigue, and frustration have been washed away. You are like a lighthouse to me. No matter how far away I may be on a dark sea, through a storm, with your light I can always find my way home. I also want to thank my daughter Huanxi. Your birth made me realise that life is always brighter. I remember the first time I held you, the first time I saw your smile, the first time I saw you walk, and so on. These first moments with you were among the most memorable of my life. I used to joke that when it came time to write the acknowledgements, I would say, “If my

daughter hadn't been born, my research would have been completed two years earlier." At this time, I would like to say that having you here is the greatest honour of my life. You were the one who taught me that work is just work and that there are far more valuable things in life. Those indescribably beautiful feelings, I believe, are the greatest gift I have received. I am always enchanted by the time I spend with you. Nothing can now compare to the joy that being with you every day brings me. And this wonderful feeling is something I had never felt before you entered my life.

I would like to thank my parents, Hengyi and Xiuzhi, who are my forever home. I may have my own family now, but I know you are always my forever family. I owe you so much that I cannot even begin to express my gratitude. This gratitude that is beyond words has merged into my very being. Or, to put it another way, you have always felt like a physical extension of my body to me. You have never stopped loving and supporting me. I have never had anyone ask so little of me. The only thing you wished for me all these years was that I be happy every day. Whatever gratitude I could possibly express would be insufficient. There are no words that can adequately convey the depth of my love and appreciation for you. I will never be able to adequately repay the love that you have shown to me. Even if I were to say something, all I could say is that the best way I can possibly express my gratitude is to focus on my own happiness. Now, just as you would like me to, I sincerely hope that you are also happy every day.

I want to thank a lot of other kind people as well. I would like to express my gratitude to Professor Shuji Cao, Professor Sheilagh Ogilvie, and Professor Dan Song for the selfless support and invaluable guidance that you gave me. Your kindness, your encouragement, means a lot to me. I have always been moved by your concern and support for young students. Your concern for students serves as the example for me to follow in the future when I am a scholar. I aspire to be able to impart this noble quality of yours to the next generation of youth so that they may experience the warmth it brings. Professor Eric Chaney, Professor Bozhong Li, Professor Zhan Lin, Professor Denggao Long, Professor Zhaohui Lou, Professor Kent Deng, Professor James Fenske, Professor

Bishnupriya Gupta, Professor Debin Ma, Professor Patrick O'Brien, Professor Kevin O'Rourke, Professor Catherine Schenk, Professor Jan Luiten van Zanden, thank you for your thoughtful and insightful advice regarding my research. I really appreciate it. The time I have spent conversing with you has been extremely beneficial to me. Also I would like to express my gratitude to my friends Mengzhen Chai, Ling Gao, Yipeng Han, Sijie Hu, Chang Liu, Xizi Luo, Lemin Wu, Qiong Wu. You have been significant to me in ways that go beyond the realm of academia. First and foremost, it is a tremendous blessing to count such wonderful people as yourselves among my friends. I have learnt many noble qualities from you all. You have given me more happiness than I have words to express.

I would also like to extend my thanks to the many other friends who have been there for me throughout this journey. Thank you also to the many academics who have provided helpful feedback at various seminars and conferences. Finally, I would like to express my gratitude to the Oxford History Faculty, the Oxford Centre for Economic and Social History, and the Economic History Society for providing me with an excellent academic environment and generous financial support.

WEIGHTS, MEASURES AND MONEY

1. Weight:

1 Shi dan/picul = 100 Shi jin/catties = 50 kg

1 Huizhou cheng = 20 Jin

1 Huizhou ju = 25 Jin

1 Tang/Song jin = 1.36 Shi jin

1 Ming/Qing jin = 1.19 Shi jin

2. Volume:

1 Shi shi = 10 Shi dou = 100 Shi sheng/litters = 22 English gallons

1 Tang shi = 0.59 Shi shi

1 Song shi = 0.66 Shi shi

1 Yuan shi = 0.95 Shi shi

1 Ming/Qing shi = 1.0355 Shi shi

3. Weight and Volume conversions

Husked rice: 1 Shi shi = 160 Shi jin/catties

Unhusked rice: 1 Shi shi = 130 Shi jin/catties

Wheat: 1 Shi shi = 140 Shi jin/catties

Beans: 1 Shi shi = 140 Shi jin/catties

Fava beans: 1 Shi shi = 125 Shi jin

Rapeseed: 1 Shi shi = 150 Shi jin

4. Area:

1 hectare = 15 Shi mu = 10,000 sqm = 2.5 acres

1 Chinese qing = 100 Mu

1 Tang big mu = 0.2266 Shi mu

1 Tang small mu = 0.5438 Shi mu

1 Song mu = 0.876 Shi mu

1 Ming mu = 0.9597 Shi mu

1 Qing mu = 0.9216 Shi mu

5. Money:

1 Tael of silver = 10 Qian of silver = 100 Fen of silver

1 Song tael of silver = 40 gram of silver

1 Ming tael of silver = 36.9 gram of silver

1 Qing tael of silver =37.3 gram of silver

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CHAPTER ONE: INTRODUCTION

1.1 The Great Divergence: A New Look at an Old Issue

700 years ago, Marco Polo declared a wonderful world at the easternmost tip of Eurasia; 246 years ago, Adam Smith asserted in his famous book that the cost of labour differed between East and West; 110 years ago, Max Weber observed the whole world tirelessly and continuously, chatting from the spirit of Western capitalism all the way to the religions of the East; 68 years ago, Joseph Needham began to conceive of the so-called Grand Question; 22 years ago, Angus Maddison and Kenneth Pomeranz respectively began to rethink comparative global growth in numbers rather than words.

For nearly a millennium, the question has been hotly debated: what is the comparative trajectory of development in the Eastern and Western worlds? Civilisations flourished at both ends of the Eurasia continent. However, until the 18th century, the two sides knew almost nothing about each other, despite having a keen interest in it. As the Industrial Revolution paved the way for modern growth in the West, civilisations in Eurasia's far east appeared less untouchable and even less respectable. The mystery of Asian Eastern civilisations was lifted in the aftermath of European global colonial activities. Europeans discovered that the once-admired lands of wealth were disappointing. However, this had no negative impact on the discussion of East-West comparisons, which had even evolved into a more lively and ongoing discussion of why the East lagged behind the West.

For a long time, however, people did not seem to realise that a question like the East-West comparison had two sides. Some twenty years ago, although questions were asked in different forms, almost all of them focused on one essence, namely "why did the Industrial Revolution not take place in the East or in China" or "why did the West

succeed and the East fail". Max Weber's study of spirit of capitalism and his discussion of Chinese religion did not go much beyond this question. Also, the famous Needham Puzzle, proposed later by Joseph Needham, a historian of science and technology who had a significant influence on Chinese scholars, is a reformulation of this question. There has long been a preconception that the East has always been backward. As a result, most East-West comparative studies have focused on why the West succeeded and the East failed.

Explaining the West's success is a critical component of the literature on economic development and growth. There have been numerous explanatory frameworks proposed. Culture, geography, human capital, institutions, scientific revolution, population, resource endowments, state, and even Darwinism have all been advanced (e.g., Acemoglu, Johnson and Robinson, 2001, 2002, 2005a; 2005b; Allen, 2009a, 2011; Baten and van Zanden, 2008; Broadberry, 2021; Buringh and van Zanden, 2009; Clark, 1987, 2008; Diamond, 1999; Galor, 2005; Galor and Weil, 2000; Galor and Moav, 2004; Greif and Tabellini, 2010; Lin, 1995; Mokyr, 1992, 2005, 2018; de Moor and van Zanden, 2010; North, 1981, 1990; North and Thomas, 1973; North and Weingast, 1989; Sokoloff and Engerman, 2000; Voigtländer and Voth, 2006, 2013; van Zanden, 2009b). For a time, explaining the rise of the West seemed to be as popular a topic as rock stars.

However, as interest in the quantitative situation in the early historical period has grown, another facet of comparative East-West research has gradually emerged. The publication of Maddison's ambitious project on historical GDP (Maddison, 1995, 1998, 2001) and the emergence of revisionists represented by Pomeranz (Pomeranz, 2000) forced a gradual realisation that for a long time we appeared to be in a somewhat awkward position: in the matter of East-West comparisons, were those pre-determined turning points, such as the Industrial Revolution or some earlier event, truly the turning point in the East's backwardness? Was observing the East's backwardness so late in the colonial era equivalent to the East being backward from even earlier? Is the relevant explanatory framework therefore misleading if previous preconceptions about the course

of Eastern civilisation's backwardness are incorrect? When was the true turning point in the development of East and West? Could it have happened after or before the Industrial Revolution? These are questions that have rarely been addressed. Unfortunately, we know far too little about past economies. For a long time, there has been no agreement on when the West came to power. Even serious responses based on quantitative evidence are uncommon. All we seem to know is that "the West was successful".

The traditional starting point for international comparison studies, that the East was always behind, has been called into question. "Get the facts first, then talk about the causes", has gradually become a consensus. The old problem of East-West comparisons appears to have taken on a whole new guise over the last two decades, thanks in no small part to a group of researchers known as the California School[1], represented by Pomeranz. These China-focused historians have taken the issue of East-West comparisons to a new level.

Pomeranz, in particular, put forward the very novel but controversial view at the time, in his famous book *The Great Divergence*, that in the early nineteenth century China and the West practically looked comparable and were not very different in any sense. This viewpoint was seen at the time as a challenge to so-called Eurocentrism, the traditional literature that exaggerated the West's successes and the East's failures. All of the somewhat arrogant interpretations of Western success might not have been warranted if the East had not failed so spectacularly.

Although Pomeranz's final, somewhat arbitrary attribution of Western success to some very late contingencies, such as coal mining and the New World, does not seem very convincing, and even his suggestion of a turning point in the development of East and West now appears problematic, one of the most significant contributions of these anti-Eurocentric studies, as represented by him, is to bring to light the dubious nature of the

[1] A detailed account of the California School can be found in Vries (2010).

crude presuppositions of Eastern backwardness. If a more convincing framework of interpretation for the West's success is to be provided, a clear understanding of the specific processes and trajectories of development between East and West is required. Any further discussion can take place only after identifying the turning points in the development of East and West. In short, one of the California School's most important contributions has been to uphold the fundamental dignity of academic research, namely that any interpretative theory should be based on facts rather than preconceived imagination.

Thus, rather than discussing the causes, researchers have spent the last two decades painting a picture of historical global growth. Even popular themes from decades ago to explain why the West succeeded or the East failed have emerged rarely or cautiously. Economic historians' focus has shifted to creating detailed databases and extending the evidence back in time. A new age of East-West comparisons is basically considered to have begun. More quantitative evidence is being collected, and the process of pre-modern economic development is becoming clearer by the day.

As new research has been conducted, it has become clear that the supposed turning point in the development of East and West did not appear to be as late as the nineteenth century, as the California School claims, nor merely the uncontroversial Industrial Revolution, which is highly praised in almost all of the literature, but that the East-West Divergence may have been foreshadowed much earlier (Allen, 2009b; Allen et al., 2011; Bassino and Ma, 2006; Bassino et al, 2019; Baten et al., 2010; Broadberry and Gupta, 2006, 2009; Broadberry, Custodis and Gupta, 2015; Broadberry and Guan, 2022; Broadberry, Guan and Li, 2018, 2021; Broadberry and Wallis, 2017; Li, 2010b; Li and van Zanden, 2012; Xu et al., 2017; van Zanden, 2009a). The renewed emphasis on data and facts reveals that many previously assumed imaginations of pre-modern economic development must be revised. This could be the undisputed contribution that sparks interest in the Great Divergence.

The last two decades have seen a gradual standardisation of criteria for evaluating historical development. Wages, GDP, productivity, and other indicators of standard of living or welfare such as height, nutrition, age-heaping, inequality, and so on are the most common. In contrast to today, where more accurate and comprehensive statistics are available, many indicators in the pre-modern period were often chosen based on the availability of local historical sources.

In European cases, the wage indicator is typically used. The availability of a large number of account books describing wages over successive centuries has enabled relevant research in Europe to go further than in Asian countries such as China and India (Allen, 2001; Allen, et al., 2011; Álvarez-Nogal and Prados de la Escosura, 2013; Clark, 2001, 2005, 2007, 2008; Malanima, 2011; Palma and Reis, 2019; Ridolfi, 2019; van Zanden, 1999, 2009b, etc.). Cross-country wage comparisons in Europe were investigated using these data almost simultaneously, if not earlier, than the Great Divergence topic (e.g., Allen, 2000, 2001; van Zanden, 1999).

However, if such cross-country comparisons are to be applied to East-West comparisons, wage data for Eastern economies must also be found. Unfortunately, the East's historical wage legacy, particularly in China, is much poorer than that of Europe. Allen et al. (2011) published one of the most widely cited studies on wages in China. An exhaustive search by the five authors, however, yields only a few hundred scattered records from the 18th to early 20th centuries in China. This calls into question the findings of the Chinese wage study (e.g., Deng and O'Brien, 2016). Indeed, even if wage samples in China were as large as those in Europe or even Britain, wage research would most likely be deficient.

Wage criticism has been rampant in recent years. A book titled *Seven Centuries of Unreal Wages* has even been published (Hatcher and Stephenson, eds., 2018). Leaving aside some of the specific shortcomings of wages, the following are the main issues with current wages for the purposes of the Great Divergence or East-West comparison:

(1) Daily or annual wages? The majority of current wage studies focus on daily wage rates, which are the most easily accessible figures. The annual wage is probably the more appropriate item for comparing living standards. Yet even in Britain, an economy with a rich record of wages, only 6,800 observations of male annual wages can be found (Humphries and Weisdorf, 2019), compared to tens of thousands of daily wage records after the 13th century (Clark, 2005, 2007). The primary distinction between annual and daily wages is the number of days worked. If the number of workdays in a year is assumed to be constant, then these two measures of living standards are problem-free, as demonstrated by Allen et al. (2011) and Clark (2010). However, in practice, this is difficult to achieve. In Britain, the so-called "industrious revolution" suggests that the length of the working year might have been increasing prior to the Industrial Revolution (e.g., Allen and Weisdorf, 2011; Humphries and Weisdorf, 2019; Koyama, 2012; Voth, 2000, 2001, 2003; de Vries, 1994, 2008). As a result, annual income calculated for a fixed number of workdays can have a significant trend error.

(2) In-kind payments. Another issue with annual wages as opposed to daily wages is how payments in kind are calculated. For employees with annual contracts, payments in kind are a significant source of income in addition to monetary wages. However, these records are frequently difficult to locate. Deng and O'Brien (2016) argue in a critical study of wages in China that in-kind payments for annual contract workers in the Chinese labour market are likely to exceed 70 percent. If this proportion is misestimated it could yield widely varying results.

(3) Who should be compared? With so many occupational categories to choose from, it can be difficult to determine which occupations best represent the local context in comparison studies. Unskilled workers, as represented by construction workers, are the most commonly used occupations in wage studies (Allen, 2001). However, differences in labour markets across countries can result in occupations of representative workers that are likely to differ. Deng and O'Brien (2016) suggest that wages for construction

or urban workers may not accurately represent China's welfare situation. Agricultural workers are expected to outnumber construction workers in the Chinese labour market. In a study of annual wages in England, the authors also reselect agricultural workers rather than construction workers as the basic unit for establishing wage series data (Humphries and Weisdorf, 2019).

(4) What exactly do the wage records we are currently viewing mean? Wages on the account books don't always match what workers got. Contractors frequently took a cut, resulting in recorded wages that did not correspond to what workers were actually earning. If the contractor's share remains constant, wage trends will remain unchanged. Nevertheless, if cross-country comparisons are to be made, the error arising from the wage level values may be quite substantial.

Given the scarcity of wage data in China and the difficulties of wage research, the road to incorporating the Chinese case into the Great Divergence may be particularly difficult from a wage standpoint[2]. The literature on wages in China is also, in fact, far less broad than for other indicators of productivity or GDP. The Chinese situation is fortunate in this regard. In contrast to the lack of micro wage sources, China's macro history is well documented. Population, cultivated land, public finance, and a variety of other macro statistics were prioritised by successive Chinese dynasties. These one-of-a-kind sources, which can be found in Chinese historical publications or archives, aid in understanding the history of Chinese economic growth, particularly productivity and GDP, from a macro perspective. Macro data were created for tax purposes. Some cannot be

[2] A new study appears to have gathered more wage records in China (Liu, 2022). Over 6,000 wage samples have been used. This is most likely a new development in Chinese wage research. Unfortunately, there are still a lot of unresolved old questions. On the one hand, a large number of local civil servants' wages have been used. These records are most likely not the full income of civil servants, but rather a government budget. On the other hand, since the 18th century, no additional data has been discovered beyond Allen et al. (2011). The discovery of thousands of piece-rate records of engravers in the Yangzi Delta between the mid-17th and early 18th centuries, at a time when data was scarce, may be the study's most significant contribution. However, whether these data can be used to describe a long-term wage series in China should be approached with caution. The first challenge is determining how to convert the piece rate into daily or annual wages. Second, are the workers capable of carving the monuments only highly skilled and not representative of unskilled workers? In any case, it appears that this ongoing study is a new result of wage research in China.

used directly because they do not always accurately reflect the real world economy. Historians and economists, on the other hand, have adjusted the raw data based on a large body of reliable evidence and created long-term population and land databases (e.g., Cao, 2000, 2001, 2018, 2022; Dong, 2002; Durand, 1960; Ge, 2000; Hou, 2001; Liu and Hwang, 1979; Perkins, 1969; Shi, 2011, 2015, 2017; Wang S., 1999; Wu, 2000). Based on the adjusted macrodata, China is well positioned to participate in the East-West comparative growth dialogue, particularly from the standpoint of productivity and GDP via an output-based approach.

As a result, GDP research in China has grown rapidly over the last decade, owing to the greater availability of historical data compared to wages. The findings of several studies are largely consistent: for the comparative study of China as a whole, the "Great Divergence" occurred before the revisionists claim (Broadberry, Guan and Li, 2018, 2021; Li, 2010b; Li and van Zanden, 2012; Ma and de Jong, 2019; Xu et al., 2017). In conjunction with the long tradition of agricultural productivity research by Chinese economic historians and some recent wage studies (e.g., Allen, 2009b; Allen et al., 2011; Fang, 1996, 1997, 1999; Guo, 2010; Huang, 1985, 1990; Li, 1998, 2010b; Peng, 2013; Shi, 2017), some indirect regional discussions appear to lead to similar conclusions.

Given the close proximity of China's entire territory to the entirety of Europe, it seems reasonable to reduce "China" to a smaller scale, as the California School suggests, in order to obtain more accurate results. Reaching regional levels, on the other hand, is a much more difficult task than studying China's aggregate productivity or GDP. The main reason for this is that the data recorded in Chinese historical sources is mostly aggregated, and there is very little high-quality quantitative regional evidence. Few low-level primary archives exist prior to the 18th century. Early aggregated data can be found in well-known official publications like the *Twenty-Four Histories* (二十四史) or *Shilu* (Veritable Records of the Dynasty, 实录). However, the majority of the underlying primary archives used to obtain the aggregate data are inaccessible. We know

very little about how these national aggregates were formed, although it is intuitively clear that they must have come from lower-level sub-regional figures.

Broadberry and Guan (2022) narrow their study of national GDP to a few large Chinese regions. However, due to a lack of data, their approach is more indirect. They find some regional data relative to the China average to calculate the share of agriculture, and use regional urbanisation relative to the China average to predict the non-agricultural share, based on their estimates of China's GDP as a whole. This method produces GDP estimates for several sub-regions for the years 1400, 1580, 1770, and 1850 (in their study, about two to three Chinese provinces are combined into one sub-region). However, due to a lack of data, they provide more crude indirect estimates than the several sub-regions mentioned above for China's long-standing regional hotspot, the Yangzi Delta. Nonetheless, it is the only study of China's regional GDP available at the moment. This study, almost for the first time, opens the black box of Chinese historical regional economy and confirms that the Great Divergence must have occurred much earlier than the California School suggests.

Although a new age of East-West comparisons has dawned in the last two decades and many details of historical economic growth are being portrayed for the first time, the criteria used to measure economic growth or living standards in different regions depend largely on which indicators are better generated by local historical sources. Wages are more appropriate in the European context, whereas in China or even East Asia, such as Japan, a macro view of output may be a better choice. More novel developments in this supposedly new era result from including the history of previously underappreciated Asian economies in the discussion, especially when taking into account the tradition of quantitative research in European economic history. China, in particular, has always been a much-needed gap in the Great Divergence discussion. Studies of China's aggregate GDP have gradually unlocked the Chinese economic history's black box. Despite the difficulties, recent attempts to work down from aggregate GDP to regional GDP have also allowed for a more in-depth examination of China's economic growth

history. Unfortunately, however, the Great Divergence question has not been studied in a particularly straightforward manner. There is widespread agreement that the Great Divergence predates the 19th century, but it is unclear how far back.

Broadberry's team uses an indirect approach to determine the exact time of the Great Divergence, assuming that the per capita income of China's most developed regions was 1.7 times the China average. However, this is not a straightforward answer. Other studies rarely dialogically discuss such attempts, except for a few dubious remarks (e.g., Solar, 2021a, 2021b). In other words, we still don't know when the Great Divergence occurred. The primary reason for this is that the per capita income or welfare of China's representative economy in the Great Divergence topic, the Yangzi Delta, has yet to be directly measured. Another difficulty in using the average Chinese GDP per capita multiplied by a factor is that the current series of Chinese GDP is not continuous. There are decades of gaps in available GDP data in the 17th century, which is suspected of containing the date of the Great Divergence, due to the dark ages of data generated by Ming and Qing dynastic changes.

Recent research has pushed the date of the Great Divergence closer by the day. So far, it appears that it is time to put the final piece of the jigsaw puzzle together. Realising that now may be the time, I have attempted for the first time in the literature to explore the economic growth of the Yangzi Delta, one of the most important objects of study on the Great Divergence in the East, over seven centuries. The most important question that this study must address is: what was the long-term trajectory of per capita income and economic development in the Yangzi Delta, particularly during the pre-modern period? In contrast to the lengthy research background I have described above, my research questions are exceptionally concise, with little repetition. The background to the problem of the Great Divergence may necessitate many words, but how to solve the problem of the Great Divergence does not necessitate much description in the literal sense, even if the process of solving it may take an inordinate amount of time and effort. Data is the short answer. With data, pre-modern economic growth, East-West

development comparisons, and the Great Divergence are all solved. My research revolves around data.

For the first time, I compile an annual GDP series for the Yangzi Delta from 1393 to 1953, spanning 561 years or seven centuries (late 14th to mid-20th century) for the nine Prefectures centred on Taihu Lake. With the new findings, I discover that the Yangzi Delta, widely regarded as the most economically developed region, exhibited a strong "high level equilibrium trap" pattern (Elvin, 1973) in the 400 years preceding the mid-nineteenth century. The economic costs of population growth appeared to outweigh the potential benefits. It wasn't until the end of the nineteenth century that the local economy began to show even a sliver of a chance of entering modern economic growth. In seven centuries of economic growth history, the period in which the Yangzi Delta lagged behind the most developed European economies occurred in the late 17th century, consistent with Broadberry and Guan (2022) and Broadberry, Guan and Li (2018, 2021) in concluding that the Great Divergence was earlier than the revisionists believed and later than Eurocentrism, also is the so-called "Third Way".

So far, the date of the Great Divergence has received the first direct response. The Yangzi Delta's economic trajectory has been fully charted. The most important contribution of this study, in my opinion, should be a precise date for the Great Divergence. Perhaps my results do not close the Great Divergence debate yet, but in a way it may be a new beginning for the Great Divergence debate. Another contribution is that GDP per capita in China's most developed regions has been pushed back to the late 14th century for the first time, also in the form of annual frequencies. The inclusion of the Yangzi Delta will provide more early evidence for historical economic growth in Asia, as the only current studies of historical economic growth in Asia as early as the 14th century appear to be the cases of overall Chinese GDP by Broadberry's team (2018, 2021) and Japan by Bassino et al (2019). Furthermore, previous studies of China's historical economic growth have tended to be based on very cautious decadal or even longer intervals of data, making short term economic cycles poorly studied. For the first

time, data on China's annual frequency prior to the nineteenth century are available, which I believe will be useful in studying China's historical business cycles. It is also noteworthy for shedding light on China's regional economic growth history. It is impossible to comprehend China's economic growth process without understanding its regional economies, as I have previously stated and will continue to do so in the future. However, mapping out the regional situation in China is extremely difficult. Broadberry and Guan's study of Chinese regional economic history is a first step toward opening the black box, and I hope to contribute further to the process.

It is worth noting that, as my discussion suggests, my answer to the date of the Great Divergence is based on the work of countless forefathers. Many previous scholars have also influenced my research on economic growth in the Yangzi Delta, though no detailed study of GDP in the Yangzi Delta over time has been conducted. LI Bozhong's[3] decades of in-depth study of the Yangzi Delta's economic history are an important prerequisite for my research (Li, 1990, 1998, 2002, 2003, 2010a [2000], 2010b). Understanding much of the economic history of the Yangzi Delta begins with Philip Huang's (1990) investigation of the agricultural economy of the region. It has taught a generation, including me, the conceptual framework of local economic development.

Because the Yangzi Delta has been a traditional focus of Chinese economic history, the research of many other Chinese scholars, such as CAO Xingrui's study of local rural economy written using first-hand survey data from the Republican period (Cao, 1996), FAN Jinmin and his co-authors' study of the local silk industry (Fan, 2016; Fan and Jin, 1993), HUANG Jingbin's (2009) comprehensive discussion of consumption in the Yangzi Delta from 1750 to 1930, XU Xinwu's exhaustive search for materials on the local cotton textile industry (Xu, 1992), and ZHANG Zhongmin's (2015 [1990]) survey of the economic history of the Shanghai region spanning six centuries, etc. Of course, there are numerous other scholars whose discussions of various aspects of Yangzi Delta

[3] Due to the writing conventions of Chinese author names, the surnames of Chinese authors are listed in capital letters in front of their given names in the text that follows.

history are too numerous to mention. The Yangzi Delta has become as significant to the study of Chinese economic history as England is to the study of European economic history, thanks to the quantity and quality of information available about the region. It is a long-discussed and studied region. Not only is it a good time to pursue the Great Divergence topic further, but it may also be a good time to attempt to reach the GDP for the study of the Yangzi Delta's local economic history.

Finally, as with many previous studies, estimating historical GDP does not yield the same exact results as modern GDP statistics (Deng and O'Brien, 2017; van Zanden and Ma, 2017). Such efforts, however, are intended to provide some point of reference for plotting long-term development trajectories. We can only get to the end by taking the first step. Some scholars remain sceptical of the study of historical GDP, but I believe it is worthwhile to try, even if the results are unlikely to be perfect. The finish line in the long study of historical economic growth may be unreachable, but running forward is still beneficial to our understanding of the past. Even the most pessimistic possibility of running in the wrong direction may benefit future generations by teaching them which directions to avoid. In the long-term macro-historical picture, it may be difficult to draw a particular detail accurately, but this usually doesn't hurt understanding a development issue as a macro one. Excessive attention to detail is thus not always warranted. There is reason to believe that such a compass-like reference aids in better understanding past economies, allowing us to one day discover a new world rather than resembling a lost ship in a dark mediaeval sea.

1.2 Questions for the question: What and How

1.2.1 Where is the Yangzi Delta?

Before we can begin to formally discuss the Yangzi Delta economy, we must first address a number of specific issues. The first question is, what is the Yangzi Delta exactly? There is no universally accepted standard for the definition of the Yangzi Delta (Fan,

2012: 2-10). It has existed as a hazy region for a long time. However, there is no doubt that the name implies a relatively prosperous region in China's lower Yangzi River.

Specifically, definitions provided by the government and academics frequently differ significantly. Recent official regional development plans provide a clear definition for the government. They propose a region equivalent to four provincial administrative units - Jiangsu, Zhejiang, Anhui, and Shanghai - on the northern and southern banks of the lower Yangzi River (National Assembly of the People's Republic of China, 2016), also known as Chang Sanjiao (which translates as "Lower Yangzi River Delta").

However, this definition appears to be too broad in the academic history of the Yangzi Delta. Scholars have traditionally studied much smaller areas. The "Lower Yangzi River Region" is a well-known definition in the literature that was first formalised by William Skinner (1985). The Lower Yangzi River Region, according to his unique definition of Chinese geography, is a zone centred on two rivers, roughly equivalent to a section of the Yangzi River in Jiangsu Province and a small area on both sides of the Qiantang River in Zhejiang Province. On a very rough scale, it could be considered the southern half of Jiangsu province and roughly half of northern Zhejiang province. Nevertheless, the region includes some of the less culturally and economically unified outskirts. As a result, some historians' work sometimes narrows this area even further (Li, 1990, 1998, 2010b; Pomeranz, 2000). This smaller area roughly refers only to the so-called "Zhexi (浙西)", an area derived from the Song Dynasty's provincial administrative unit Zhexi Lu. Indeed, this is the same "Jiangnan (江南)" mentioned in a great deal of Chinese historical literature.

However, Jiangnan has a complicated definition. Prior to the Qing Dynasty, the definition of Jiangnan's largest area could even be extended to all areas south of the Yangzi River, which is what "the world south of the river" literally means. While definitions in the literature vary, they all share a significant overlap. That is, a small area centred on Taihu Lake included nine Qing Dynasty prefectures: Yingtian Prefecture, Suzhou

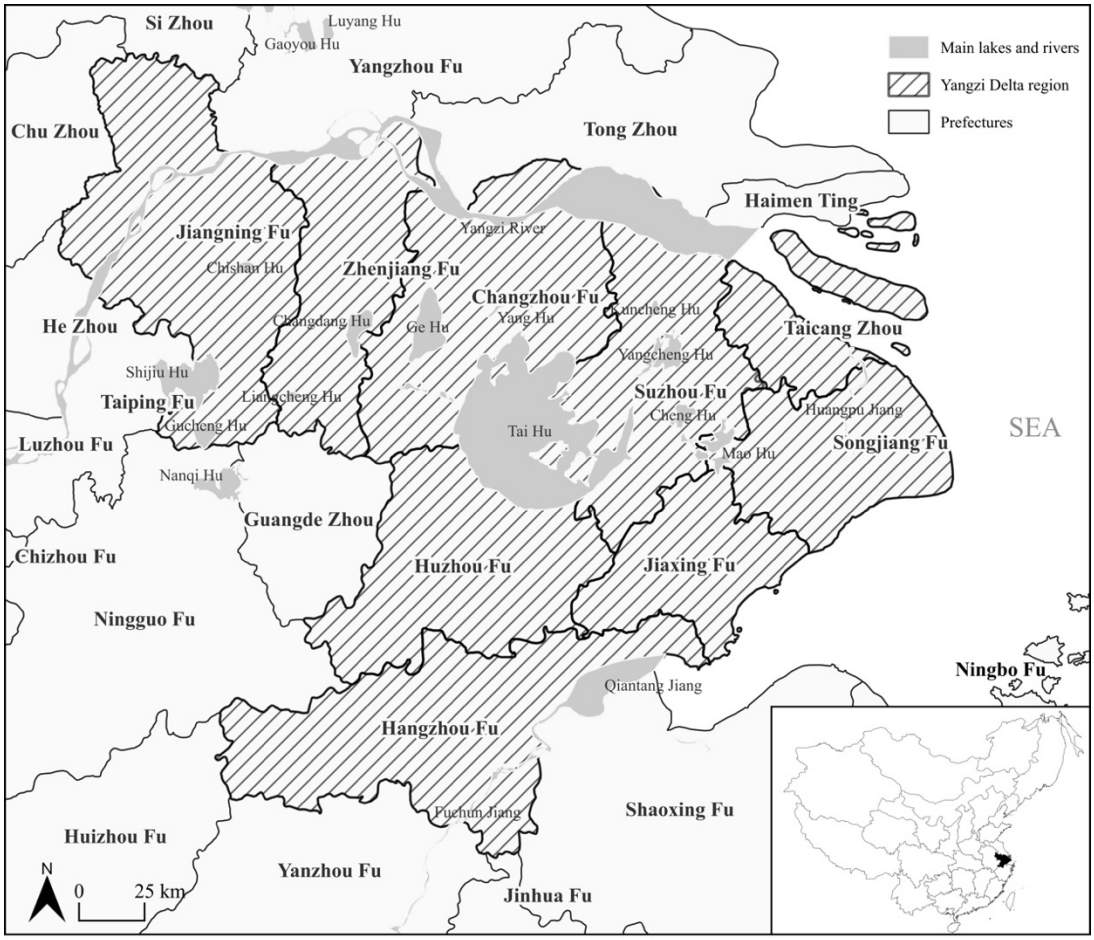

Figure 1.1 Territory of the Yangzi Delta in 1820

Sources and notes: the map shown is based on Chinese territory in the 1820s, as obtained from Harvard University's CHGIS V6. In this study, the dark area on the map represents the Yangzi Delta, which includes nine prefectures: Jiangning Fu, Suzhou Fu, Changzhou Fu, Zhenjiang Fu, Songjiang Fu, Taicang Zhou, Hangzhou Fu, Huzhou Fu, and Jiaxing Fu. The box in the lower right corner is a provincial map of the Qing Dynasty in 1820, with the location of the Yangzi Delta defined in this research marked in black.

Prefecture, Changzhou Prefecture, Zhenjiang Prefecture, Songjiang Prefecture, Taicang Prefecture, Hangzhou Prefecture, Huzhou Prefecture, and Jiaxing Prefecture. The definition of the nine prefectural regions is also used in a series of well-known studies by LI Bozhong and the California School. There is a tacit agreement that any definition that includes this core region, not exceeding Anhui, Jiangsu, Shanghai, and Zhejiang, can be considered the Yangzi Delta. As a result, referring to this core region as the Yangzi Delta in this study not only allows for a technical conversation with the

California School, connecting the topic of the Great Divergence, but it also captures the intersection or common ground of this exceptionally vaguely defined region[4].

Figure 1.1 depicts the core area of the nine prefectures, which is also this study's territory. Many accounts of the Yangzi Delta overlap with this region. The area depicted is divided into three sections, each centred on Taihu Lake. Suzhou, Taicang, and Songjiang (Shanghai) are to the east and are widely regarded as the Yangzi Delta's most developed areas. Jiangning, Zhenjiang, and Changzhou are to the west of Taihu Lake, with Jiangning, now Nanjing, serving as China's capital during the early Ming Dynasty and the mid and late Republic of China. South of Taihu Lake are the three Zhejiang Province regions of Hangzhou, Huzhou, and Jiaxing, with Hangzhou serving as the province's capital for many years and as the capital of China's southern regime during the Southern Song Dynasty (1127-1279). The Yangzi River enters the region from Jiangning and flows into the sea at Taicang, which is located at the northernmost end of the Yangzi Delta. The Yangzi Delta is made up of nine prefectures and covers 51,100 square kilometres, or 0.53 percent of Chinese territory. With a population of 27.64 million in 1800, this area was one of the most densely populated areas in China in recent centuries, accounting for approximately 8 percent of China's total population (Cao, 2000, 2001, 2018). However, it should be noted that, while the aforementioned area is frequently mentioned in much of the literature, this does not imply that the so-called Yangzi Delta, as it is often referred to, has reached a consensus. As previously stated, the name has long meant various things to various groups of people. To follow the intersection of groups and conventions in the Great Divergence topic, I chose nine prefectures as the Yangzi Delta. I have no intention of changing how people perceive the region, whether it is called the Yangzi Delta, Chang Sanjiao, or Jiangnan.

[4] There are smaller definitions, such as Philip Huang (1990). It is probably equal to Suzhou, Taicang and Songjiang on the east bank of Taihu Lake. This region is undeniably the core of the nine prefectures, but it is too small for many scholars to use.

1.2.2 Methodology and data

1.2.2.1 A brief introduction of methodology and data

To explain my Yangzi Delta GDP calculation, I briefly describe the main research methods and data. The main method for assessing a region's economic performance is output accounting. The ideal approach is to obtain a large number of sectoral output data and then use common GDP accounting methods to calculate per capita income, such as the SNA system. However, accounting for historical GDP is heavily reliant on the availability and quality of data. Before the 17th century, the output-based method is only applicable to the economies of Britain and Holland in Europe. In recent years, pre-modern GDP estimates for China as a whole have been included in the output-based methodology framework for regions other than Europe: nine benchmark years' GDP estimates from 1661-1933 (Xu et al. 2017), decadal GDP from 980-1840 (Broadberry, Guan and Li, 2018, 2021, BGL hereafter) and 1600-1840 (Liu, 2009), and annual GDP in 1840-1912 (Ma and de Jong, 2019) and 1402-1626 (Guan and Li, 2010), etc.

The feasibility of China's overall GDP, however, does not imply that the same approach can be used for China's regional GDP. When compared to regional data, China has a wealth of aggregate data. Aggregate data, such as population, land, sectoral output (mining, salt, tea, wine), and trade volumes, can be found in central government publications as well as unpublished archives, such as *Guanxiu Shishu* (官修史书, Official Compiled History for the Previous Dynasty), *Ming/Qing Shilu* (明清实录, Veritable Records of the Ming Dynasty and Qing Dynasty), *Ming/Qing Huidian* (明清会典, Collected Statutes of the Ming Dynasty and Qing Dynasty), *Kuaijilu* (会计录, Fiscal Yearbooks), etc. Furthermore, there are numerous Ming and Qing central government archives[5].

[5] For detailed discussion, see BGL (2018).

The sources and backing for the aggregated data, or local data, are, however, very disjointed. Lower-level county and prefecture sources are less systematic, whereas central government sources typically show neat provincial information, such as land taxation, population, and land. On the other hand, while frequently cited gazetteers and other local publications can be used to understand local economies, the data in them is far less continuous than that published by the central government for the country as a whole. For instance, the population and land area figures published by the Ming and Qing Dynasties' central government are typically continuous, despite requiring numerous adjustments for use. It implies that the local data used to create aggregate statistics ought to be continuous as well. Local sources, however, do not have as much data that can be used for time-series research as central government sources. Gazetteers, as local history encyclopaedias, are better for cross-sectional studies like finding many county-specific variables in the same base year. All of this suggests that regional GDP calculations may not be feasible using China-wide methods.

GDP can be calculated indirectly as well as output-based. This method categorises GDP into agricultural and non-agricultural sectors. For the agricultural sector, the basic consumer theory of economics can be applied, which assumes that per capita food consumption is related to prices and wages. Per capita agricultural product consumption is calculated using visible price and wage data, as well as some empirical parameters. The total agricultural output is then calculated using population after taking into account imports and exports of agricultural commodities (Allen, 2000). In the case of the non-agricultural sector, the urbanisation rates or the occupational structure, with some adjustments, serve as a proxy for the structure of the economy. The total GDP can then be determined by dividing the agricultural output by the economy's structure (e.g., Álvarez-Nogal and Prados de la Escosura, 2013; Malanima, 2011; Palma and Reis, 2019).

In China, indirect regional GDP methods cannot use wage data like in Europe. As previously stated, there is a scarcity of wage data in China. But the central government's obsession with agricultural taxes preserves a lot of data on local population, land, and

land productivity, which helps estimate agricultural output directly. In the absence of good quality data on non-agricultural output, data on the structure of the economy can be obtained in a similar way to Europe based on urbanisation, resulting in the final GDP calculation. This method is similar to that used in Japan, where GDP is estimated using direct estimates of agricultural output and indirect estimates of non-agricultural shares (Bassino et al., 2019). Broadberry and Guan's China regional GDP study follows this method.

Returning to the Yangzi Delta, the quality and availability of local data is actually far superior to that of other regions in China. The output-based GDP approach for the three sectors and the indirect approach for Chinese regions can be combined. This is due to the Yangzi Delta's wealth of local historical materials, which includes gazetteers, agricultural handbooks, private publications of local observers, local archives, manorial account books, genealogy books, and other items. The agricultural information, in particular, is impressive. In comparison to other parts of China, the local population, land, agricultural productivity, farming methods, and crop varieties can be supported by a variety of sources. This abundance of direct evidence paints a clear picture of the region's agricultural development (Allen, 2009b; Brenner and Isett, 2002; Huang, 1990; Li, 1998, 2010b; Pomeranz, 2000).

As for the non-agricultural sector, the output of many industrial sectors that use agriculture as an intermediate input can be calculated using the agricultural sector's crop details (Li, 2010a [2000], 2010b). With the total and urban population in mind, as outlined by Broadberry et al. (2015) for Britain, it is also possible to account for some sectors in manufacturing, construction and services. Manufacturing and textiles dominated the Yangzi Delta industry due to a lack of mining and slow development in the salt industry (Li, 2010a [2000]). Therefore, there is not a significant information deficiency when attempting to gauge the size of the industrial sector. Some information on economic structural changes can be a reliable source for determining long-run trends in non-agricultural output. For example, the large number of direct and indirect accounts

of urbanisation rates contribute to telling a very clear story about the local economic structural change trend (Cao, 2000, 2001, 2018; Jiang, 2013; Xu, van Leeuwen and van Zanden, 2018).

In particular, population and land are the starting points for calculating agricultural output (Chapter Two). Gazetteers are the go-to reference for population statistics in most areas. The raw figures from many gazetteers cannot be used directly because they only reflect tax collection. CAO Shuji's adjusted population database, based on thousands of gazetteers, is the most comprehensive account of Ming and Qing China's regions. For the Yangzi Delta, I follow Cao's classic study (2000, 2001) and his latest unpublished and updated manuscript (Cao, 2018). My research into Cao's population studies, however, suggests that his numbers may reflect the region somewhat more credibly than China as a whole, as will be described in the following chapter.

The problem with land numbers is more complicated. Indeed, the land records left from the Ming and Qing Dynasties cannot be taken into direct use either. For one thing, the unit of accounting "Tax Mu" used to record taxed lands in historical publications needs to be reconverted into real-world figures (the so-called *Zhe Mu* phenomenon discussed in detail in Chapter Two). Military land, on the other hand, is recorded separately and thus necessitates additional calculations. Thirdly, the original land figures include mountains and water, which should be excluded. Additionally, land concealment needs to be addressed. Based on the assumption that the Yangzi Delta had been fully reclaimed with no room for expansion, almost all previous studies on local cultivated land simply adopted the Wanli period land survey figures without any adjustment, the so-called 45 million Ming/Qing mu (Li, 1998). I now consider this approach to be somewhat arbitrary, and for the first time in the literature, I have reconstructed local cultivated land data from the late 14th century to the 1950s using a wealth of primary and secondary information.

Three stages comprise the agricultural calculation (Chapter Three). The first factor is grain yields. I collect a sample of 3,196 grain yields from the Yangzi Delta and its neighbouring Huizhou Prefecture based on a large amount of primary materials, such as land transaction contracts, rent ledgers, survey data, gazetteer records, and observer reports, among other things, combined with previous research. I create an annual grain yield series for 1393-1953 by combining this with around 20,000 subjective gazetteer descriptions of local agricultural harvests. The types of crops come next. Over 90 percent of the crops grown are thoroughly researched, including rice, cotton, mulberry, wheat, beans, and rapeseed. The remaining crops, animals, and forestry are also discussed. Finally, I investigate and calculate each crop's intermediate inputs and added value. Furthermore, old issues such as Involution or Development (Huang, 2002), as debated by Philip Huang and the California School, are revisited based on the agricultural data obtained.

Non-agricultural data are not as good as agricultural data. As a result, I discuss the development of the non-agricultural sector using both qualitative and quantitative methods (Chapter Four). I begin by looking at the qualitative evidence that describes the growth of non-agricultural output in the Yangzi Delta. Then, indirect evidence is added to this, such as data on urbanisation rate. With the combined information, I can get a rough idea of the upper and lower bounds of non-agricultural output growth in the Yangzi Delta. Using this as a reference system, I then make direct estimates of output for industry and services. The final non-agricultural output figures are obtained.

GDP comes from agricultural and non-agricultural output. The Yangzi Delta's economic growth process over seven centuries is discussed in detail using the new data. Fundamental economic trends and breaks are investigated. Some unresolved stories are also discussed in depth, including the Malthusian Trap, the Boserupian Agricultural Revolution, Smithian growth, the "high level equilibrium trap", and the Yangzi Delta's march toward modern economic growth (Chapter Five). As the topic that is likely to be

of most interest, the final discussion of the Great Divergence could be the end of this study or the start of future research (Chapter Six).

1.2.2.2 Data reliability assessment and sensitivity analysis

Despite the feasibility of utilising an output-based method to produce estimates of GDP for the Yangzi Delta, as stated in the preceding section, it is critical to thoroughly analyse the data quality to assure the credibility of the conclusions reached from it. As Feinstein and Thomas (2002) suggest in *A Plea for Errors*, it is essential to clarify the reliability of the data used in estimating historical economic data, as well as the potential errors related to deriving conclusions from such data. Readers may notice an imbalance in the Yangzi economy's data quality in the calculations presented in the following chapters. Simply put, the agricultural sector in the Yangzi region has considerably higher data quality than the non-agricultural sectors. As a result, it is crucial to understand how data quality issues in the Yangzi economy's non-agricultural sector may affect our results. At the very least, we should be aware of how much confidence we may have in the findings drawn from the data used in this study.

I have included thorough talks on the quality of various data series that are used in the estimating process in the following chapters. A summarised presentation is still required, however, to provide readers with an intuitive idea of the data quality employed in this study and the range of errors in the final GDP figures. Three commonly used methods can be employed to assess data quality (Feinstein and Thomas, 2002): comparison of alternative estimates, assignment of subjective margins of error, and sensitivity analysis. In Chapter Five and Chapter Six, I attempt to examine my Yangzi GDP results using the comparison of alternative estimates method. However, as Feinstein and Thomas point out, finding other independent and alternative results for historical data comparison might be difficult. There are limited other options for comparing Yangzi GDP estimations[6]. As a result, I prefer subjective margins of error and

[6] BGL (2018, 2021) and Broadberry and Guan (2022) provide some indirect discussions on Yangzi GDP, and the differences between their results and mine are not big.

sensitivity analysis for assessing data quality. These two strategies can be used separately or in conjunction to assess data quality. The method of assigning subjective margins of error has a long history, with early studies like Bowley (1911), Chapman (1953), Feinstein (1972), and Perkins (1969) using it. The fundamental idea is for researchers to assess the reliability of the data they utilise and offer subjective grades based on that assessment. Subjective margins of error for different sub-series can be aggregated to obtain margins of error for the final estimation. Feinstein and Thomas (2002) assume a 95 percent confidence level for subjective margins of error, equivalent to a variation of two standard deviations. Sensitivity analysis, on the other hand, evaluates the influence of changes in each sub-series on the overall result (e.g., GDP) to assist readers in understanding which components' data quality is most important for the final result. In recent years, studies on global historical economic growth accounting have begun to use subjective margins of error or sensitivity analysis methods to assess the quality of GDP estimates (e.g., Xu et al., 2017; van Zanden and van Leeuween, 2012), or a combination of both methods (Bassino et al., 2019; BGL, 2018).

In this section, I use the combination method developed by Bassino et al. (2019) and BGL (2018) to assess the quality or reliability of Yangzi economic data. The combined method works by assigning subjective margins of error to each sub-series that makes up GDP and then calculating the percentage impact of a change in the average subjective margins of error for each series on GDP. This way, readers can understand the data reliability of each sub-series and identify which series are important and how much impact they may have on GDP. The findings of the quality assessment of Yangzi data are reported in Table 1.1 using this approach. Section A of the table displays the rating criteria used for assigning subjective margins of error, which are based on the work of Bassino et al., BGL, and Feinstein. In simple terms, firm figures have an allocated error of less than $\pm$ 5 percent, good figures are $\pm$ 5 to 15 percent, rough estimates are $\pm$ 15 to 25 percent, and conjectures are greater than $\pm$ 25 percent. The results of subjective margins of error for different sub-series that comprise GDP, as well as the aggregated results of subjective margins of error, are shown in section B of the table, based

Table 1.1 Data reliability assessments and sensitivity analysis

A. Data Reliability Grades		
Reliability Grades	Margin of Error	Average Margin of Error
A. Firm figures	± <5 percent	± 2.5 percent
B. Good figures	± 5-15 percent	± 10 percent
C. Rough estimates	± 15-25 percent	± 20 percent
D. Conjectures	± >25 percent	± 40 percent

B. Reliability Assessments (subjective margin of error)				
		Ming	Qing	Post-Qing
AGRICULTURE				
Cultivated land		B	A	A
Double cropping index		B	A	A
First season	Rice area	A	A	A
	Rice yields	B	B	B
	Cotton area	B	A	A
	Cotton yields*	B	A	A
	Mulberry area	B	A	A
	Mulberry yields*	B	B	A
	Miscellaneous grains area	C	B	A
	Miscellaneous grains yields*	C	B	B
	Other cash crops yields*	C	B	B
Second season	Wheat area	C	B	A
	Wheat yields*	B	B	A
	Beans area	C	B	A
	Beans yields*	B	B	A
	Rapeseed yields	B	B	A
Non-farming value-added relative to farming		C	B	B
Agricultural output		B	A	A
INDUSTRY				
Artisan manufacturing		C	B	B
Silk		B	B	B
Cotton and hemp		B	B	B
Food processing		C	B	B
Construction		B	B	B
Other		B	B	B
Industrial output		B	B	B
SERVICES				
Government, commercial and financial services		C	B	B
Housing and domestic services		C	B	B
Services output		C	B	B
AGGREGATES				
GDP		B	A	A
Population		B	A	A

(continued)

GDP per capita		B	B	B
C. Sensitivity Analysis for Yangzi GDP (in percent)				
		Ming	Qing	Post-Qing
AGRICULTURE				
Cultivated land		± 4.538	± 1.051	± 0.799
Double cropping index		± 1.481	± 0.461	± 0.350
First season	Rice area	∓ 0.101	± 0.231	± 0.390
	Rice yields	± 4.538	± 4.627	± 3.831
	Cotton area	∓ 0.257	∓ 0.073	∓ 0.041
	Cotton yields*	± 0.748	± 0.160	± 0.082
	Mulberry area	∓ 0.054	∓ 0.016	∓ 0.011
	Mulberry yields*	± 0.106	± 0.217	± 0.067
	Miscellaneous grains area	∓ 0.578	∓ 0.651	∓ 0.294
	Miscellaneous grains yields*	± 0.064	± 0.072	± 0.131
	Other cash crops yields*	± 0.689	± 0.229	± 0.130
Second season	Wheat area	∓ 0.671	∓ 0.678	∓ 0.229
	Wheat yields*	± 0.149	± 0.299	± 0.095
	Beans area	∓ 0.261	∓ 0.235	∓ 0.020
	Beans yields*	± 0.095	± 0.170	± 0.015
	Rapeseed yields*	± 0.113	± 0.204	± 0.022
Non-farming value-added relative to farming		± 2.360	± 1.093	± 0.831
INDUSTRY				
Artisan manufacturing		± 0.671	± 0.362	± 0.403
Silk		± 0.034	± 0.069	± 0.086
Cotton and hemp		± 0.616	± 0.666	± 1.112
Food processing		± 1.896	± 1.025	± 1.138
Construction		± 0.223	± 0.209	± 0.185
Other		± 0.219	± 0.237	± 0.263
SERVICES				
Government, commercial and financial services		± 5.091	± 2.643	± 2.966
Housing and domestic services		± 1.082	± 0.584	± 0.649

Sources and notes: Data reliability grades refers to the works of Bassino et al. (2019), BGL (2018), and the earlier study by Feinstein (1972). Sensitivity analysis reveals the changes in GDP percentage caused by the increase or decrease of one average margin of error for each series. The crops denoted by * represent their relative yields to rice yields.

on this criteria and the details of each series data and their sources used in this study. The aggregation process and methods of subjective margins of error for different sub-

series follows the appendix section of Feinstein and Thomas (2002)[7]. The results of the sensitivity analysis are shown in section C of the table.

Overall, the data quality of the non-agricultural sub-series is lower than that of the agricultural sector. In the agricultural sector, the sensitivity analysis results show that only the sub-series of cultivated land and double-cropping have an obvious impact on GDP, exceeding 2 percent but still below 5 percent. In the non-agricultural sector, the sub-series of government, commercial, and financial services has a considerable impact on GDP, even slightly exceeding 5 percent during the Ming Dynasty. However, the aggregated results indicate that the data quality of GDP estimates is good, with average margins of error well below 10 percent and below 5 percent after the Ming Dynasty. The average margins of error for per capita GDP are also kept within 10 percent. This means that, overall, the GDP estimates and conclusions of this study are generally reliable. Although there are larger errors in non-agricultural sectors, the impact on the final result is still within acceptable ranges. It is especially interesting that the agricultural sector results have small errors, indicating more accurate conclusions reached from the agricultural sector investigation. Future research may unearth further fascinating insights about the Yangzi agricultural economy based on this high-quality data.

[7] Specifically, considering $F=f(X, Y)$, where X and Y are components of the dependent variable F. The error structure or margins of error (in standard errors form) for each variable is σ_i ($i=F, X, Y$). Therefore,

$$\sigma_F^2=(F_x\sigma_x)^2+\left(F_y\sigma_y\right)^2+2\left(F_xF_y\sigma_x\sigma_yR_{xy}\right)^2,$$

where F_x and F_y are partial derivatives of F with respect to X and Y, respectively. R_{xy} is the correlation between σ_x and σ_y. This means that if each sub-series is independently constructed, these errors will offset each other in the aggregates.

PART I: MEASURING ECONOMIC GROWTH

CHAPTER TWO: POPULATION AND LAND

2.1 Introduction

Historical GDP calculations and understanding pre-modern economic growth commonly begin with population and land. As a series of early economic historians did, if we assume that per capita consumption or output changed very little in pre-modern times, then accurate macroscopic population figures will reveal the economy's consumption or output[8]. Another determining factor is land. It is safe to say that agriculture was the backbone of most pre-modern economies, often accounting for more than 60 percent or 70 percent of total national output. Considering the extremely limited growth in grain yields before modern agriculture, it is almost as if cultivated land determined the size of the agricultural economy.

In his discussions with the Broadberry, Guan and Li team on China's GDP estimates, Peter Solar has criticised BGL's estimates for relying too heavily on population and land figures. However, BGL's calculations may get to the heart of the matter. It is prudent to select the variables that contribute most to the overall economy when analysing the economic performance of pre-modern economies, where data quality and sources cannot be compared to modern surveys. While the contribution of niche but intriguing industries like the sedan chair industry to Chinese society may be of greater interest to social historians, for our purposes here, understanding the Great Divergence requires us to focus on population and land. As a result, my calculations begin with population and land[9].

[8] This is, of course, a very sloppy treatment, as has been shown by Allen (2000) via the consumption equation, which displays that doing so ignores the most fundamental substitution and income effects in consumer theory. In the real world, income and prices of all kinds influence the amount of consumer goods or products possessed per capita. Even so, population is still the most important factor in determining the size of the premodern economy.

[9] Because of the importance of population and land, their errors are nearly the most sensitive to the final GDP calculation. Fortunately, it is uncommon for population and land data to be extremely inaccurate.

Two parts make up the following text. It starts with a quick examination of China's historical population and land statistics to demonstrate its macro data accessibility. Population and land data for the Yangzi Delta are built in the second part. The particular construction of population and land data is detailed in two sections. I begin by outlining the institutional setting of population or land statistics in China before diving into the specifics of data construction for the Yangzi Delta. This is because most of China's historical statistics are fiscal designs and cannot be utilised directly. Therefore, moving from data accessibility to data usability requires an analysis of China's statistical system, including what these raw numbers mean and which data reflect real-world facts. Not all academics have faith in China's statistics (e.g., Deng and O'Brien, 2016, 2021). But pessimistic arguments that reject all raw numbers are similarly arbitrary. For this reason, it is important to convey the institutional context of the numbers we can now observe. Clarifying the meanings of the given raw data in this manner enables the construction of Yangzi Delta data, which is the main contribution of this chapter.

2.2 Data accessibility: China's millennial obsession with macroeconomic statistics

China has a long history of macro-historical statistical systems, particularly for recording population and land. Political implications of land and population are self-evident. As a centralised state with a long history, population and land represent, in some ways, the regime's legitimacy. The famous *Twenty-Four Histories* (二十四史) of China, which are extremely concise and word-shy, record many seemingly boring and tedious population and land figures. An important part of traditional dynastic surrender rituals

On the one hand, in most peaceful periods, population and land changes are very predictable in the long run. In the absence of a major historical event, a pre-modern population or land increase of more than 20 per thousand per year or an abnormal stagnation or decline would remind us to be cautious with our estimates. BGL (2018) and Maddison (1998) indicate that fast population increase over a short time is unjustified and should be smoothed out in their examination of Liu and Hwang's (1979) Chinese population estimates. Furthermore, early macro estimates of population and land figures can be tested against modern survey data. Any estimate with too much error can become a stumbling block in the process of bridging contemporary survey data.

was the presentation of the population and land records of the country on their knees by the outgoing emperor and officials to the incoming monarch. Frontier ethnic minorities also often surrendered by submitting population or land registers to the central government.

A century of history in a western Chinese frontier region vividly illustrates the situation. The well-known An Shi Rebellion (安史之乱) erupted in China in the middle of the eighth century AD. To relieve pressure on the central government, garrisons were recalled from China's western frontiers. The Tibetan Tubo regime quickly surrounded the region, isolating it from the rest of China. The remaining local troops fought independently for decades, becoming grey-haired, elderly soldiers, but were eventually defeated by the Tibetan Tubo regime. The western regions of Gansu and Xinjiang were no longer under Chinese government control. Nearly a century and a half later, in 848, a local man named ZHANG Yichao led the recruitment of soldiers who repulsed the Tubo garrison and occupied the area once controlled by the Chinese government for decades thereafter. In 851, General Zhang sent his brother to present a local population register to the central government in Capital Chang'an, signalling the region's return to Tang Dynasty control. This is the famous "The Returned Army" (归义军) in Chinese history.

The rulers saw control of the local population and land as an important means of confirming the legitimacy of their regime. The Imperial Treasury's most important task in any period of traditional China was to collect information on population and land. Beyond politics, there was a very important reason for this: when agriculture dominated the economy, these two indicators meant a source of taxation and wealth for the state. As agricultural tax was so central to the Chinese dynasties, political propaganda was important for the legitimacy of the regime, but the practical benefits were likely more important. The first thing a new ruler did after receiving the previous ruler's registers was to set up his own tax system. As a result, we have access to a wealth of macroeconomic data on traditional China, particularly population and land. In the absence of

many local documents prior to the 11th century, statistics for this time period are primarily derived from publications detailing the history of the central government. Regional statistics were frequently attached as annexes to central aggregates. Following this period, the appearance of an increasing number of locally compiled historical publications known as gazetteers resulted in an increase in regional detail. Until the Ming and Qing Dynasties, gazetteers could be found in almost every regional administrative unit.

Overall, population figures outnumber land figures by a wide margin. The earliest figures that include national and sub-regional population data can now be found date back to 2 AD, at the end of the Western Han Dynasty. Since then, similar statistics for almost all dynasties have been discovered in historical sources and publications (Liang, 2008 [1980]). Even aggregate population figures appear with high frequency for 2-3 consecutive years in several unified regimes from the 10th century onwards (Deng, 2004; Wu, 2000). The earliest cultivated land figures can also be traced back to the Western Han period, but they are far less common in comparison. Figures that show how the land changed over thousands of years, however, are generally sufficient. These rich primary records inform our understanding of China's population and land. Based on original first-hand figures from Chinese history, this chapter constructs population and cultivated land figures for the Yangzi Delta region from the 14th to the mid-20th centuries.

2.3 Population

2.3.1 The institutional context of population statistics: how do we use the data we see?

Even though we have access to the data collected by various dynasties, there are likely many flaws in these numbers. HO Pingti's seminal study (Ho, 1959) shows that most population and land figures in Chinese historical materials were inaccurate, especially

in Ming and Qing Dynasties[10]. They are taxable population or land, not the real situation. This pessimistic viewpoint appears to have influenced a group of researchers. But as Ho acknowledges, there is still more than enough truth to be found in the historical legacy, especially in the population figures.

Ho's approach is divided into three major steps. He first determines if a high-quality statistical survey system existed at the time, then whether its implementation would have produced reasonable statistics. Finally, he compares data from currently accessible historical publications and archives and discusses whether the figures we see accurately depict the world at the time. This line of thinking and approach sparked off new areas of study. The general consensus, including Ho's, is that there have been several large-scale, well-executed population surveys, at least during the Ming and Qing Dynasties, and that the results are now available and accurate.

Ho's institutional analysis has undoubtedly become required reading in Chinese population studies. Many subsequent attempts to revise and reconstruct Chinese population estimates can be traced back to Ho, including those by Perkins (1969), Liu and Hwang (1979), Maddison (1998), Cao (2000, 2001, 2018, 2022), and so on[11]. These studies generally agree with Ho that the population figures in official Chinese publications from the late fourteenth to the mid-eighteenth centuries are "frozen figures" used to set quotas for servitude and not representative of real-world population conditions. These figures usually come from the late 14th-century Hongwu emperor's nationwide population census. That is to say, the count taken by the Hongwu emperor is accurate, and

[10] Pre-Ming and Qing population statistics are less uncertain. One reason is that early statistics appear "normal", with clear upward and downward trends that match historical facts. After the Ming and Qing Dynasties, population growth has been seemingly abnormal, stagnating in a fixed range with no upward or downward trend.

[11] Wang (1995) and Zhao and Xie (1989) are two other influential works in Chinese writing literature. In particular, Zhao and Xie use sub-province data to reconstruct high-resolution population databases for almost every period in Chinese history. Durand (1960) is also widely known in English; it is nearly the earliest attempt to reconstruct data using Ho's methods. Deng (2004) also proposes examining the relationship between negative shocks like disasters and population change to test the accuracy of current population figures. However, Deng's projections for the Ming and early Qing Dynasties appear to be different from Ho's theories.

the subsequent taxation of serfs is based on the same data. After the Hongwu emperor, official figures no longer reflect reality.

However, regional differences do exist. After Hongwu, some northern Chinese provinces, like Henan, continued to implement the decennial census, but southern China did not until the mid-Qing period. Therefore, northern China's official population figures increased normally, while southern China's declined for several hundred years after the Hongwu period due to the extinction of many families. The net effect of these two trends is to keep the official population figures for the entire Ming Dynasty at around 50-60 million.

After the Qing replaced the Ming, the system probably remained unchanged for almost a century. Although the early Qing Dynasty rulers required local officials to keep careful statistics on the so-called "Ding" (丁, literally adult men), the statistics that actually appeared in government publications are not the real adult men, but the so-called poll tax generated by the gradual conversion of servitude into money submission, which began in the late 17th century. The "Ding" was used to calculate the poll tax and had no relation to the real population[12]. The post-Hongwu Ming and early Qing Dynasties'

[12] Recent studies have shown that "Ding" has different meanings in different regions and is not just a meaningless tax bookkeeping tool as Ho originally claimed (Cao and Yuan, 2020). Statistics in some regions used it only as a unit of account, resulting in many decimal points. Other areas recorded the Ding based on local population changes.

This confusion stemmed from the 16th-century fiscal reforms. Following the fiscal reforms of the late Ming Dynasty, the levy of servitude was replaced in some areas by a monetary levy. A fixed total amount was then set, and it was then distributed equally over the land tax to be imposed. This complicated taxation system began with the late Ming Dynasty's "One Whip Law" (一条鞭法) and evolved into the early Qing Dynasty's "Apportionment of Ding into Acres" (摊丁入亩). Both were essentially corvée labour turned into money.

To put it simply, the "One Whip Law" converted the servitude that should have been levied into money, such as silver, in accordance with the prescribed criteria, while the "Apportionment of Ding into Acres" meant that the poll tax converted into silver was then equally distributed to the cultivated land that needed to be taxed and collected and handed over in a uniform manner with the land tax.
This policy is one of China's most important fiscal reforms after the 16th century and has changed the definition of "population" in government publications from a fixed number of people who had been in servitude for most of the Ming Dynasty to a bookkeeping tool.

The literature on "Ding" can be found in Ho (1959), Xue (2012), and others. For literature on fiscal reform and the formation of fiscal figures during the Ming and Qing Dynasties, see Chen (2013), Huang (1974), Liu Zh. (1997, 2004 (ed.)), Liu Zi. (2022), Qiu (2018), Zhang and Zhou (2015), Zelin (1984), Zhou (2020), etc.

official “population” registers may not accurately reflect China’s real population size. The poll tax reform, which had been in place since the 16th century to convert corvée labour into money, was likely nearly complete under the Qianlong emperor. In 1741, the emperor ordered officials to take a serious look at China’s real population outside of the tax system, so a community policing system called “Baojia” (保甲) was established, and statistics similar to the Hongwu census were gradually revived.

A series of discussions on Ming and Qing Dynasty population statistics from the beginning of Ho to the present have revealed the following: (1) The large number of official publications on “population” in Ming and Qing China did not really represent the concept of population; they primarily serve the tax system, so when the fiscal system changes, the figures we see now may have a different connotation. (2) However, these seemingly frozen figures are from several real censuses. (3) The late 14th century Hongwu survey and officially published population figures after the mid-18th century, particularly those of 1776, are to some extent reliable. (4) Despite the dark ages of data during this period, some areas at the regional level were still rigorously implementing serious censuses so that their population growth patterns could be referred to.

This pattern, in which population and land numbers served the fiscal system, was followed not only in Ming and Qing China but probably throughout all of China for over a thousand years prior to the 14th century. It is more important that these population and land figures match the government’s fiscal system and ensure tax collection than that they are accurate.

Poll tax was the main source of public finance in China before the 8th century. The central government often claimed that they collected taxes based on land, but real land surveying did not occur until much later, so nominal land taxes were usually collected based on population. It appears that the actual existence of these “lands” was not taken seriously. The central government of the Sui Dynasty (589–618) assumed that each person held 70 Mu of lands and therefore collected taxes on it, resulting in official

publications containing an incredible amount of land, more than at any other time in Chinese history.

Ho notes that China did not survey land before the Southern Song, except for a few attempts in the mid-Northern Song, despite CHAO Kang's disagreement (Chao, 1986). However, there is no doubt that from the Ming Dynasty onwards, government-run, instrument-based, and nationwide land measurement gradually emerged. It is just a matter of debate whether this national survey took place at the beginning of the Ming Dynasty or after the late-Ming (Chao, 1986; Ho, 1959, 1995). Before this time, although various land figures appear in official publications, many are likely to have come from peasant self-reporting (自实) and the government did not have very detailed and specific maps describing the shape, area, and ownership of a small piece of land ("Yulin Ce", 鱼鳞册, literally a map of lands arranged like fish scales) as it did during the Southern Song and especially after the Ming Dynasty. In addition to the poll tax, ordinary Chinese before the 8th century were forced to perform corvée work, such as building infrastructure, policing, and defending. Thus, population was the central government's main fiscal concern before the 8th century reform of the "Twice-a-year Tax Law" (两税法)[13]. Thus, official population figures before the Song Dynasty seem reasonable, while those after seem absurd.

[13] The "Twice-a-year Tax Law" was a significant fiscal reform in Chinese history during the eighth century. For a long time, the poll tax was the backbone of China's fiscal system. However, with growing inequalities, widespread population concealment, and the emergence of a new gentry class, this approach soon proved unsustainable. Yang Yan, Tang Dynasty prime minister, introduced this new fiscal system in 780. As the name implies, this system collected agricultural taxes in summer and autumn. The essence of this reform was a switch from a poll tax to a property tax. The ideal situation for the central government was to survey the population's wealth and levy different taxes based on wealth. As a result, it is easy to see that land's significance grew substantially, perhaps even more so than that of population.

But it would have been difficult to implement such an ambitious fiscal reform after the An Shi Rebellion in the middle of the Tang Dynasty, which severely weakened the central government. Consequently, this fiscal reform was not finished quickly, but tended to "weaken the poll tax and strengthen the property tax", and it took a number of dynasties until the Ming Dynasty to fully realise the original design. Despite the Song Dynasty's more mature "Twice-a-year Tax Law" system, the poll tax was still a major factor, as shown by prime minister Wang Anshi's famous fiscal reforms (1069-1085).

Details for the "Twice-a-year Tax Law" reform are discussed in Chen and Sun (2015), Li (1995), Zheng ed. (1994), Zhou (1981), and others.



Figure 2.1 Officially published "Household" (户) statistics, 996-1626

Sources and notes: official statistics are summarised by Liang (2008 [1980]). I do not show "population" (口, literally "Mouth") figures because the fiscal system's connotation of "population" changed over time. For example, the "population" figure for the Song Dynasty is suspected to be more than half underestimated, implying that it does not include the entire population. The Qing Dynasty published only the "Ding" (丁, literally "Adult Men") and the "Mouth", but the "Ding" was not an adult man either. Thus, comparing "Population/Mouth" figures from different eras may be inappropriate.

Figure 2.1 shows China's officially registered households (户) from 996-1626. In the absence of major wars and disasters, the Northern Song period (980-1125) saw normal household growth. However, after the Northern Song Dynasty and especially during the Ming Dynasty, household growth rates seemed to defy logic. Without a major negative population shock, it is hard to imagine what a society would have been like with a similar birth and death rate. Based on the historical overview provided above, it is clear that a fiscal system change should have occurred. The poll tax lost prominence after the Ming Dynasty, particularly after comprehensive national land mapping was completed. Adult men or household-based taxes from the Song and Yuan Dynasties were gone. They were replaced by a land-based agricultural tax. The population was more for the government to levy servitude, including grassroots communities, infrastructure builders, transporters, the entourage of officials, the royal family's artisans and transporters, and so on, so it was sufficient to maintain a population figure that

could handle it (Huang, 1974; Lai, 1983; Liu, 1997). Thus, the government seemed uninterested in investigating the true population. After the mid-Ming and Qing poll tax reform, the population was completely removed from the fiscal system. Only then did the real population registration system return.

Looking back at China's population registration system, it is clear that the "population" figures we see today are strongly linked to the fiscal system behind them. The famous Hongwu census and the rapid introduction of the Baojia system after the population was removed from the fiscal system during the Qianlong period suggest that traditional Chinese government was capable of population surveys. The fiscal system, particularly the corvée system, determines whether the "population" registration matches reality. After the fiscal system was reformed in the middle of the Tang Dynasty, population gradually became less important over the succeeding centuries. Official national "population" figures froze after the Southern Song Dynasty (Wu, 2000). The Mongol system's preference for poll taxes made "population" figures reasonable during the Yuan Dynasty. But by the start of the Ming Dynasty, it was nearly impossible to use directly published population figures, and most "population" figures in official publication stayed within a stable range with little updating.

2.3.2 Population in the Yangzi Delta

The design of the Ming and Qing census systems appears to suggest that understanding the true population of the period may be difficult. Even Ho, who is the first to question the period's raw numbers, has not ruled out reconstructing the Ming-Qing population database. On the basis of the statistical system Ho describes, a variety of academics, including Ho himself, have tried to estimate the population of China during the Ming and Qing Dynasties. The basic ideas are consistent: (1) choosing information from the year in which the census was actually conducted as a benchmark, such as the Hongwu census; (2) making corrections to the benchmark year's data based on historical facts and other information, such as adjusting for abnormal sex ratios; and (3) for data dark

ages, using regional information like population growth rates in areas with "normal" population growth to derive the real picture.

This approach may seem less rigorous than the relatively high-quality direct population records in historical documents before the Ming and Qing Dynasties. Despite the lack of a national census, determining the population for the years in between known counts is entirely possible thanks to the abundance of regional sources available during the Ming and Qing Dynasties. One reason for this is that numerous local governments conducted regular population counts.

Following Ho's lead, subsequent scholars have attempted to estimate China's population after the 15th century in a variety of ways. CAO Shuji's reconstructions are currently regarded as of the highest calibre (Cao, 2000, 2001, 2018, 2022)[14]. The institutional framework and methodology that Cao employs in his population estimates are direct descendents of Ho's ideas. The key difference is that Cao uses more than 3000 gazetteers in his work. Cao is able to verify the results of the original census on a county-by-county basis thanks to the vast amount of regional historical materials. He eventually constructs China's population data from 1393 to 1953 (1393, 1580, 1630, 1650, 1680, 1776, 1820, 1851, 1880, 1910, 1953), using the prefecture as the smallest unit. Cao's data is also used as a reference for the majority of my research on the population of the Yangzi Delta's nine prefectures.

Before showing the Yangzi Delta's final population, I need to briefly review the Cao methodology's main flaws. When looking at national aggregate data, Cao's population figures are the highest of almost all estimates, especially during the Ming and early Qing periods (Deng, 2004; Solar, 2021a). His projection for the Ming population peak

[14] Cao published his reconstructions of the Ming and Qing populations in 2000 and 2001, respectively. In any case, he has been tweaking his demographic data ever since, and has just finished the final database. The most recent summary article can be found in Chapter Eight of Volume 1 of Debin Ma and Richard von Glahn's *Cambridge Economic History of China* (2022). I am fortunate to obtain his most recent regional results prior to publication. The gratitude I feel toward Professor Cao is immeasurable.

is 200 million. The methodology he employs is largely responsible for the seemingly optimistic outcome. Before, academics tended to work with raw data from very high administrative levels, such as provincial populations or even national aggregates. Cao's work, on the other hand, can go down to the county level. Therefore, from a material standpoint, he relies on much stronger evidence. But as the data scale gets smaller, it's possible that the errors involved will also get worse. Two typical examples illustrate this point. (1) In the Hongwu survey, which Ho claims is very close to a modern census, some county-level population figures are clearly unreasonable, such as a gender ratio close to 160 or 200. Ho and other early scholars did little to fix this. According to Cao's investigation, such anomalous sex ratios are typically the result of an imbalance in the sex ratio among children, i.e., an underrecording of female children. The sex ratios shown in Ming and Qing registers for the adult population tend to remain around 110 (Cao, 2000: 39-43). Cao adopts a sex ratio of 110 to adjust for these recorded statistics in order to produce new population estimates in places where the sex ratios appear to be quite unusual. Overall, this method is acceptable, especially given the small number of places where it occurs. However, because much of the basic information for Cao is collected at the county level, using a uniform correction ratio may increase the margins of error in the final aggregated population.

(2) Since taxation in imperial China was frequently based on the household as the basic unit, the "household" (Hu, 户) in China's population registers is often more accurate than the "population" (Kou, 口). Thus, "household" is often used as more trustworthy information by Chinese historical demographic researchers (Deng, 2004). In the case of sub-regional population records, sometimes quite "strange" household size statistics emerge, and there is agreement to use household records to estimate the "true" population numbers. While any variation in household size is possible – urban versus rural, different industrial areas, etc. – the household size that appears in Chinese macro-censuses at the county level and above has remained at five people per household from the second year AD, when the earliest census figures are available, until the early twentieth century (BGL, 2018; Deng, 2004). Furthermore, in many ancient Chinese proverbs, a

typical Chinese family consists of five people (sometimes called a "family of five", 五口之家). For a long time, Chinese historical demographic scholars employed this criterion to assess the accuracy of population figures in historical publications. In macro-demographic statistics for places above the county level, a family size of 4-6 is frequently regarded as normal. If census materials show household sizes that differ considerably from this criterion, it indicates a possible population under-recording. According to the literature on Chinese demographic history, a large deviation of less than four is more frequent in both "abnormal" deviations. This also confirms that population under-recording is a possible factor. Cao uses this criterion when revising the Ming and Qing's official population statistics. In summary, when he discovers that the population figures for a given area deviate greatly from this criterion in terms of household size, he tends to put less faith in the "population" records and more faith in the "household" records. He then takes the average of the recorded household size in the surrounding area as the new criterion to arrive at a new population estimate. If there is no clear proof of household size in the neighbourhood, he chooses to correct the original population record with five as the criterion for household size. However, such a compromise correction may result in accumulating errors in the aggregate population of China. Indeed, while five may be a realistic criteria, macro-statistics for various areas of China may show minor variances in household size; for example, in the northern regions of China, household size may be near six at times (Wu, 2000). Cao's decision to use the aforesaid procedure to fix the original records is understandable when confronted with some genuinely questionable data. However, as previously discussed, these methods are likely to generate an accumulation of errors if the data for different regions are added together to obtain the national population.

While both of the correcting strategies discussed above are likely to cause both overestimation and underestimation bias, it is evident from reading Cao's research that his correction is likely to produce some type of upward bias, i.e., overestimation, in most cases. Corrections for sex ratio anomalies, for example, inflate the aggregated population estimate. What's more, when there is an "abnormal" household size, the usual

scenario is that the household size in the original records is too small. This leads to revisions in such cases that inflate the aggregate population estimates. This could explain why Cao's estimates of China's population in the Ming and early Qing periods appear to be larger than those of other historians. Despite the fact that Cao's population figures are widely regarded as the best in the literature, we should be cautious of the possibility of inflationary bias in them during the Ming and early Qing periods.

This flaw in Cao's data, however, has no bearing on the Yangzi population figures. Cao's adjustments pertain mostly to the original population estimates for Zhejiang province's three prefectures of Hangzhou, Jiaxing, and Huzhou during the early Ming Dynasty. He notices that the gazetteers for these three areas imply a household size of roughly three in the early Ming, which differs greatly from the average household size of five in central government publications for the entire Zhejiang province. However, all the gazetteers Cao finds for other areas of Zhejiang province in this period show a household size of around three, which was also clearly different from the central government's household size published during the same period. So Cao concludes that the gazetteers probably had institutional population under-recording, such as the absence of non-taxable people like children. Cao revises the population figures for the three prefectures based on the central government's results on average household size in Zhejiang province for the same period, which averaged five people per household (Cao, 2000: 137-141). In general, this treatment is reasonable, given that other surveys conducted before and after the Ming period reveal that the average household size in Zhejiang province stood at approximately five for a long time (Wu, 2000; Cao, 2001). As a result, the likelihood of population inflation mentioned in Cao's population estimates has no bearing on Yangzi population figures.

Past descriptions of Yangzi Delta's population suggest that it grew steadily from the Hongwu period until the late Ming Dynasty's wars, took several decades to recover after the mid-17th century wars, and then grew steadily until the Taiping Rebellion of the mid-19th century. The materials and methods used to estimate the local population

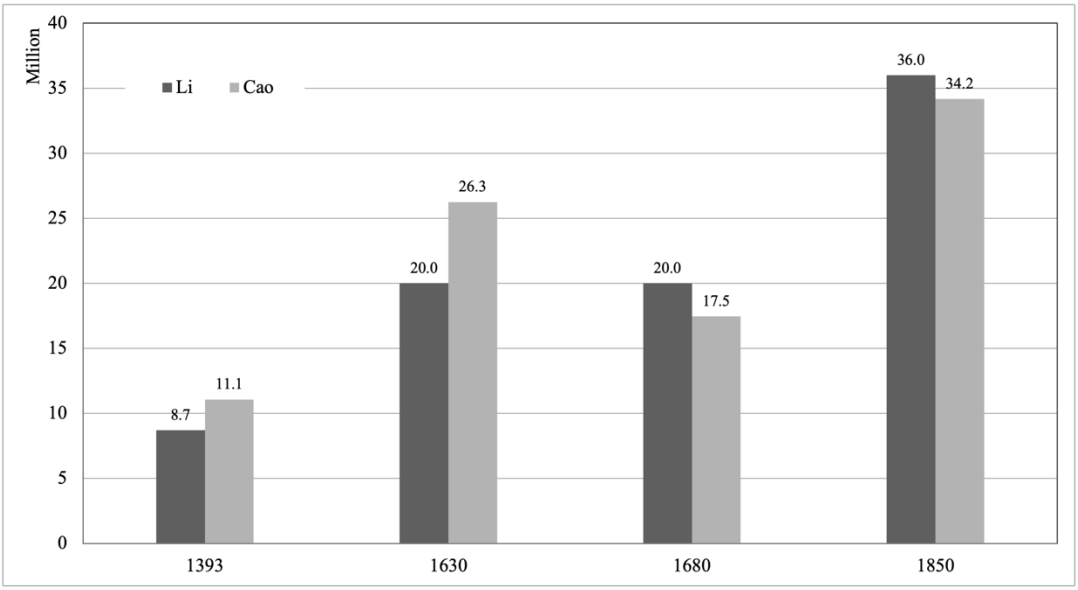

Figure 2.2 Population estimates of the Yangzi Delta from Cao and Li, 1393-1850
Sources and notes: Cao's figures are based on Cao (2000, 2001, 2018), with a focus on the most recent data in 2018. Li's data is derived from Li (1994).

are congruent. LI Bozhong's early exploration of the local population is based on Ho, Perkins, and genealogical population studies (Li, 1994). This approach is similar to Cao's, but Cao uses more sources and details.

Figure 2.2 compares Li's and Cao's benchmark years' Yangzi Delta population estimates. Clearly, the two outcomes are not inconsistent with the overall trend. The level difference is also small. The only difference is that Cao estimates a slightly larger population for the Ming Dynasty and Li for the Qing. However, we believe Cao's estimates are more accurate. Not only because Cao's study is newer and includes more sources; more importantly, Li directly refers to the official census of the Hongwu period, which, as Cao's study shows, excluded part female and military populations. Li's 1680 population estimate is higher than Cao's, and one assumption is that the population recovered to 1630 levels. Cao concludes that the local population did not return to pre-war levels in 1680. At least Cao's calculation based on some growth rate may be more reasonable than Li's subjective prescription of a population recovery moment. In terms of population in 1850, Li assumes that the local population in 1850 is the same as it was in 1820 as a proportion of the population of Jiangsu and Zhejiang provinces, and then

uses the provincial population in 1850 to calculate the population of Yangzi. As Li himself notes, it is evident that during the peaceful period of the Qing Dynasty, the local population, which was the most densely populated region, grew at a slower rate than other regions. Li's method is equivalent to assuming that the local population growth is the same as that in sparsely populated northern Jiangsu and southern Zhejiang, which does not hold up. The actual population in 1850 would have been lower than Li's estimate. As a result, we are more likely to trust Cao's estimates.

But further elaboration is needed on the discrepancy identified by Li and Cao in 1680. The observed difference, though seemingly insignificant, could play a crucial role in determining the timing of the Great Divergence in this study. The results of the following chapters show that around the late 17th century, the Yangzi region had a peak in per capita GDP, which temporarily surpassed that of the European leaders, and the Great Divergence occurred during this period. Li's population estimate for 1680 is greater than Cao's used by this study, indicating a lower per capita GDP. In fact, this is a key argument addressed by Peter Solar in his criticism of the BGL series of research (Solar, 2021a, 2021b). However, this population disparity in the Yangzi region does not change the Great Divergence result.

First, as I noted in the preceding paragraph, Li's population estimate for 1680 is based on a supposition with no historical basis, namely that the population in 1680 should recover to pre-war levels. Cao's estimate, on the other hand, is based on a wealth of micro and macro information, such as the trend of population growth in the Yangzi region shown through genealogy and government surveys. In addition to being more data-based, Cao's estimate avoids an inexplicably high growth rate deriving from Li's assumption. According to Cao, during the Ming-Qing Transition period, wars, plagues, and climate shocks had a significant impact on the local population, resulting in the deaths of approximately 10 million people. Whether using Cao's population loss ratio of 42 percent or a level value loss, the recovery of the population to its 1630 level by 1680 would necessitate an annual growth rate of approximately 0.015 for the Yangzi

population between 1645 and 1680, as required by Li's population estimate. This rate remains rare in pre-modern Chinese population studies. In the aftermath of the Taiping Rebellion, which resulted in a comparable loss of population, the local population's growth rate per year, as reported in the following database, was only approximately 0.008 over a span of nearly 70 years. The Yangzi population growth rate was barely approximately 0.003 per year for the majority of the time. Thus, if Li believes that the local population had recovered in 1680, it is puzzling why no micro-population survey (e.g., Hu, 2020; Liu, 1992, 1993, 1995; Wu, 2005) or qualitative records show this abnormally high growth rate. In addition, whether optimistic (BGL, 2018; Maddison, 1998) or conservative (Cao, 2000, 2001; Shi, 2017) estimates of population growth after the Ming-Qing Transition, it is generally believed that the Chinese population did not recover to the pre-war level until the mid-18th century. Li's estimate of the Yangzi population in 1680 is evidently inflated.

Of fact, even if we ultimately pick Li's population estimate, assuming the GDP total estimate remains unchanged, the Yangzi's per capita GDP in 1680 would be 88 percent of what this study provides. Given that some estimates of output in the non-agricultural sector are tied to population, applying Li's population estimate is predicted to raise the total GDP estimate. As a result, using Li's data would make Yangzi per capita GDP estimate arrive at over 90 percent of this study's. According to the data in Chapter Six, this has no effect on the robustness of the Great Divergence time point.

Therefore, this study uses Cao's Yangzi Delta reconstruction as a benchmark. Previous studies lacked estimates of significant population loss, such as the Ming-Qing Transition period and the Taiping Rebellion. This deficiency is addressed by Cao's study. He emphasises population loss during wars and disasters. Cao's data shows several large local population losses. The first was the Yongle Emperor's relocation of the capital in 1420. The local Nanjing was transformed from the Ming Dynasty's capital to an ordinary administrative district, with a population loss of approximately 700,000. The second time was between 1630 and 1645, when about 10,896,000 people died due to the

plague and war. The Taiping Rebellion of 1851-1865 was the third, with an estimated population loss of 22,156,000.

Because Cao's data captures the three primary population losses in the Yangzi Delta (war, plagues, and political migration)[15], I can apply log-linear interpolation to derive population data between different benchmark years. In other words, the underlying premise of this approach is that population growth was steady between these benchmark years. Is this a reasonable assumption? Obviously, there were numerous short-term effects on population growth caused by climate or disease, in addition to big events that can change long-term population growth trends (Lee et al., 2017). The ideal condition would be to acquire accurate estimates of the modest changes in population growth rates produced by each such population impact, however due to a lack of data, this strategy is simply not practicable. Nonetheless, many evidence suggests that assuming a steady population growth rate over the so-called "peaceful years of population growth" with no large population losses will not result in significant inaccuracies in comprehending Yangzi population dynamics.

The first is evidence from micro-population studies. Genealogical studies have always been as important as population studies. LIU Ts'ui-jung (1992) examines the population growth patterns of diverse Chinese families throughout several centuries using samples of tens of thousands of people from 50 families after the 15th century. The genealogy shows that China's micro-population growth between these "major events" was very constant, agreeing with Cao's tale of significant population loss events[16]. Peng and Hou's (1996) investigation of a common family in the Yangzi area over four centuries reveal that population growth rates remained essentially steady between the benchmark years supplied by Cao. The second piece of evidence comes from gazetteer

[15] Cao addresses not only war-related population losses in the Yangzi Delta, but also plague-related like the 1630 plague that spread from the north. He calculates that millions died between 1630 and 1644 due to the plague (Cao, 2000: 451).

[16] In reality, Cao also refers to Liu's micro-study in his population research to demonstrate that his judgement of macro-growth rates is reasonable.

records. In Chapter Three, I have explored Yangzi gazetteers and found over 20,000 qualitative data documenting local agricultural harvests, disasters, plagues, etc. Some records include information regarding population losses. Short-term population impact events were obviously not uncommon in Yangzi history, but it is also clear from gazetteer records that even catastrophic short-term climatic or epidemic impact events might have resulted in losses of less than 10,000 people each time. In comparison to Yangzi's long-term population of 20-30 million, these short-term effects did influence the short-term population growth rate, but their impact might be relatively minor. It makes sense that this phenomenon exists. On the one hand, very major population loss events are easy to discover in qualitative descriptions, and these are the ones Cao is attempting to capture. On the other hand, while population growth during periods with no major population losses may still be affected by short-term climate or disease shocks, the existence of a mature relief system during the Ming and Qing Dynasties (Hao and Liu, 2020; Li X., 1995) suggests the possibility of institutional factors mitigating short-term population losses. Similar examples may be seen in Europe, such as England's population growth, which remained relatively steady in the absence of significant wars, plagues, and famines (e.g., Broadberry et al., 2015; Wrigley and Schofield, 1981). As a result, while the assumption of "continuous growth" may not be ideal for periods without substantial population loss events, evidence from the Yangzi region demonstrates that this option does not result in deceptive departures from population fluctuations in the real world.

Cao's estimate focuses on the period preceding the twentieth century. We also need to be cautious about population figures from the 20th century, especially those from modern statistical surveys. Numerous issues exist with the data released by the government of the Republic of China. Under-recording and gender ratio anomalies, though less severe than under imperial China, still produced some unexpected results. I agree with Hou (2001) that the Republic of China data was problematic, but the 1936 population data is reliable to some extent for political elections and voting. For New China population data, I cite Cao (2000, 2001, 2018), Hou (2001), and Jiang (2013). An assumption

underlying this line of reasoning is that the CCP data from the 1953 census is reliable. Although there appears to be some underestimation in the CCP police system data from 1949-1953, the data can be adjusted to the 1953 benchmark figures to obtain the real population variations if we believe that their relative trends are reasonable. Thus, we can extrapolate the population after WWII in 1946 using these years' approximate population growth rates. During this time, the local population may have shrunk by 3,155,000.

Over the seven centuries from 1393 to 1953, the annual growth rate of the Yangzi Delta's population was only 1.5 people per 1,000. This is a significantly lower rate of growth than the national average of 3.7 people per 1,000 in China. War-related population loss was the main cause. During the Ming Dynasty, when China averaged about 4.5‰ according to BGL or 4.4‰ according to Cao (2022), the local population grew at a rate of about 3.7‰ per year in times of peace. The 3.8‰ that LI Bozhong calculates for the Ming Dynasty is consistent with our findings. The peacetime situation in the Qing Dynasty was about 3.9‰ per annum, not much higher than in the Ming Dynasty (Li's estimate is 3‰), when the national population growth rate was about 7.8‰ per annum according to BGL and about 5‰ per annum according to Cao. The peacetime population growth rate in the Yangzi Delta is comparable to that of most European economies from 1400-1870, averaging 5‰ per year in Britain (Broadberry et al., 2015: 227-244), 2.5‰ in France, 2.7‰ in Italy, 3.8‰ in the Netherlands, and 3.2‰ in Europe as a whole (Malanima, 2009: 9).

Figure 2.3 compares this study's Yangzi Delta population to China average. I use data from BGL (2018, 2021) until 1840 for the China average, which can be traced back to Maddison (1998), Liu and Hwang (1979), Perkins (1969), and Ho (1959) on a late to early basis. Cao's aggregate data are likely to be more inaccurate at the national level, which is why I have not chosen them, but this does not mean I reject them. The conclusions of various scholars from the mid-18th century onward are very close, but which of the earlier data is more plausible remains to be answered by future research, and this

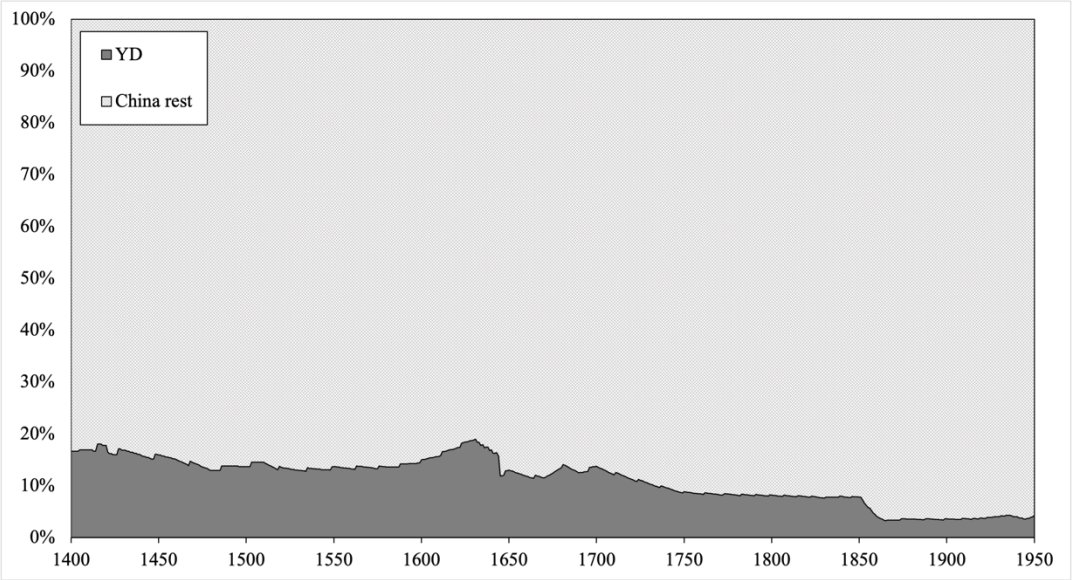

Figure 2.3 Status of the Yangzi population in China, 1400-1950

Sources: see the text.

study does not address this. I connect the data after 1840 to the situation before 1840 using Zhai and Lou's findings (2022).

Over the period 1400-1950, the Yangzi Delta's population grew slower than the China average, supporting the empirical observation that higher population density areas grow slower. A large population would have been unsustainable for the area due to its small size. With the development of frontier areas like south-western China, the region's population dropped to about 10 percent of China's total during the Qing Dynasty from over 15 percent during the Ming. After the Taiping Rebellion in the mid-19th century, the region lost more population than the rest of China and was already below 10 percent of China's total. In the late 19th century, many foreign companies invested in the region and new commercial ports were built, but the rest of China also experienced rapid population growth. After the Taiping Rebellion, the Yangzi population shrank relative to the rest of China and has never fully recovered to its pre-modern levels.

2.4 Cultivated land

2.4.1 The institutional context of land statistics: how do we use the data we see?

Cultivated land data is more problematic than population data. In contrast to his belief in population, Ho is sceptical of land data. Ho's land studies, unlike population studies, are based on fragmentary evidence and speculation, which is why CHAO Kang (1986) strongly refutes them. Ho doubts a national land survey was done in the early Ming Dynasty. He claims that Hongwu's early land surveys did not extend beyond the Yangzi region. The chapters on land taxation in the gazetteers of different regions of China almost always mention that the Hongwu Emperor had sent students (监生) from the Imperial Confucian School to survey the land in the region and produce the *Yulin Ce*, which I mentioned earlier. Ho claims that the Yangzi Delta was the only place the land survey was done. Other regional gazetteers simply reprinted the well-known central government proclamation on the Yangzi Delta to illustrate an institutional design. So where did the land numbers for other regions of the period originate? Ho claims it is a copy of figures from previous dynasties. Then, where did the data from the previous dynasty come from? Ho suggests this may have originated from either self-reporting by locals across multiple time periods or from government guesswork based on previous land taxes and tax rates.

However, I would like to emphasise why the question of whether or not land mapping was mandated is so crucial. Self-reporting, or *Zishi*, was the main way early Chinese dynasties understood their economies. In terms of population, this method was generally not too problematic, as the government faced few difficulties verifying self-reporting. The Hongwu emperor's census edict states that he would send his army to the countryside to verify the self-reported population, and anyone who lied would be severely punished. However, the issue of cultivated land was complicated. Due to complex geometric knowledge and mapping procedures, the central government could not verify how much cultivated land the people reported. Only the Wanli emperor

conducted a national land survey after the Hongwu emperor, and no other Qing Dynasty emperor did so. Mapping many irregularities was expensive. Self-reported numbers might not have been too far off in the days before land surveying was done. However, the figures derived from large-scale land mapping appear to be more credible in any case.

We go back to Ho's study. Ho's conclusions are bold and subversive, but his evidence is insufficient. There is growing evidence that the Hongwu emperor conducted a national land survey in the middle and late years of his reign, and that these figures are preserved in numerous local gazetteers and official publications (Liu S., 2009). Even if we accept the most conservative view that China's early Ming Dynasty cultivated land figures are problematic, it is unlikely that they have remained in the dark ages until the 1950s, as Ho suggests. At least in the early years of the Wanli emperor of the Ming Dynasty (1581), nationwide land surveys were credible. Local land survey reports like the *Shanxi Zhangdi Jianming Wence* (A Simple Report of the Shanxi Land Survey) and the *Yulin Ce* preserved can confirm the detailed process by which the land figures were formed, rather than just a few descriptive sentences from the gazetteer as Ho suspects. Conservatively, the extent of land mapping in Hongwu-period China may still be questioned. But during the reigns of Hongwu and Wanli, at the very least we know that land census mapping was conducted in the Yangzi Delta. If we can clarify the figures in historical publications or archives, we can reconstruct cultivated land figures like we do population figures.

Having examined the institutions and their implementation does not mean that the historical figures we see today are not problematic. (1) The first issue is the measurement unit. Understanding the "Unit" of cultivated land is more complicated than with population. The term "one person" usually refers to a single human being. Mu (亩), however, is an unintuitive unit of measurement used in China to describe the size of land. In modern China, standardised and uniformed metrology makes it easy to know that one English acre is roughly equivalent to six Chinese Mu, whereas the pre-modern situation

is much harder to describe. The institutional "Mu" that the central government proposed in traditional China was frequently used for land taxation and was by its very nature a suggestion to nearby farmers. The real market Mu in the north was often several times larger than the official recommendation, while in the south it was closer to the official definition and sometimes even smaller. The north-south land per capita difference may explain this. Another reason could be that such traditional criteria are more tax-friendly. Simply put, poor land would therefore lose welfare if the same tax is charged on land of different productivity. North China's land was more infertile, so combining larger but infertile lands into an imaginary unit helped taxation. This is why many northern Mu in the archives have larger lands than southern China. This is known as the "Large Mu and Small Mu" issue[17]. Thus, unit conversions are necessary because the real size of one Mu varied from place to place. However, these unit conversion practises can usually be found in local gazetteers or archives, making land figures reconstruction possible.

Another problem is more technical. (2) Some official publications and archives have shown figures that defy reality. A very serious central government bulletin from the early Ming Dynasty, for example, mentions figures for cultivated land in various provinces at the time. Some of the numbers, however, are so far out of line with reality that they are impossible to comprehend. A major issue is why Henan Province's cultivated land appears to have been ten times larger than usual. It is unlikely that there was ever so much land locally for many years afterwards. This obsession has caused Chinese scholars to debate for years (Fan S., 1984; Gu, 1986, 1989; Wan, 2000; Wang Q., 1981; Yang, 2017; Zhang and Lin, 1987; Zhang, 1994, etc.). GU Cheng famously hypothesised that early Ming military land was hidden and added to Henan accounts (Gu, 1986, 1989). However, a consensus developed that transcription or printing errors were mostly to blame. The strange figures have confused scholars for centuries due to

[17] Specifically, in Ming China, 1 "Mu" equaled 240 "Square Steps", known as the "Small Mu". In order to collect taxes more easily, the late Ming government expanded the unit of barren land. In many northern provinces, 1 "Mu" equaled 480 or 720 "Square Steps". Consequently, the "Mu" became excessively large, or "Large Mu", in many locations by the end of the Ming Dynasty.

printing errors. Typographical errors were not limited to pre-modern China. The Republican government's famous agricultural, industrial, and commercial statistical tables in the 1910s had many transcription errors in the figures for cultivated land.

(3) The third question is whether the figures include all local cultivated land. As I mentioned in the population section, the military system was different from the civilian system, and its statistics were rarely published together. Despite his flawed study of Henan's land figures, GU Cheng is right that military land was not recorded in central government accounting publications. Many gazetteers record military land separately, and central government statistics rarely include military lands. Additionally, traditional Chinese land types must be noted. Paddy fields, dry lands, mountains, and lakes (田地山塘) were the four basic taxable land types. But the land figures we now see often include non-arable areas like mountains and lakes, which should be noted when looking at pre-modern China's land figures.

The above issues mean that historical figures must be adjusted to understand traditional Chinese land cultivation. I provide a concise summary of the preceding discussion. The first is about the Ming Dynasty figures. The general rules are these. (1) land measurements from Hongwu-era gazetteers and official publications are referred to as "Small Mu", indicating that no conversion of land units is necessary when making adjustments to the figures. (2) Military system lands are not included in Hongwu figures. (3) A national land survey was conducted in China under the Wanli emperor. The famous "Change of Mu (*Zhemu*, 折亩)" occurred when the land figures were published with "Large Mu" units. Thus, the land unit needs to be converted to estimate cultivated land size. (4) Under the Wanli emperor, military areas were still excluded from land figures. Meanwhile, many Wanli military horse pastures were converted into cultivated land and must be recalculated. (5) Finally, the Hongwu and Wanli figures include non-cultivated land like mountains and lakes, which must be removed.

The Qing Dynasty inherited the fiscal system and land data from the late Ming Dynasty. Taxes were fixed in a stable quota called *Yuan'e* (原额). Qing rulers did not conduct national surveys like the Ming. However, the Qing government conducted some land surveys to ensure that tax quotas did not drop below late Ming levels. Thus, local governors generally did not increase fiscal system figures when real land figures exceeded land quotas. This explains the slow growth of Qing Dynasty land figures in official publications. To some extent, the situation in the late Ming can be compared to the early Qing when it comes to the construction of cultivated land figures (as Broadberry and Guan (2022) do). But mid- to late-Qing period raw cultivated land figures are unrealistic, so any reconstructions made after that time period must be linked to land survey results from the 20th century. Dwight Perkins (1969) and SHI Zhihong (2011, 2015, 2017) use 1950s Communist land survey figures to estimate Republican and mid-Qing cultivated land. No evidence suggests major issues with land statistics occurred during the New China era. Although the Communist government had limited statistical capacity in the early 1950s (Liu and Yeh, 1965: 55-59), the Party's policy was to redistribute lands to gain political support from the masses, so land figures are generally accurate.

2.4.2 Cultivated land in the Yangzi Delta

In general, reconstructing China's historical land figures is difficult but not impossible. The Yangzi Delta, the focus of this study, is actually situated in a more advantageous environment than other parts of China. Whether an opponent like HO Ping-ti or an optimist like CHAO Kang, the consensus is that land surveys were conducted prior to the Ming Dynasty in the Yangzi Delta. Clarifying the local cultivated land situation should be possible by obtaining the land numbers in the available materials and applying certain adjustment methods. But the limitations of statistical territory make studying the Yangzi Delta difficult. The majority of the land data we can see now is at the provincial level. Land figures below the provincial level are only summarised in partial literature like *Ming Huidian* (明会典) and *Wanli Kuaiji Lu* (万历会计录). Most prefecture-specific details are only available in regional gazetteers. The nine Yangzi Delta

prefectures are spread out across multiple provinces, making it difficult to compile consistent and meaningful data. As a result, academics have long assumed that the Yangzi Delta's cultivated land area was 45 million Mu from the late Ming to the Qing Dynasties. (Allen, 2009b; Li, 1998). This widely quoted result is derived directly from the original Wanli Land Survey figures and assumes no subsequent increase in local cultivated land. But as I have just explained, even if the land figures in the Wanli Survey are reasonable, they still need to be adjusted before they can be used. Subsequent analysis confirms that the cultivated land of the Yangzi Delta was not constant after the 15th century, and that 45 million Mu may not be the optimal setting.

We begin with Ming. The gazetteers can be used to adjust Ming Dynasty cultivated lands. WANG Shejiao (1999) estimates prefectural land data in Jiangsu, Zhejiang, Anhui, and Jiangxi, which can be used as a reference. Wang collects a lot of prefectural numbers from gazetteers and considers military lands, *Zhemu*, and non-arable areas. The new results show that the local cultivated land was only 38 million Mu at the end of the 14th century and the beginning of the 15th century, and 42 million Mu after Wanli Survey. Maintaining such a growth rate, cultivated land might exceed 42 million Mu in 1630 before population loss began. However, millions of locals may have died from the arrival of the northern plague between 1630 and 1644 (Cao, 2000: 451), so it is reasonable to anticipate that cultivated land would grow very slowly during this time. But could a major loss occur? Such things, in my opinion, should not exist. According to the data I subsequently compiled for the early Qing Dynasty, the Yangzi Delta still had 37 million Mu of cultivated land in 1645, despite the Ming-Qing Transition. If the loss of local population and land continued at the same rate between 1630 and 1644, the land in 1644 would be 32 million Mu, based on the 1.6 Mu of land per person. It implies that after the Ming-Qing Transition, local cultivated land should increase by at least 5 million Mu, which is obviously impossible. Thus, I accept that the local farmland remained relatively unchanged from 1630 to 1644.

It may have been more complicated in the early Qing Dynasty. After the victory, Qing leaders started collecting taxes based on land and fiscal data from the late Wanli period of the Ming Dynasty. Land was surveyed at this time for the sole purpose of evaluating the Wanli Quota. In light of this, the so-called *Yuan'e* or Quota and existing cultivated land figures in the land registers were only meant for comparison with the late Wanli standards and could not be used directly. Local officials reported no more lands than the quota figures once the land situation in the current period was better than the late Wanli survey. In other words, only figures below the quota are likely to be meaningful for our reconstruction of real land figures. WU Jianhua (2005: 138) examines cultivated land figures for Suzhou, Songjiang, Taicang, Hangzhou, Jiaxing, and Huzhou gazetteers and finds that the land in 1645 was 89 percent of the Wanli period quota. If this ratio is applied to the entire Yangzi Delta, the cultivated land after the war of 1645 was 37 million Mu. This suggests that the Ming and Qing wars had less of an impact on local lands than on the population. The *General Gazetteer of Jiangnan Province* (江南通志), written during the reign of Kangxi, provides further proof. Most local lands were restored to their Wanli period quotas, or 42 million Mu, in the 14th year of the Shunzhi reign (1657), earlier than the China average (Shi, 2017: 33). This implies that local lands abandoned quickly recovered. Local wars' short duration may be a major factor. In many cases, land was abandoned for too long due to events that could lead to permanent loss, but short-term abandonment could lead to rapid recovery and increased land fertility. The frequent use of the word "harvest" in local gazetteers after 1645 may provide some indirect evidence of this.

What was happening in the 18th century? The amount of land in gazetteers no longer matches reality, where it remained at a quota level. SHI Zhihong (2017: 21) estimates that Jiangsu and Zhejiang had 20 percent hidden lands in 1724. However, the local land concealment in 1724 ought to have been lower given that newly reclaimed land in the Yangzi Delta was typically slower than the average for the two provinces. Taking Shi's 20 percent into account, the local cultivated land in 1724 would have been 50 million Mu, which is clearly excessive, representing 39 percent of the two provinces' cultivated

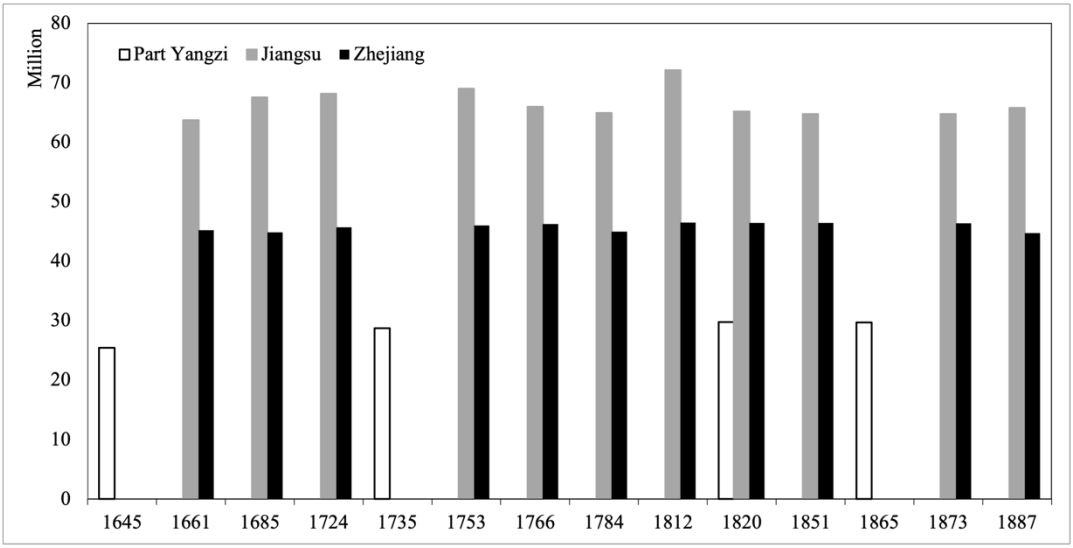

Figure 2.4 Official figures for cultivated land in the six prefectures of the Yangzi Delta and all areas of Jiangsu and Zhejiang, 1645-1887

Sources and notes: figures for six prefectures in the Yangzi Delta (Suzhou, Songjiang, Taicang, Hangzhou, Jiaxing, Huzhou) are from Wu (2005: 138). Data for cultivated land in Jiangsu and Zhejiang comes from Shi (2017: Appendix II).

area. I therefore assume that the ratio of the Yangzi Delta's cultivated land to all of Jiangsu and Zhejiang's cultivated land in 1724 was the same as it was in the 1930s. According to my discussion in the following section, the Yangzi Delta accounted for about 35 percent of the cultivated land in Jiangsu and Zhejiang in the 1930s, which is nearly the same as the pre-war situation in the 1850s. Taking this into account, the revised estimate of less than 46 million Mu of cultivated land in 1724 seems more plausible.

Official materials are almost useless for mid-Qing land figures. Official land statistics are almost frozen. Figure 2.4 shows long-term land figures from official sources. Neither the official numbers for "cultivated land" in Jiangsu and Zhejiang provinces nor the six prefectures in the Yangzi Delta have undergone any appreciable change. There could be no new cultivation areas in the Yangzi Delta, but it is unlikely that Jiangsu and Zhejiang had none. Since the northern part of Jiangsu, and especially Xuzhou Prefecture, shared a climate and culture with the neighbouring Henan-Shandong region, it is unlikely that these areas were untouched by reclamation during the Qing Dynasty. To

clarify the situation in the 19th century, I follow the conventional methodology and link data in early Qing to a more modern survey in the 20th century. Information about farmland by county in the 1920s can be found in a comprehensive national agricultural survey (Chang, 1929a, 1929b). However, the figures are primarily based on farmer self-reports. The total for all local counties was around 42 million Mu, which was very close to the previously adjusted fiscal quota. This may still be path-dependent self-reporting of fiscal quotas. Land was not directly measured until the 1930s (Jiang, 2013: 27). Based on 1930s Shanghai land mapping, Buck (1985 [1937]: 192) estimates that farmers' self-reported figures were 20 percent low. A 1934 survey of Jurong county on the western side of Taihu Lake also finds that 10 percent of local cultivated land was hidden (Chang, Tao and Zhuang, 1934: 179). In conclusion, I estimate that 15 percent of the cultivated land in the Yangzi Delta was likely hidden in the 1930s, bringing the total cultivated land numbers to around 48 million Mu. If the Taiping Rebellion's land losses were considered to have returned to pre-war levels by the 1930s, then the peak of cultivated land prior to the 1850s was 48 million Mu, or 35 percent of the total cultivated land in Jiangsu and Zhejiang at the time, which is consistent with the situation in the 1930s.

The final question is: why not use 1950s New China statistics like previous provincial studies? Official statistics from the early 1950s indicate that after decades of war, there were only about 38 million Mu of cultivated land left in the region. However, in 1957, when most of China's cultivated land peaked over the next 50 years, the Yangzi Delta still had around 38 million Mu of cultivated land, with no significant growth. This suggests little cultivated land growth in the Yangzi Delta during New China. Perhaps the rise in available building plots caused by urbanisation and industrialization played a role. For this reason, using data from the 1950s as the peak of cultivated land in the past may be an unreasonable assumption to make.

No direct evidence exists to quantify the Taiping Rebellion's land loss in the Yangzi Delta. But after the war, local authorities conducted land checks to restore the quota,

and this is important information that we can now use. According to postwar local governor MA Xinyi, only 40-50 percent of the prewar land quota remained in the Jiangsu region of the Yangzi Delta, and about 30-50 percent remained in the Zhejiang region (Li, 1957: 158-160). This report, while seemingly sketchy, is in line with the fact that the region had been in turmoil for over a decade. Based on Jiangsu and Zhejiang's land quotas and Ma's report, the Yangzi Delta's post-war cultivated land was about 43 percent of its pre-war quota. The pre-rebellion land quota was 46 million Mu (Wu, 2005: 140). An estimate of the Yangzi Delta's post-war cultivated land area of around 18 million Mu can be made using the aforementioned method for converting quotas into actual cultivated land areas.

Thus, the local cultivated land is mostly mapped out for us. Table 2.1 displays this chapter's population and cultivated land data. Local cultivated land was growing slowly, with an annual growth rate of 0.4 thousandths from 1353 to 1936. This suggests constant land resource pressure relative to population. Even during peacetime, the Ming Dynasty's annual growth rate was 0.5 thousandths. The Qing Dynasty saw a larger increase to 1.3 thousandths from 1645-1851, but it was still below the population growth rate. The decline in per capita cultivated land is consistent with almost all scholars' opinions (Allen, 2009b; Brenner and Isett, 2002; Huang, 2002; Li, 1998; Pomeranz, 2000). Both the California School and its opponents acknowledge that local land per capita decreased over time.

In fact, there were methods employed to alleviate population-land tensions in China. During the Ming and Qing eras, migration from the central regions to the periphery was relatively prevalent. This period witnessed the establishment of stable populations exceeding 100 million and the cultivation of billions of Mu of cultivated land. The central dynasty's geographical boundaries extended beyond the Great Wall and deserts. Peripheral areas that had previously been sparsely populated by "barbarians" became administrative areas of the empire, with centrally selected professional bureaucrats gradually displacing indigenous leaders through a process of "Bureaucratization of Native

Table 2.1 Population and cultivated land in the Yangzi Delta, 1393-1953

Year	Population thousand	Cultivated land thousand Shi Mu	Year	Population thousand	Cultivated land thousand Shi Mu
1393	11,065	38,122	1776	24,824	
1420	12,942		1820	30,225	
1421	12,242		1851	34,178	48,354
1580	21,872		1865	12,022	18,314
1582		41,593	1880	12,903	
1630	26,251	42,523	1910	15,599	
1644	20,251	42,523	1935	21,930	
1645	15,355	37,204	1936	22,231	48,354
1657		41,593	1945	19,076	35,835
1680	17,458		1952	24,355	38,072
1724		45,779	1953	25,220	38,403

Sources and notes: population in 1393, 1580, 1630, 1680, 1776, 1820, 1851, 1865, 1880, 1910 is taken from Cao (2018). Data in 1421 is extrapolated based on the growth rate from 1580-1630, while the population loss during 1420/1421 comes from Cao (2000: 307). Population loss in 1630-1644 is taken from Cao (2000: 451). Figure in 1645 is extrapolated with growth rate from 1680-1776 and double checked with Cao's description (2001, 2018). For data in 1935 and 1936, I refer to the results of Jiang (2013). However, because the Yangzi Delta defined by Jiang is slightly different from mine, I adjust his population figures with the official data defined in this research in the 1950s. The population figures for 1952 and 1953 are from official statistics, which are obtained from "Jiangsu Agricultural Statistics" (1976), "Shanghai General Gazetteer (Volume 1)" (2005), "New Zhejiang Fifty Years Statistical Data Collection" (2000) and "Jiaxing City Gazetteer" (1997). The 1945 data is extrapolated from the growth rate in 1950s.

The land figures of 1393 and 1582 are from WANG Shejiao (1999). Figure in 1630 is obtained by interpolating the growth rate from 1393 to 1582. 1644 cultivated land is considered to be the same as in 1630. Cultivated land in 1645 is calculated based on Wu (2005). 1657 cultivated land is restored to the 1582 situation. Cultivated land in 1724 is considered to be 35 percent of the total cultivated land in Jiangsu and Zhejiang. Cultivated land figures for Jiangsu and Zhejiang are from Shi (2017).The cultivated land figure for 1851 is the same as for 1936. Cultivated land calculations after the 1865 war are based on MA Xinyi's report to the central government. See text for details of the calculation process. Cultivated land figure in 1936 is based on the survey results of Chang (1929a, 1929b) and adjusted for land concealment. Land concealment is based on Buck (1985 [1937]) and Chang, Tao and Zhuang (1934). Figures in the 1950s come from official statistics, which are consistent with the population data sources of the same period mentioned above. Situation in 1945 is extrapolated from the growth rate in the 1950s.

Officers (改土归流)". Despite these precautions, population growth during the Ming and Qing Dynasties surpassed the resources of newly acquired regions, putting constant pressure on per capita land. In traditional commercial centres such as the eastern coastal

regions, population-land tensions might have been much more severe than in the rest of China.

Another possible solution to the per capita land shortage is a demographic transition comparable to the well-known European Marriage Pattern (EMP), which is characterised by a high proportion of late marriage, never marrying, and nuclear families (Dennison and Ogilvie, 2014). Unfortunately, investigating this scenario necessitates extensive micro-level demographic evidence, notably on marriage ages, which is lacking in Chinese sources. Some speculative inferences based on macro-level population figures and micro-level resources such as genealogy records, on the other hand, may help provide an overview of whether fertility behaviour changed in China and the Yangzi region during the Ming and Qing periods. Figure 2.5 depicts an estimate of China's birth rates based on macro population statistics and the male birth rates based on a genealogical record of a commoner-like family[18] in the Yangzi region. Although these data do not reflect marital behaviour, they suggest that China's fertility behaviour might not have changed during the Ming and Qing dynasties. At least the male birth rates depicted in the figure did not exhibit a trend change but instead maintained a long-term stable pattern. If this is correct, it appears that the fertility transition might not occur during the Ming-Qing periods. However, such conclusions are beyond the scope of this study and necessitate the discovery of more data. Furthermore, even if a fertility transition occurred, its impact on reducing population-land tensions is questionable because slower population growth may lessen the desire for land cultivation. In fact, the impacts of the fertility transition on economic growth are still being debated and will need more studies in the future.

[18] The information comes from the Fan family of Jiangyin County, Yangzi Delta. The famous Northern Song Dynasty prime minister FAN Zhongyan (989-1052) was an ancestor of this family. In the 14th century, the family relocated from the prosperous city of Suzhou to the little-known county of Jiangyin (Peng and Hou, 1996). This family is considered ordinary because they only had one *Jinshi* title and a few low-ranking officials in 600 years of Ming and Qing Dynasties history. In comparison to the genealogical books of other local families with glittering celebrity histories, the Fan genealogy members are nearly the most mundane.

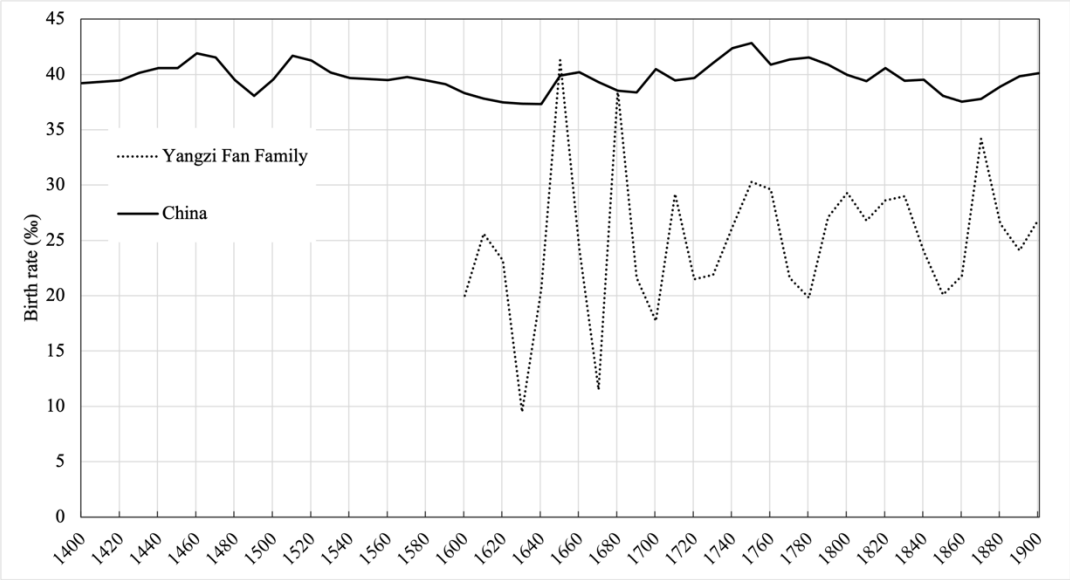

Figure 2.5 Birth rate (‰) in China and the Yangzi Delta, 1400-1900

Sources and notes: the average birth rate in China comes from Liu and Hwang (1979), while the birth rate in the Yangzi Delta is derived from Peng and Hou (1996). For Peng and Hou (1996), it is the ratio of male births to male population and is not a birth rate in the strictest sense.

2.5 Conclusion

In this chapter, I examine the relationship between population/land and the fiscal system in China and try to construct a dataset of population and cultivated land in the Yangzi Delta. I study population and land history in order of "whether the system existed, how it was implemented, and what the numbers obtained represent". A very intuitive finding is the long-standing tension between population and land that seemed to be increasing, which is also the trend in China as a whole. What does declining cultivated land per capita indicate? Economic performance in pre-modern China suggests that per capita cultivated land might heavily influence China's GDP per capita (BGL, 2018, 2021; Xu et al., 2017). In other words, a long-term decline in cultivated land per capita is likely to lower GDP per capita. In an economy with little land productivity change (like most pre-industrial economies), a decline in per capita cultivated land means a decline in food holdings. It is obvious that agricultural output per capita was declining if one considers an economy like China, where non-food agriculture represented a very small portion of the economy. This indicates that a radical shift in

economic structure is required if we are to avoid a decline in GDP per capita. That is, instead of maintaining a static economic structure, the non-agricultural sector had to grow significantly. In the real world, if one saw a long-term pattern of declining cultivated land per capita, income per capita would likely decline in the absence of a dramatic increase in land productivity and economic structure. This will be covered in depth in the following chapters. I will pay close attention to land productivity and economic structure in order to help determine how the local economy was doing in the long run.

CHAPTER THREE: AGRICULTURE

3.1 Introduction

Agriculture has always been a hot topic in Yangzi Delta economic history. Most local economic history studies began with agriculture. The Yangzi Delta's agricultural economy is well documented thanks to local primary sources like macro government statistics, micro-level landowners' ledgers, contracts, and many observers' agricultural handbooks and other notes. However, literature on local agriculture performance has two opposing views. Philip Huang represents a school of thought that is sceptical of local agricultural development. He believes that the region's agricultural development was caused by nothing more than a rise in total population without any corresponding rise in agricultural output per person (the so-called Involution model). The California School counters that local agriculture underwent many new changes in response to growing population pressures, making it appear to be a picture of total vitality rather than stagnation. The latter is best exemplified by *Agricultural Development in Jiangnan*, a book published by LI Bozhong in 1998. This book provides a wealth of agricultural data on population, cultivated land area, grain yields, and more, making it one of the most important references for understanding the Yangzi Delta's agricultural economy. To a large extent, it is the foundation upon which the California School and even all of English literature rests with regard to understanding the local agricultural economic history. When there is enough evidence, opinions should not differ so much. However, there is a significant difference between the Involution view and the California School, which reached a climax a year or two after the publication of Pomeranz's book on the Great Divergence.

In some ways, most of the writing on Chinese economic history is about agriculture, and most of the writing on Chinese agriculture is about the Yangzi Delta. With so much

information at hand, how are we to make sense of the fact that competing viewpoints exist? The answer may appear to be surprisingly simple. Reading the works of the two schools of thought, we find that the seemingly opposing viewpoints are actually about different things. The Involution school assesses agricultural performance and finds no per capita progress in the local agricultural economy, only a low-quality scale expansion. However, the California School identified many new agricultural production patterns, such as intensification, seasonality, the fertiliser revolution, multiple cropping, and others. Perhaps there is no real disagreement between the two studies and they are actually discussing different topics. The assessment of growth is mainly concerned with the input-output efficiency or productivity. In other words, stagnation in the agricultural economy in terms of output per capita does not necessarily preclude the development of new modes of operation or technologies. Yet, does the introduction of a novel agricultural model automatically lead to increased productivity? Indeed, this is also questionable. Both sides agree there was long-term local population pressure. If, as Malthus argues, population pressure has a negative impact on economic growth, then it may also be true, as Boserup emphasises, that coping with population pressure will give rise to new technologies, business models, and even organisations. In the end, there may be instances in the economy in which the negative effects outweigh the positive or vice versa. So that means these seemingly contradictory existences are actually compatible and can be reconciled.

In this chapter, I hope to help reconcile these differences by constructing a comprehensive series of agricultural output over centuries. The main content is divided into two parts, measuring agricultural growth and analysing agricultural growth. First, from an output-based perspective, I discuss grain yields, multi-cropping, types of agricultural crops, and whether the so-called cash crop or cotton revolution occurred. Furthermore, I use a growth accounting framework to assess the performance of local agriculture over time. The calculations support the California School's claim that new phenomena emerged, but they also show that demographic pressures drove these changes and did not improve the input-output efficiency or productivity as Huang claims. This may

imply that I lean toward a particular Philip Huang perspective when assessing economic performance, but it certainly doesn't mean that agriculture in the Yangzi Delta was completely stagnant. New things or models continued to emerge over a long period of time, but it does not contradict the stagnation of input-output efficiency in terms of results. Many seemingly incompatible things may, like the Yin and Yang of Chinese Taoism, actually be reconciled with one another. The concept of the "high-level equilibrium trap", proposed by Mark Elvin in 1973, could serve as a viable compromise between these two perspectives.

3.2 Measuring agricultural growth: calculating agricultural output

3.2.1 Grain yields

Once cultivated land is available, grain yields are one of the most important factors in calculating agricultural output. However, even in the best-recorded areas, it is impossible to study grain yields without using observational data from historical sources in the absence of modern agricultural surveys. With enough data points, we can construct a fundamental series of grain yields, as was done in England (Broadberry et al., 2015). In fact, this is a very onerous requirement. Evidence of sporadic grain yields can be found in various countries or regions, but large samples are rare. England is a good example, with thousands of records describing crop yields at the micro level. In China, Perkins is the first scholar to try this route. To study Chinese land productivity over the centuries, he searches gazetteers for hundreds of grain yield observations from the Ming to the Qing Dynasty. Shi (2017) publishes in the appendix of his latest book a sample of more than 3,000 grain yields from various provinces of Qing China, mostly from gazetteers on government-run school rents. This research goes far beyond Perkins'. Most public schools relied on rented land to cover their daily expenses after receiving land from government grants or local donations. Gazetteers contain accurate information about such land rents. In the Chinese land market, rent was usually half of the first crop yield for multiple cropping, which means rent data can indicate grain yields.

Even so, it's important to note that most gazetteer criteria for rent are fixed rents rather than split rents. But many scholars believe fixed rents were designed using the splitting criterion (e.g., Chao et al., 1995; Guo, 2010; Perkins, 1969; Shi, 2011, 2015, 2017; Wu, 2016 [1985]).

This method works across China because gazetteers exist in all provinces. More specific resources for each region become available upon further exploration, thanks to the wide variety of archival sources that have survived to the present day. Local materials like account books, transaction contracts, personal diaries, agricultural monographs of observers, and gazetteers are abundant in the Yangzi Delta. Therefore, there should be an abundance of data on grain yields in the area. First, hundreds of grain yield records can be found in the Yangzi Delta's extensive gazetteers. The second is the abundance of agricultural handbooks and observer diaries that are used by pioneering scholars like LI Bozhong. Third, many landowners and estate owners' account books and contracts are useful references. Ming Dynasty land contracts usually record a generalised rent for this land. Particularly, the presence of the renowned Huizhou merchants in the Huizhou region adjacent to the Hangzhou prefecture in the Yangzi Delta has resulted in the preservation of the largest and most comprehensive collection of land contracts and account books in Chinese history, spanning from the 12th to the 20th century. Although this is not a first-hand account of the Yangzi Delta, its proximity to the region allows me to use these resources in my investigation of crop yields in the Yangzi.

What was the situation in the Yangzi Delta in terms of land productivity over the centuries? This section addresses this question. I begin by gathering all available information on local crop yields. I then apply classical Hedonic regression to the data. In contrast to England's abundant high-quality crop yield observations, the Yangzi Delta's information that can be used to describe crop yields comes in a wide variety of formats. Direct records, rent collection indexes in landowners' account books without units, and even data from the Huizhou region that is not even in the Yangzi Delta all exist (as Huizhou borders the Yangzi Delta and has a large amount of data). I have therefore

recalculated local long-term crop yields using only direct information describing Yangzi Delta crop yields and ignoring all other indirect information. The two approaches take into consideration, respectively, the two cases of maximising data quantity and maximising information quality. Both results match historical facts and are consistent. In the end, I decide to use the second method's results, which had higher sample quality, to determine the long-term trend of crop yields in the Yangzi Delta.

3.2.1.1 Long-run trend

I begin by collecting 3196 observations that describe grain yields in the Yangzi Delta, either directly or indirectly. These samples come from a wide range of sources and take many different forms, from directly recorded grain yields to those inferred from land rents with a 50/50 split, as SHI Zhihong has done. Furthermore, there is a category of data from land rent books that reflect changes in the actual rent of a piece of land over decades or even centuries. However, I am unsure of the exact size of the land for a large portion of this data. In other words, I only know the yield of a piece of land, not its size, so I cannot directly calculate grain yields per plot using the land rent method. But this does not render the data meaningless; since the data typically cover the same plot of land over the course of several decades, the land rent growth index can reveal shifts in grain output (Chao et al, 1995: 10). Besides the Yangzi Delta, I have also used data on crop yields in Huizhou. This is because the data from Huizhou are very large in terms of both time span and volume, as well as the fact that the Huizhou prefecture shares a border with the Hangzhou Prefecture in the Yangzi Delta (see Figure 1.1 in Chapter One), which represents the large mountainous area in the southwest of the Yangzi Delta.

I use a hedonic regression method similar to Broadberry et al. (2015) and Clark (2005) to make a coherent series of this information from different sources and units. Unlike England's better grain yield samples, I need more dummy variables for the Yangzi Delta to capture data source and pattern differences. For example, because there is no size information for the decades of yield index for the specific piece of land just

discussed, I set dummy variables to distinguish this type of data from others. I do not plan to set annual dummy variables because doing so could make the predicted results too volatile and contain too much error given that the variation in these samples can be large but the sample size is not particularly large. Specifically, using a sample of 3,196 to predict 561 years with an average of six observations per year may not be appropriate. Thus, I have extended temporal dummy variables to 50-100 years. Despite not including annual variation, such a regression prediction better reflects long-term trends. To guarantee the most precise long-term trend, I use seven time dummy variables with eight time intervals and an average of nearly 400 observations per interval. Here is the regression equation:

$$ln(Yield_{it}) = \alpha + \sum_{i=1}^{4} \beta_i Loc_i + \sum_{j=1}^{79} \gamma_j Unit_j + \sum_{t=1}^{7} \delta_t Period_t + \theta Rice + \varepsilon_{it}$$

where $Yield_{it}$ refers to the yield of rice for a certain land on location i in period t. Loc_i are the dummy variables for each location of Huibei (Anhui outside Huizhou), Huizhou, the Yangzi Delta, Zhedong (Zhejiang outside the Yangzi Delta), Subei (Jiangsu outside the Yangzi Delta). $Unit_j$ are the dummy variables capturing various unit of the grain yields, including directly recorded grain yields, yield indices with no units, etc. The size of the land in each ledger is unknown, so I set a separate dummy variable for almost every ledger. $Period_t$ are dummy variables for various periods of 1501-1600, 1601-1700, 1701-1750, 1751-1800, 1801-1850, 1851-1900, 1901-1953. *Rice* is a dummy variable used to differentiate between dozens of dryland crop situation. α is a constant, representing unhusked rice yields (Jin per Mu) of Huibei (Anhui outside Huizhou) from 1390-1500. ε_{it} is the error term.

Table 3.1 shows rice yield regression results. Table 3.2 shows regression-predicted husked rice yields per Mu. Rice yield per Mu increased from the Ming to the early Qing Dynasty, as most scholars expected. Land productivity declined since the early 19th century, which also matches most predictions (e.g., Chao et al. 1995; Jiang and Su, 1993; Ma and de Jong, 2019; Shi, 2017; Zhai and Lou, 2022). However, the above reg-

Table 3.1 Regression of unhusked rice yield per Mu (Catties or Jin) in Multi-factors, 1390-1953

	Coefficient	Stand error	T-value
Constant	4.954	0.084	59.32
Yangzi Delta	0.275	0.043	6.46
Rice	0.903	0.078	11.64
1501-1600	0.021	0.039	0.53
1601-1700	0.072	0.038	1.89
1701-1750	-0.082	0.051	-1.61
1751-1800	0.000	0.043	0.00
1801-1850	0.109	0.034	3.16
1851-1900	0.061	0.042	1.45
1901-1953	-0.065	0.046	-1.40
F(91, 3104)	500.89		
Adjusted R-squared	0.934		
Observations	3196		

Sources and Notes: see the text.

Table 3.2 Husked rice yield (in Shi Shi per Shi Mu), 1390-1953

year	Husked rice Shi Shi/Shi Mu
1390-1500	1.77
1501-1600	1.81
1601-1700	1.90
1701-1750	1.63
1751-1800	1.77
1801-1850	1.97
1851-1900	1.88
1901-1953	1.66

Sources and notes: unhusked rice yield is predicted based on the equation in Table 3.1. For the convenience of comparison, I convert the unit to Shi Shi, following 1 Shi Shi of unhusked rice = 130 Shi Catties of unhusked rice; 1 Shi Shi of unhusked rice=0.5 Shi Shi of husked rice.

ression method still has issues in practice. First, I have a lot of data from Huizhou prefecture, especially in the Ming Dynasty, which is much larger than the Yangzi Delta sample. The second is that I have included many series of yield indices without specific units in the equation rather than the actual yield per Mu, which may affect the final results' robustness. One point to discuss is that my equation seems to predict smaller

level values than LI Bozhong's estimates, particularly for the Qing Dynasty, and Li suggests that rice in the Yangzi Delta may have reached over 2.6 Shi Shi per Shi Mu[19] in the early 19th century. My data, on the other hand, suggests only 2 Shi per Mu. How can these distinctions be comprehended?

One option is to list the Yangzi Delta's most directly recorded grain yields, excluding the Huizhou case and unitless yield indices. This is not a large number of records in the total sample; I find 204 such records, which is a lot more than the previous 17 by Perkins (1969), 50 by Xu and Wu (1985), and 19 by Min (1984). I use LOWESS (Locally Weighted Scatterplot Smoothing)[20] to get a smooth curve for 1390-1953 from these scattered samples. To discuss the Yangzi Delta's long-term grain yield trend, I compare this result with the regression's predictions and LI Bozhong's previous estimates. I expect the regression results to match the direct evidence's long-term trend, and any discrepancies can be explained by "the interference of the Huizhou data I used".

Figure 3.1 compares local long-term grain yield trends from three perspectives. The curve obtained from LOWESS smoothing is highly consistent with regression predictions, with a full-time average of 1.87 Shi for the former and 1.81 Shi for the latter. Both results suggest an increase from the Ming to the mid-Qing Dynasties and a decline afterward. The regression predicts lower growth rates in the Ming and Qing Dynasties

[19] Shi (石) is the main unit of weight measurement in traditional China. However the exact weight of Shi varied slightly from period to period. Shi Shi (市石) is the contemporary accepted standardised unit. Generally speaking, 1 Song Shi (literally, Shi in the Song Dynasty, and later Yuan Shi and Ming/Qing Shi in a similar sense) equals 0.66 Shi Shi, while 1 Yuan Shi = 0.95 Shi Shi and 1 Ming/Qing Shi = 1.03 Shi Shi (Li, 2003: 81). Shi appearing in the text of this study refers to Shi Shi if not specified. Mu (亩) as a unit of size has varied slightly over time. According to Wu (2016 [1985]: 335), 1 Song Mu = 0.876 Shi Mu, 1 Ming Mu = 0.9597 Shi Mu, 1 Qing Mu = 0.9216 Shi Mu. The Mu used in this study are all Shi Mu (市亩) if not specifically noted.

[20] Classic linear fits may not be appropriate for determining long-term crop yield trends in the Yangzi Delta. Traditional techniques like moving averages may not be as effective at capturing long-term trends as non-parametric techniques because of the relatively small size and uneven distribution of the sample. Like Chen and Peng (2022), I employ the simple non-parametric method of Locally Weighted Scatterplot Smoothing. This method involves performing multiple regressions on local sample areas to give each area a unique fit pattern. More weight is given to things closer to the point of interest. In the end, this will give us a rough idea of the data sample's long-term trend over time. This study's bandwidth is set to 0.7.

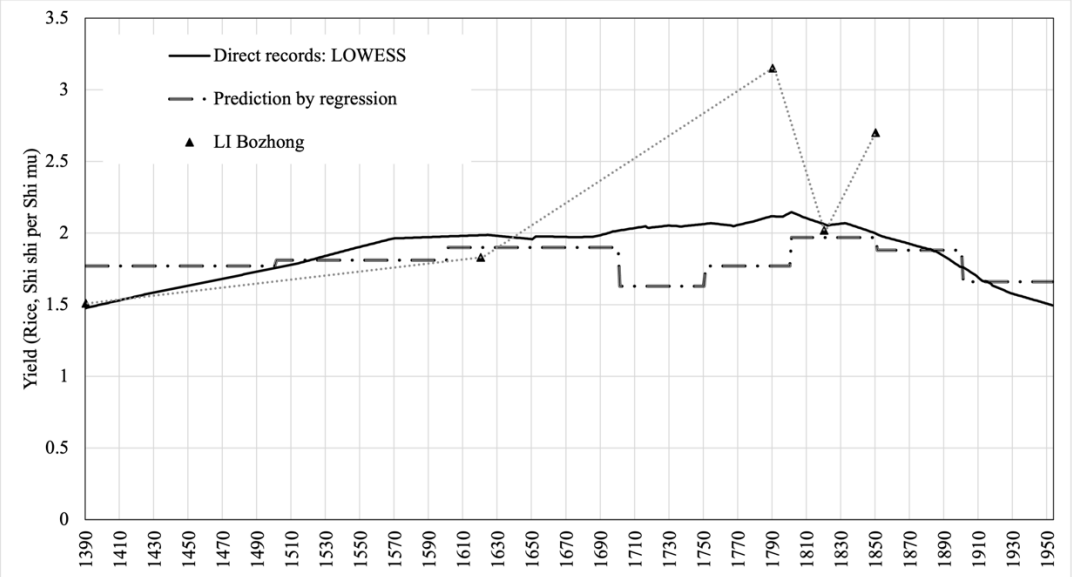

Figure 3.1 Long-term trends in Yangzi Delta rice yields per Mu

Sources and notes: for data other than LI Bozhong, see the text; for Li's data, see Li (2003: 83, 128, 326-7; 2010b: 395-398).

than the LOWESS method. One important reason for this is that the majority of the Ming Dynasty sample in the regression equation comes from Huizhou. In other words, during the Ming Dynasty, the difference between rice yields in the Yangzi Delta and Huizhou appeared to be much greater than during the post-Ming Dynasty. As predicted by the regression equation using more Huizhou samples, this increased rice yields in the Yangzi Delta during the Ming Dynasty. Rice yield records from earlier periods in the Yangzi Delta confirm this. Li (2003: 83) synthesises most of the visible evidence from the Song and Yuan Dynasties with previous literature to find that local rice yields were 1.0 Shi per Mu in the Southern Song (1127-1279), 1.4 in the Yuan (1279-1368), and 1.5 in the early Ming. It is evident that rice yields had increased over time, and it is likely that more than 1 Shi Shi occurred in the 13th century. However, if we believe that Huizhou rice yields can be applied to the Yangzi Delta, then rice yields in the Yangzi Delta in the early Ming are predicted to be 1.7-1.8 Shi, which appears to be too high.

Another thing to notice is that the series of regression predictions for the 18th century appears to be declining. How can we explain this period? Most of the materials available in China at the time are evaluated in depth by CHAO Kang et al. (1995), who speculate that there may have been a long-term decline in yield per Mu beginning in the 18th century. However, Chao et al.'s evidence comes from the many land rental ledgers south of the Yangzi River, which often show a declining output trend in land rent over time. My data also includes these ledgers. However, these ledgers may overestimate grain yield decline over time. Many of the ledgers only show a tiny plot of land, and that plot often produced nothing at all over the course of a year. Another significant factor is that the 50/50 sharecropping split ratio was assumed to remain constant when estimating land output from changes in land rent, as Ma and Peng (2022) point out. Yet, as fixed rents gradually replaced rent sharing in late Ming and Qing China, the ratio might have skewed even further in favour of tenant farmers. This means that landowners' rental ledgers may be exaggerating the Qing Dynasty decline shown in them. The only time Shi's national evidence for the Qing Dynasty's decline in land productivity should be considered is after the 19th century, when the literature nearly unanimously agreed upon a decline. Shi does not find a significant decline in yields per Mu in the 18th century, only a slowdown in growth rates.

Returning to the Yangzi Delta, there is little narrative support for a drop in land productivity during this time, despite Huizhou's close proximity to it. The late 18th century was the peak of local land productivity for centuries, with grain prices falling to the point that traders from outside the region found it unprofitable to export grain to the Yangzi Delta (Li, 2003: 327). This suggests that land productivity should be increasing in the area at the time. Although Li's results appear to be a little overly optimistic, his projections for this time period show a clear upward trend. His estimates for the 1790s were extrapolated using population consumption and cultivated land area, yielding an incredibly high result of over 3 Shi. But even with a conservative estimate of 2 Shi, the 18th century saw an increase. The LOWESS findings are much more eclectic because they neither support the 18th century's wildly inflated growth rates nor do they contest

the fact that the long-term trend slowed down during this time. This makes LOWESS result a good long-term trend for the Yangzi Delta.

Combining regression and direct methods makes it clear that land productivity increased from the late 14th century to the early 19th century. Rice yields declined until the 1950s from the 19th century. When comparing Li's 1850s data to 1950s survey data, this trend becomes even more evident. But how well do Li's estimates of such rapid growth rates hold up? There are two rather inflated results in Li's data: one for the 1790s, and another for the 1850s. The rest of the results match my predictions. Li's data sources should not exceed my sample. The calculation of grain yields is the main issue, not the data source. Li knows that extrapolating from sporadic evidence across a macro area is unreliable, so he uses the demand approach to calculate rice yields. This is accomplished by assuming a constant per capita rice consumption and calculating total local rice demand using macro population data. He then deducts the amount of imported rice and divides it by the area of rice sown to get the rice yields per Mu. However, the calculation error is a big issue.

Even with accurate population, cultivated land, and rice import figures, it is difficult to estimate per capita rice consumption. Li sets Yangzi Delta rice consumption at 3 Qing Shi per person (Li, 1998: 111-112). After reviewing the majority of quantitative and narrative sources, HUANG Jingbin uses Republic of China statistical surveys to argue that, on average, people should not eat more than 2.7 Qing Shi of rice per year, and that anything over 3 Qing Shi should come from adult males (Huang, 2009: 70). Huang estimates that the mid-Qing's per capita rice consumption was 2.3 Qing Shi, similar to the Republican period survey, because there was still a population that did not eat rice. If the per capita consumption of 2.3 Qing Shi is used in Li's method, the local rice yields during the mid-Qing period would likely not exceed 2.2 Shi Shi per Shi Mu. In fact, in response to Yu's (1980) and Min's (1984) estimates of 2.2 Shi Shi per Shi Mu of rice, Li uses his method to calculate that if 2.2 was correct, per capita consumption would have been 2.4 Qing Shi of rice per year (Li, 1998: 126). As a result, Li's approach

is extremely sensitive to variations in per capita consumption, with even a moderate shift having a noticeable impact on the final tally. Additionally, Huang uses this information to determine how much land would need to be dedicated to growing rice in the area, and he finds that rice production would necessitate 72.2 percent of all farmland (Huang, 2009: 70). This agrees closely with the estimate of 70-75 percent of the cultivated area that I will give later for rice sowing during the Qing Dynasty, while Li suggests over 90 percent for this (Li, 1998: 138). Overall, the supposed peak at the beginning of the nineteenth century should not have exceeded 2 Shi Shi too much. Indeed, Li's later study of two Shanghai counties reveals that Shanghai's rice yields in the 1820s were just under 2 Shi Shi per Shi Mu (Li, 2010b).

After correcting Li's data, Li and my results are mostly reconciled, clarifying the Yangzi Delta's long-term land productivity or grain yields. The sustained decline in grain yields after the 19th century, however, warrants a brief discussion. It is a "consensus" opinion because the majority of the literary and historical sources back up the phenomenon. Scholars cite increased natural disasters, ecological degradation, frequent wars, the government engaging in excessive exploitation of the agricultural sector in response to fiscal pressures, damaged water infrastructure, and the environmental impact of New World crop introductions like maize as the main causes (Chao et al., 1995: Chapter Seven; Shi, 2017: 71-76). However, in the agricultural section of the most recent Cambridge Economic History of China, volume 2, Ma and Peng (2022) cast doubt on this. They acknowledge that most scholars agree that land productivity declined for a long time in the nineteenth century, but they suggest that these declines may have been exaggerated for technical reasons. After breaking down Shi's dataset by Northern China and Southern China, they find no evidence of a declining trend in the 19th century. However, when averaging the provincial-level data in Shi's book and further conducting regional averages of the entire sample, it becomes evident that grain yields in southern China during the late Qing Dynasty were slightly lower than in the early Qing period (Shi, 2017: 76). Therefore, the observed differences between Shi and Ma and Peng could likely be attributed to differences in calculation methods. Brunt and Fidalgo

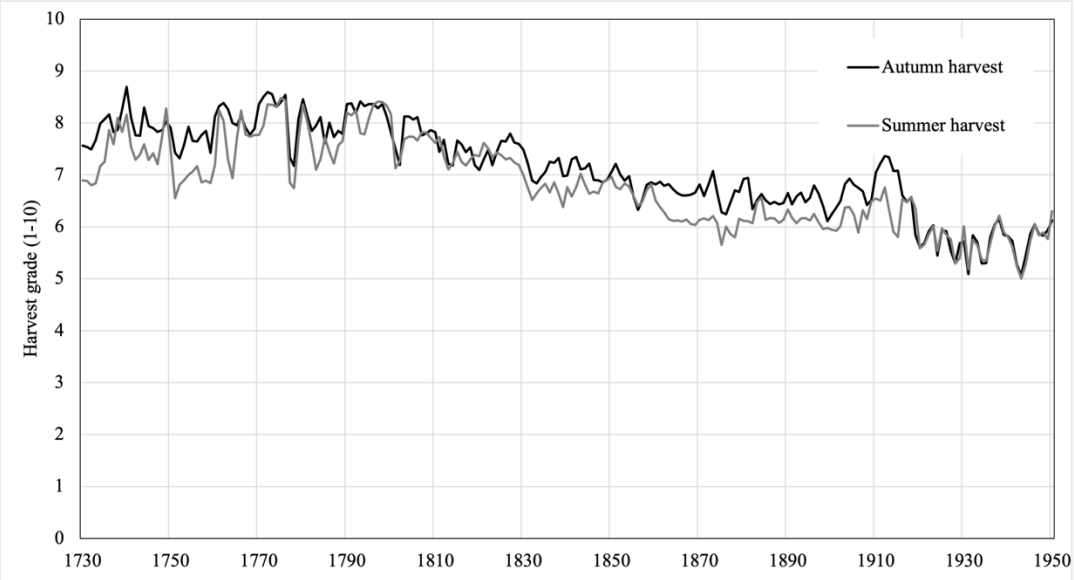

Figure 3.2 Harvest index in China, 1730-1950

Sources: see the text.

(2018) conduct a regression analysis that may shed light on these discrepancies. They regress Shi's complete original data and find a significant decline in rice yields, particularly in Jiangsu and Zhejiang provinces, where the Yangzi Delta belongs. This implies that even though there is still ongoing debate about the overall national trend, the decline in land productivity in the Yangzi region during the late Qing Dynasty can be accepted.

Another feature of Shi's data is that many of the original records are from long-term land rent criteria for local public school properties, which change very slowly and are more likely to reflect long-term trends than short-term ones. It is likely that the long-term rent rates for a given site would not have varied greatly between the early and middle 19th century, despite the fact that actual grain yields would have varied by a factor of several orders of magnitude. In fact, Shi is cognizant of this issue, so he downgrades the data from the late 19th century based on a wealth of qualitative evidence to better reflect the realities (Shi, 2017: 76). The local government's farming harvest assessment provides more context. During the Qing Dynasty, local governments were

tasked with annually subjectively rating agricultural harvests (Shi, 2017: 75)[21]. These local sources can summarise the national harvest. The subjective evaluation indices (on a scale of 1 to 10) used by local governments to rate the quality of summer and autumn harvests declined steadily beginning in the nineteenth century. Figure 3.2 depicts the national subjective harvest indices for autumn and summer crops from Zhang's (1996: 415-419) collection of local government harvest reports and other sources.

In any case, the decline in grain yields in the Yangzi Delta after the 19th century should be confirmed, even if the national decline is perhaps still more or less controversial.

3.2.1.2 Short-run volatility

We expect information that reflects annual variations, i.e. the short-term agricultural cycle, after we have clarified the long-term trends in the main local grain yields. Unlike the British case, I am unable to directly obtain annual volatilities from the regression equation due to a lack of data. However, the Chinese story can take a different approach. Early in the 18th century, local governments in China started informing the emperor on a regular basis about local grain prices, precipitation, and harvest indices. Price data, for example, became an important foundation for studying the history of markets and prices (e.g., Chen, 1992; Peng, 2006; Shiue, 2002; Shiue and Keller, 2007; Wang, 1992). The agricultural harvest index is a unique item in periodic reports to the central government. Local officials rate the local harvest on a 1-to-10 scale (Xie, 2010). Typically, the maximum local grain yield expected is 10. Other numbers below 10 can be interpreted as a percentage of maximum production (e.g., 7 represents 70 percent of maximum expected production), and numbers below 5 indicate an impending disaster. With the dual purpose of aiding in disaster relief and assisting landowners in rent collection, subjective grades are a useful indicator of the agricultural business cycle (Marks, 1998a, 1998b).

[21] A system I will discuss in detail in the following text.

Ma and de Jong (2019) are the first to use officially recorded harvest indices from the Qing Dynasty to estimate actual grain yields. They attempt to estimate the annual grain yields per Mu in China from 1840 to 1912 by utilising the national agricultural harvest index calculated based on local harvest reports by Zhang (1996: 394-432). Specifically, Zhang's agricultural total harvest index, derived from reports by local governments and gazetteers, is a unitless rank index that measures short-term fluctuations in land productivity. By combining this unitless short-term fluctuation series with benchmark data on reliable grain yields, the absolute values of annual grain yields can be calculated. Ma and de Jong combine Zhang's harvest index with average grain yields surveyed in the 1930s to derive the grain yields per Mu of cultivated land for the entire period from 1840 to 1912 in China. However, this assumes that the land's maximum expected yield remained constant from 1840 to 1912. Since they only look at 73 years, the margin of error should be small.

Unfortunately, local governments did not create such detailed harvest indices until the 18th century. However, many local sources use standardised and subjective language to describe the year's harvest, such as "a golden bumper harvest year", "not poor", or "very poor". The Qing Huidian (清会典, *Compilation of Qing Dynasty Regulations*) from 1899 details the grain yields represented by these standard expressions. "Very poor" means less than 40 percent of the expected maximum yield, "poor" 40-50 percent, "slightly poor" 50-60 percent, "average" 60-70 percent, "near bumper" 70-80 percent, and "bumper" 80 percent or more (Hao et al., 2020). Therefore, many Chinese geographers have used the abundant descriptive historical data found in a wide range of Chinese sources to develop early harvest indices that align closely with local government rating standards (e.g., Hao et al., 2020; Su, Fang and Yin, 2014; Yin, Fang and Su, 2016). However, few regional studies have been conducted. In fact, there is a wealth of historical information on the Yangzi Delta, especially in the gazetteer chapters on *Local Climate and Agricultural Production* (灾异), which include many statements that are fairly typical of agricultural harvests. Thus, following the detailed scoring criteria of Su, Fang, and Yin (2014) and Hao et al. (2020), I collect over 20,000 words or sentences

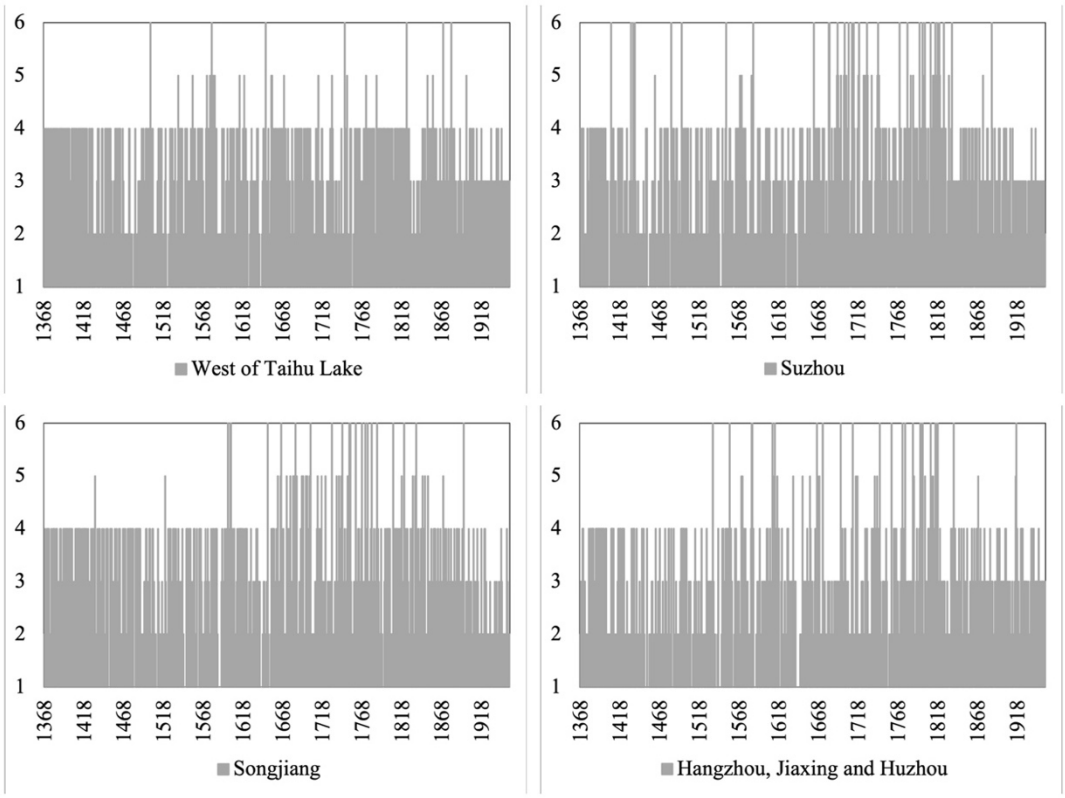

Figure 3.3 Agricultural harvest grades for west of Taihu Lake, Suzhou, Songjiang and Hangzhou, Jiaxing and Huzhou, 1368-1953

Sources and notes: The harvest grades are based mainly on gazetteers and meteorological records. Records prior to 1912 are summarised in Zhang (1994). Records in Jiangsu after 1912 are summarised in Shi, Zhang and Yang (2005), information in Shanghai is summarised in Liu (2010), and information in Zhejiang is visible in *Historical Information on the Climate in Eastern China over the Last 500 Years* (1978).

For the vertical axis in the graphs, 1 = "very poor", 2 = "poor", 3 = "slightly poor", 4 = "average", 5 = "near bumper", 6 = "bumper".

describing local agricultural harvests from gazetteers and meteorological reports for different periods. Appendix B lists the rating criteria. Specifically, I divide the Yangzi Delta into four observation stations[22]: one in the western part of Taihu Lake, two in the

[22] The division is primarily based on a comprehensive consideration of geography and economic size. Taihu Lake geographically divides the Yangzi Delta into three regions: Western Taihu, Eastern Taihu, and Southern Taihu (with the Yangzi River primarily occupying the northern part). These three regions have distinct geographical environments, with the eastern part being mostly plains, while the western and southern parts are adjacent to some mountainous areas. The vast Taihu Lake contributes to the climate variations among these regions, which are also reflected in meteorological records found in gazetteers. However, I do not classify them as three separate observation stations, mainly because during most of the Ming and Qing Dynasties, Suzhou was a regional economic centre with a much larger population and economic scale than other areas. Treating the eastern side of Taihu as a whole could potentially underestimate the weight of this region in calculations. Therefore, I divided the eastern side of Taihu into two observation stations.

eastern part, Suzhou and Songjiang (including Taicang), and the last one including Jiaxing, Huzhou, and Hangzhou. I convert the subjective descriptions and statements in the local materials for each station into quantified grades, resulting in the four stations' agricultural harvest grades in Figure 3.3. My harvest grades have six levels, from 1 to 6[23]: "Very poor", "Poor", "Slightly poor", "Average", "Near bumper" and "Bumper". The above agricultural harvest grades I establish are unevenly graded, so it must be converted to a percentage of the expected maximum grain yields. Harvest grades are converted into equally spaced yield information so that the various numbers obtained are comparable. A harvest grade of 4 corresponds to 65 percent of the maximum yield, while 1 corresponds to 20 percent. It is important to remember, though, that the harvest grades derived from text analysis can have a wide range of variation. This is due to the fact that gazetteers prefer to "record anomalies rather than norms". Thus, if a gazetteer predicts a famine, we should assign a very low harvest grade of 1 or 2. In practice, this is likely because some locations in the region are indeed so bad, but not all. Thus, assigning a harvest score of 1 directly from a gazetteer may overestimate the disaster's severity. For obviously, whenever there is a serious reduction in agricultural production at a small location, the gazetteer will record it, but those other local areas outside this location that are not recorded will likely have experienced a normal harvest year. Based on this, we may be exaggerating the yield of the whole area when we give bumper years a rating of 6. As a result, these textual records based on gazetteers may overstate the harvest grades at both ends of the scale, centred on a normal year like 4. That is, a harvest grade of 4 may be equivalent to the real world, whereas a harvest grade of 1 may indicate that the actual situation is slightly better than 1. Scholars who use the same method to evaluate agricultural harvests have noticed this (Xiao and Yan, 2019). The text analysis shows the correct direction of harvest grade variation from year to year, but too large a variance can exaggerate real-world agricultural fluctuations.

[23] The classification into six levels follows the Qing Huidian criteria aforementioned and is consistent with previous studies conducted by scholars such as Hao et al. (2020), Su, Fang and Yin (2014), and Yin, Fang and Su (2016).

Because of this, I try to reduce the variance to get a more accurate reflection of the true spread of harvests. I assume that the harvest ratings obtained from gazetteer information reflect the situation in roughly half of the local area, while for the other half, I set the situation to a normal harvest of 4. Thus, when gazetteers return a text analysis result like 4, I can assume the average local situation is 4. But if the gazetteers say the harvest should be 3 in a given year, I assume this only represents 50 percent of the local situation. For the remaining 50 percent of the area not recorded, I set the harvest to 4 as in a normal year. In this manner, the harvest variance is weighted to be smaller and closer to reality. This does not change the direction of annual harvest variation, but it greatly reduces the weakness of exaggerating extreme cases when using gazetteer records for text analysis. I then calculate the Yangzi Delta's annual harvest using arithmetic average of the four stations[24]. As mentioned earlier, these harvest grades are like time series without the long-term trend, so just knowing these data does not give a true picture of grain yields. In the real world, the long-term output profile and expected maximum yield both change from period to period. To calculate the real grain yields series that incorporate long-term and short-term information, the trend in long-term grain yields must be known. Since I have previously specified local long-term grain yield trends like the LOWESS results, I could easily combine this with the current annual harvest grades to calculate the actual annual grain yield series, or rice yields. Figure 3.4 depicts the unhusked rice yields per Mu based on both long and short term data.

Annual data on rice yields appear to provide an intriguing explanation for the decline in land productivity in the nineteenth century. Local rice yields fell precipitously for two decades following 1815. Indonesian volcano Tambora erupted this year. It is believed that China's ecology suffered very negative effects. The dramatic climate and temperature changes in China changed many areas' ecological structure. China's Yellow Sea fish Clupea Palasi decreased significantly (Li, 2009), New World crops disrup-

[24] Although population and land weights are considered, the stations I have divided are not equal. However, I do not want to overcomplicate things by using anything other than a simple arithmetic average to determine the average of the four stations. Average calculations using a variety of weights show only small variations in results.

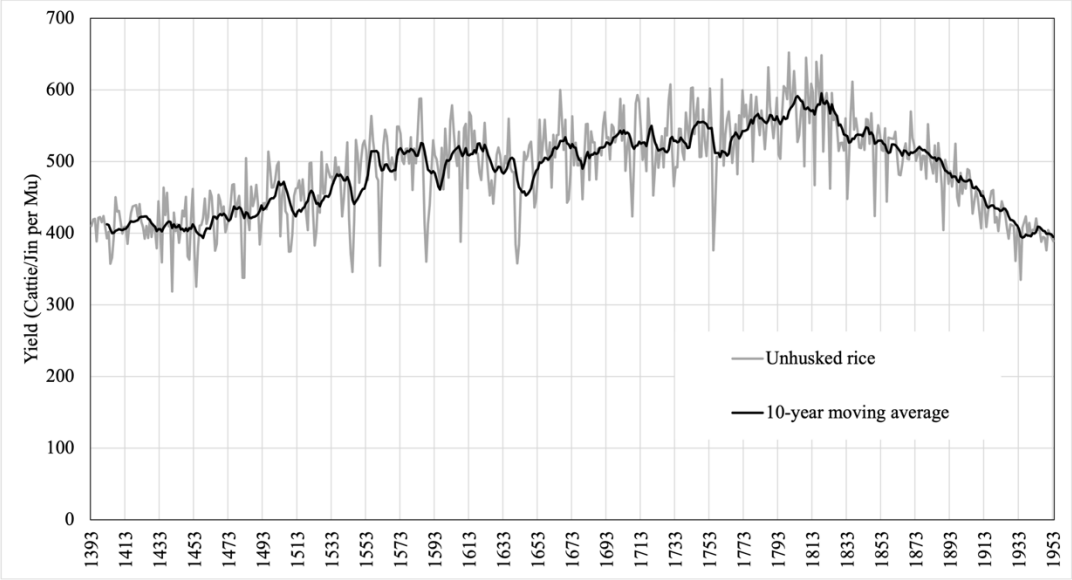

Figure 3.4 Unhusked rice yields per Mu in the Yangzi Delta, 1393-1953
Sources: see the text.

ted the Shandong Peninsula's crop structure (Wang, 2009), and Yunnan experienced a great famine due to reduced rice production (Yang, Man and Zheng, 2005). Despite the fact that the eruption cannot be said to have directly changed China's agricultural trajectory, it is logical to assume that the sudden drop in grain yields was somehow connected to the event. Worse, local land productivity continued to decline after the volcanic effects faded in the mid-19th century, though at a slower rate than in the two decades before the eruption. In any case, this global climate shift offers a potentially illuminating explanation for the period's agricultural decline.

3.2.2 Crops in the Yangzi Delta

Local crop type and share must be determined to calculate agricultural output. During the Qing Dynasty, cropping structure in the Yangzi Delta is thought to have changed dramatically, with cotton serving as the main cash crop (e.g., Li, 1998; Pomeranz, 2000). There is a proverb that says "locally produced clothes can cover the whole world" (衣被天下), referring to the success of the region's textile industry in the 19th century, which is often described as the "Cotton Revolution" (e.g., Liang, Wang, and Yamauchi, 2021; Xue, 2016). Whether or not this is the case, however, will require further

discussion. A surprising new pattern does not always indicate quantitative dominance. In 1041-1048, Chinese engraver BI Sheng invented movable type printing using clay as a mould, according to Song Dynasty scholar SHEN Kuo's *Dream Pool Essays* (Meng Xi Bi Tan, 梦溪笔谈). Even though this act is often cited as occurring 400 years before Gutenberg's invention, there is no proof that it led to a printing revolution on par with Europe's during the Northern Song Dynasty. In fact, printing on clay or wooden moulds did not work well, so engraving remained the dominant method of printing in China for a long time (Xin, 2016: 349-357). It has been argued that the Ming Dynasty saw the advent and widespread use of movable type stencils made of metal, particularly copper, which completely altered the Chinese printing industry and revolutionised BI Sheng's method. However, after a thorough examination of the records found in a variety of historical documents, Xin (2016) concludes that there is no evidence that books printed with movable metal type were popular in China prior to the early Qing Dynasty. Indeed, many Chinese inventions or "new events" are not immune to such an example; that is, just because some novel techniques are mentioned in the historical record does not mean that they were actually implemented successfully. As I will explain later, a new change's emergence is just a starting point, and its real-world impact should be quantified.

Let's go back to how the cropping structure in the Yangzi Delta changed over time. Many crops are grown locally. Researchers agree that rice, cotton, mulberry, and second-season wheat have long occupied most of the acreage (e.g., Allen, 2009b; Brenner and Isett, 2002; Huang, 1990; Li, 1998, 2010b; Pomeranz, 2000). It is necessary to know the acreage planted to these major crops in order to calculate agricultural output. Earlier studies assumed that the Yangzi Delta only had three first-season crops: rice, cotton, and mulberry (Li, 1998). Statistics from the twentieth century show, however, that many other types of food and cash crops were also cultivated in the first season (Forty Years of Agriculture in Zhejiang, 1990; Cao, 1996; Jiangsu Agricultural Statistics, 1976; Chang, 1929a, 1929b, etc.). Some low-value dryland crops might not only make up a small portion. In the Yangzi Delta, where rice has a high value-added per

plot of land, counting only the three main crops may overestimate the area under rice cultivation and the overall net agricultural output, so it is important to clarify local agricultural crops and cropping structure.

3.2.2.1 Crops in the first season

A. Rice

Unlike LI Bozhong's indirect method of "deducting cotton and mulberry plantations", rice cultivation can be directly estimated. The size of various types of cultivated land in the area was frequently detailed in Ming and Qing gazetteers. Cultivated land was generally divided into paddy and dryland based on irrigation, where rice and dryland crops such as wheat and beans were grown. Although paddy fields could be used for other dryland crops, they were typically only used for growing rice due to its higher profitability. Wang (1999: 95-97) examines land types in Ming gazetteers. In his sample, 85 percent of the Yangzi Delta was paddy fields. However, by the early twentieth century, the proportion of paddy fields was decreasing. In the late 1920s, paddy fields in the Yangzi Delta made up only 72 percent of all cultivated land, according to Chang (1929a, 1929b). My calculations based on official data from the 1950s show that local paddy fields accounted for about 78 percent (Jiangsu Agricultural Statistics, 1976; Jiaxing City Gazetteer, 1997; New Zhejiang Fifty Years Statistical Data Collection, 2000; Shanghai Comprehensive Gazetteer (Volume 1), 2005). No under-representation exists in these macro-level statistics, indicating that paddy fields were declining over time, possibly due to the growth of cotton and other cash crops. By combining the above benchmark data of the proportion of paddy fields from the early Ming to the 1950s with linear interpolation, we obtain the proportion of paddy fields for the entire time period.

But rice was not the only crop grown in paddy fields. In the survey from the 20th century mentioned above, 10 percent of the paddy fields were not used for rice farming. Sources agree on the 1920s and 1950s. In contrast, almost all of the rice fields were used for rice cultivation during the early Ming Dynasty when there were fewer cash

crop options (Wang, 1998; 1999: 319-320). In the text that follows, I make the assumption that rice was grown in all paddy fields in the early Ming Dynasty and that by the turn of the 20th century, 90 percent of all paddy fields were planted with rice. Long-term, rice share of the paddy had been dwindling. Therefore, I can get the shares of the years in between by using linear interpolation. With the area of paddy fields over time and the proportion of rice in them, I can calculate the exact area of rice cultivation over several centuries. Over the course of 500 years, the share of farmland dedicated to rice production gradually but not much decreased.

B. Cotton

Cotton acreage is a hotly debated topic. The precise number of cotton fields in the Yangzi Delta has been critical in the investigation of local proto-industrialisation. (e.g., Huang, 2002; Pomeranz, 2002). My follow-up calculations, however, show that cotton's value-added per unit of land is very close to that of rice when the output-based method is implemented to calculate GDP, suggesting that, within reasonable bounds, either an overestimation or underestimation of cotton acreage has little effect on the findings of this study. Even so, seeing how the well-known Cotton Revolution played out in this area would be fascinating.

Early 20th-century agricultural surveys are my starting point. CHANG C. C.'s 1929 county-level agricultural surveys of Zhejiang and Jiangsu provinces and 1950s official figures estimate the cotton fields at 54.81 million Mu and 34.91 million Mu, respectively. Given that war had reduced cultivated land, the 1950s decline in cotton fields is understandable. These two figures, the only statistical surveys covering almost the entire Yangzi Delta at the time, are somewhat referable. With a wealth of historical descriptions and evidence, including the original data from XU Xinwu (1992), which was relied on by both sides, HUANG Jingbin (2009) reevaluates Philip Huang and Kenneth Pomeranz's earlier arguments, with relevant refinements. He claims that cotton fields in 1750 should have been 10 percent higher than in the 1920s, and in the slightly lower

1850s, 5 percent higher than in the Republican period. According to his index, 1850's cotton fields were 5.75 million Mu and 1750's 6.02 million Mu.

LI Bozhong (1998: 110) is one of the first scholars to estimate cotton production in the late Ming and early Qing Dynasties. He calculates cotton output and planting size using Xu and Wu's (1985: 277-279) estimate of 16 million Pi of late-Ming cotton exports and 40 million in mid-Qing, along with local cotton consumption. Yet, I plan on making some changes to this. Li cites Xu and Wu's (1985) estimate of mid-Qing China's per capita cotton cloth consumption at 1.68 Pi at the end of the Ming Dynasty. This yields a cotton field of 1.9 million Mu in the early 17th century (Li, 1998: 34, 110). This is an unreasonable rate of growth compared to 1750's over 6 million Mu of cotton fields. It suggests Li's per capita consumption was too low. I use Huang's latest estimate of 3.9 lbs or 3.5 catties or Jin of cotton (around 2.7 Pi cotton cloth)[25] per person (Huang, 2009: 144-151) and combine it with Li's previous cotton exports to estimate 3.204 million Mu of cotton fields at the end of the Ming period, which is very close to Fan's (1998: 10-13) alternative estimate of 3.2 million Mu. Another issue is that the Yangzi Delta might have imported cotton from the northern cotton-producing provinces and exported cotton cloth, which may have overestimated the local cotton fields (Deng, 1999). To test this, I use Xiao's (1984) calculations for Shanghai, the largest cotton textile centre. Xiao finds that Shanghai's cotton fields' maximum production capacity was close to the actual cotton output based on the number of workers, with the actual cotton output being only 1.02 times the cotton fields' support. If this is true in Shanghai, the most productive region, it is unlikely that the gap is greater elsewhere. If this is considered, the Yangzi Delta's cotton fields at the end of the Ming Dynasty were 3.14 million Mu.

Little is known about the early Ming Dynasty. But based on the early Ming's fiscal structure, cotton was already a major crop in the region (Liang, 2008 [1980]: 256-257).

[25] Huang gives per capita cotton consumption in the 1850s and 1930s as 3.2 and 4.7 lbs, respectively. I have set the per capita consumption of cotton at the end of the Ming period at around 3.8-4 lbs, which if all calculated into cloth would be about 2.7 Pi per person, a relatively low estimate but still much higher than Li's 1.68 Pi.

The problem is that I cannot provide direct numbers. Using the growth rate from the end of the Ming Dynasty to 1750, the cotton area in the early Ming was likely less than one million Mu. However, many historical sources place the cotton revolution between the late Ming and mid-Qing Dynasties, suggesting that the early Ming Dynasty's growth rate should be lower. One way to reduce the growth rate is to assume that cotton fields as a proportion of cultivated land remained constant in the early Ming Dynasty. If cotton fields as a share of cultivated land did not rise throughout the Ming Dynasty, it is hard to fathom how the so-called cotton revolution could have occurred so suddenly at the dynasty's end. Although I no longer believe that there had to be a "Cotton Revolution", it is undeniable that many of the narrative sources show a marked increase in the importance of local cotton in the 17th century. Thus, cotton cultivation's relative growth in the region cannot be ignored. In the absence of evidence, I am referring to a famous early Ming government command (Annals of Food and Goods in Ming History (明史食货志), 1739):

When the Ming Dynasty was established, the Emperor ordered farmers to plant 0.5 Mu of mulberry, hemp, and cotton, respectively, if they had 5-10 Mu of land.

The fact that this policy is merely advice raises the possibility that it might not actually apply in practice, particularly in China as a whole. This may be based on conditions in the Yangzi Delta, where the capital was. When ZHU Yuanzhang, the first Ming emperor, declared a new dynasty in 1368, his army was still fighting in northern and southwestern China. The capital was established in 1356 in Nanjing, a western city in the Yangzi Delta, where the emperor and his staff likely gained administrative experience. Given the region's long cotton cultivation history, the information could be an upper threshold. If cotton comprised 5 percent of cultivated land, local cotton fields were 1.91 million Mu. Based on this figure, cotton fields might have grown faster than cultivated land over the course of two centuries, but not as fast as during the late Ming Dynasty's "Cotton Revolution".

As a result, several benchmark estimates of the proportion of cotton fields to cultivated land are available. I use linear interpolation to calculate the proportion of cotton to cultivated land for various time periods.

C. Mulberry

Mulberry trees were planted along Taihu Lake's southern shore, especially in the Huzhou Prefecture of Zhejiang Province. Official statistics provide the information for the 1950s. I refer to Li (1998: 40) for information from the end of the Ming Dynasty to the mid-19th century. But the problem still stems from the early Ming Dynasty. Although the aforementioned famous bulletin does provide some helpful information for the possible cotton cultivation, it is largely irrelevant to the mulberry cultivation that I am interested in. Mulberry cultivation never exceeded 5 percent in local history, and at its peak in Qing and Republican China, it was probably only 3 percent. There is no evidence that the early Ming period was better. Nonetheless, gazetteers may provide insight into this matter by detailing mulberry trees and the taxes levied on them. Fan (2016: 74-78) reports a 56 percent increase in Suzhou's taxable mulberry trees from the early Ming to 1503. Silk taxes in Hangzhou rose 65 percent from the Ming Dynasty to 1482 and 67 percent to 1572. Huzhou's taxes rose 25 percent in 1522 compared to the 1390s. Overall, it should be acceptable for the mulberry field to have doubled from the beginning to the end of the Ming Dynasty. The most conservative estimate, based on a 25 percent increase in Huzhou, leaves 560,000 Mu of mulberry fields in the early Ming Dynasty. Even with errors, this estimate would have little impact on agriculture. For the other time periods, the proportion of mulberry cultivation to cultivated land is calculated using linear interpolation, as before.

D. Other crops

About 10 percent of the remaining land was used for two crops: dryland food crops like beans, cereals, maize, and potatoes introduced at the end of the Ming Dynasty, and cash crops like hemp, vegetables, fruits, and tea. Subtracting the area of the previous three

major crops from the cultivated land yields the total area available for the remaining food and cash crops.

Food crops comprised 94 percent of this remaining cultivated land in the 1950s, while cash crops made up 6 percent. However, by the 14th century, things had changed. The famous early Ming government proposals suggest that hemp fields were probably close to cotton fields at that time. So hemp fields might be 1.9 million Mu. This is consistent with the fact that the majority of the Yangzi Delta population wore hemp cloth at the start of the Ming Dynasty. In addition to hemp, there were also other cash crops that, according to surveys conducted in the Republic of China and the 1950s, occupied about 1 percent of the total cultivated land in the long term (Li, 1998: 26), or about 380,000 Mu in the 1390s. Combined with hemp fields, the total area of all the cash crops was equivalent to about 66 percent of the remaining cultivated land in the early Ming. This means that by the end of the 14th century, 34 percent of the Yangzi Delta's cultivated land was used for food crops other than rice, cotton, and mulberry. This indicates that from the early Ming to the mid-20th century, the Yangzi Delta's food crops cultivation outpaced cash crops cultivation in the "remaining cultivated land". On the one hand, this can be explained by the spread of New World food crops like potatoes and maize in the Yangzi Delta. On the other hand, as cotton replaced hemp as the primary clothing material, the size of hemp fields shrank.

Thus, food and cash crops in these remaining cultivated land are calculated as follows. In the long run, I assume that the proportion of food crops increased and the proportion of cash crops decreased in these remaining arable fields. Based on the 1390s and 1950s shares, I use linear interpolation to calculate the proportions of food and cash crops grown in other years. This, combined with the total area of remaining cultivated land, gives me the land area under these food crops and cash crops over several centuries.

3.2.2.2 Crops in the second season

A. Double cropping index

In addition to the previously discussed crops from the first season, the region's double plantings during the second season will also require investigation. Replanting helped local farmers earn more. Commonly, wheat, beans, and rape are the crops in the second season . Replanting conditions must be examined to determine these three crops' acreage. During the Song Dynasty, repeated cultivation of local land was well known, but there is evidence that it might not have developed significantly until the end of the Southern Song (Fang, 2010: 419-446). Since the Ming Dynasty, repeat cultivation has been a nearly consensual and stable phenomenon in the area.

Then, from recent to early times, I discuss local replanting or double cropping. First, official 1950s statistics show that the local double cropping index in 1953 was 1.76, indicating that 76 percent of the land was cultivated twice a year. This is close to LI Bozhong's 1.7 estimate in the mid-19th century (1850s). During the Republic of China period, many narrative evidence shows that local farmers grew fewer winter crops (second season crops) than before the mid-19th century (Li, 1998: 32). I agree with Li's 1.6 replanting rate for the late Qing and the Republic of China[26]. In one sense, it is lower than the peak seen in the 19th century. If it is set too high, on the other hand, it may be difficult to comprehend why it increased to 1.76 in the post-war era in just a few short years.

At the end of the Ming Dynasty (1620s), I still use Li's double cropping index of 1.4. The range of values from 1.4 in the early 17th century to 1.7 in the 19th century does not seem to me to be linear. At least during the Ming-Qing transition, double-cropping should not have increased. Replanting, on the one hand, was often a reaction to the decline in agricultural land per person. Supporting replanting, on the other hand,

[26] The reason for the decline in winter crop cultivation was most likely due to population loss caused by the Taiping Rebellion in the mid-nineteenth century. As a result, I set a double cropping index of 1.6 for the years 1865 to 1945.

necessitated an increase in fertiliser. Soybean fertiliser imports were often required during peak multi-cropping in the Yangzi Delta, but this can be difficult to accomplish during periods of political instability. I therefore delayed the further advancement of double cropping until the 1660s, when the political climate was relatively calm and the relationship between the population and the cultivated land became increasingly tense.

The early Ming Dynasty's situation is somewhat complicated. The literature discusses double cropping after the 17th century, but it is rare in the early Ming Dynasty. It appears that there is little agreement among academics at the moment. Huang (1990: 78) claims local double cropping peaked in the early Ming and did not develop further. Li (1998: 30) disagrees with this upbeat outlook. However, Li does not make his own estimates for the period. Materials in the early Ming period are scarce. However, Wang's fiscal data approach is worth considering (Wang, 1998, 1999: 319). He notes that wheat might have accounted for 25 percent of cultivated land in the early Ming Dynasty, based on the wheat tax. If, as Li assumes, wheat constituted 70 percent of second-season crops, the double-crop index could be higher than 1.3. However, Wang does not explain how he calculated the wheat fields using tax data. Because of this, I have looked at early Ming wheat tax records in an effort to provide a reasonable answer.

The Ming and Qing Dynasties had a fixed fiscal system in which central taxation was unrelated to economic growth. Yet, the settings made during the reign of the Hongwu emperor were frequently the source of the quotas that were adhered to for centuries. Thus, Hongwu's fiscal standards likely reflected the cultivation structure of the time. In 1393, the Jiangsu part of the Yangzi Delta's wheat tax was 382,472 Ming Shi, while rice was 4,957,271 (Liang, 2008 [1980]: 490). Wheat accounted for 7.7 percent of rice tax. The yields per Mu of wheat was typically half that of rice, so if the tax rates for wheat and rice were set at the same level, wheat would be sown on approximately 15 percent of the rice-sown area. Based on Li's assumptions, if we consider wheat to be 70 percent of the double season crops and rice to be 85 percent of the cultivated land in Ming China, we can roughly conclude that all double season cropping should account

Table 3.3 Implementation time of LI Xu's double-season rice experiment, 1715-1720

	1715	1716	1717	1718	1719	1720
Sowing date	4.10	3.28	3.09			
Harvest date	7.13	6.04	6.21	7.03	6.15	6.24
Sowing date	7.28	6.16	7.02	7.12	6.23	7.04
Harvest date		9.15	10.02	9.20	10.03	9.28

Sources and notes: These experimental records are taken from LI Xu's reports to the Kangxi emperor, which are included in Hong's compilation of *Economic Materials on Suzhou Rural Areas in the Ming and Qing Dynasties*, pp. 188-195 (Hong, 1988). These dates are recorded in the traditional Chinese lunar calendar.

for nearly 20 percent of the cultivated land. It implies a double-crop index of 1.2 (1390s). This estimate may be reasonable since the index would be 1.4 in two centuries.

Similarly, linear interpolation is used to calculate a double cropping index for the entire period based on the benchmark data.

B. Second season crops

The second or winter crops were primarily wheat, beans, and rape. Always and everywhere, the percentages of these three stayed at around 70 percent, 20 percent, and 10 percent, respectively (Li, 1998: 35). The statistics for the 1950s were 75 percent, 13 percent, and 12 percent, respectively, confirming Li's inference was largely unproblematic. Thus, for the 19th century and before, I use Li's setting; for the 20th century, I use the 1920s Chang survey and 1950s official data. Despite what may seem like a substantial amount of double cropping relative to total cultivated land (sometimes as much as 1.7 times), subsequent analyses have shown that the added value of winter crops was relatively low. Due to the fact that the profit from wheat was only a fifth of the profit from rice, the estimation error of double cropping had little effect on the estimates of the total agricultural output. In other words, if all second season crops were calculated as in the case of wheat, their contribution to agricultural output would likely be only 10 percent at a double cropping index of 1.7.

However, the input-output efficiency of double cropping as a sort of "technological progress" might be less than ideal. While the total output per unit of land was undeniably improved, the related input expenditures might be significant. LI Xu, director of Suzhou's Royal Textile Factory, experimented with double-season rice in the early 18th century. However, in his experiments, the second season yield was only 40-60 percent of the first and contributed only 30 percent to total rice output (Shi, 2017: 59). Two-season cropping deteriorated soil fertility. Worse, poor soil fertility might reduce grain flavour, lowering its value. Another issue for farmers is that the time between double cropping was so short that there was a severe labour shortage. For instance, LI Xu's double-season rice experiment was constrained by a short growing season. He had to coordinate plantings of both traditional rice (which takes 150 days to grow) and early-maturing rice (which takes 90 days to grow) within the 200-day window that is optimal for rice cultivation in China. According to his reports to the Kangxi Emperor, it took him eight days to harvest the previous season's rice and plant the seedlings for the upcoming season (Chao, 2001: 203). Chao believes that harvesting the first season's crop while simultaneously completing all preparations for the next season's planting could require half of the local farmers' annual labour force in such a short period of time. The situation was not much better even if it was not extreme two-season rice farming. According to LI Bozhong, most winter crops were harvested before April, while rice was sown in the first half of May (Li, 1998: 68-75). This was still the busiest time of the year for farmers, leaving them with only about 15 days to complete their tasks. LI Xu's double-season rice experiment, which caught the emperor's attention, had an interval of less than 10 days (see Table 3.3), making second-season rice planting nearly impossible for ordinary farmers. In other words, maintaining double cropping in the Yangzi Delta was costly for farmers, both for common winter crops and for double-cropping rice. In the text that follows, I will go into greater detail about this.

Table 3.4 Distribution and size of sown area by crops, 1400-1950 (in percent or million Mu)

	1400	1500	1600	1700	1800	1900	1950
Rice	70.3	64.6	59.0	51.8	42.9	41.6	41.1
	(32.5)	(33.4)	(34.2)	(33.9)	(33.7)	(19.7)	(26.0)
Wheat	12.1	15.7	19.3	22.8	27.9	32.3	31.5
	(5.6)	(8.1)	(11.2)	(14.9)	(21.9)	(15.3)	(19.9)
Beans	3.5	4.4	5.5	6.4	7.9	3.4	4.9
	(1.6)	(2.3)	(3.2)	(4.2)	(6.2)	(1.6)	(3.1)
Miscellaneous grains	2.6	3.3	4.0	4.6	6.4	9.9	9.8
	(1.2)	(1.7)	(2.3)	(3.0)	(5.0)	(4.7)	(6.2)
Cotton	4.1	4.8	5.2	7.3	7.5	7.6	5.7
	(1.9)	(2.5)	(3.0)	(4.8)	(5.9)	(3.6)	(3.6)
Mulberry	0.9	1.0	1.2	1.5	1.7	1.9	1.9
	(0.4)	(0.5)	(0.7)	(1.0)	(1.3)	(0.9)	(1.2)
Rapeseed	1.7	2.3	2.8	3.2	3.9	1.9	4.4
	(0.8)	(1.2)	(1.6)	(2.1)	(3.1)	(0.9)	(2.8)
Other cash crops	4.8	3.9	3.0	2.4	1.8	1.4	0.7
	(2.2)	(2.0)	(1.8)	(1.5)	(1.4)	(0.6)	(0.4)
Double cropping index	120	130	140	150	170	160	170
Sown area size	(46.2)	(51.7)	(58.0)	(65.4)	(78.5)	(47.3)	(63.2)

Sources and notes: Data calculation details are from the text. The basic idea is to construct crop share data for benchmark years. Linear interpolation is used to calculate crop shares for other years. The years listed in this table may or may not be the benchmark years mentioned in the text. Years in the table are integer years for comparison, so most of its data is interpolated.

The area sown to crops is shown in parentheses (in millions of Mu), while the area sown to crops as a proportion of the total area sown is not bracketed. Total sown area refers to land including double cropping.

3.2.2.3 Summary

Table 3.4 provides a summary of the Yangzi Delta's cropping structure. Rice was the region's most important crop. Double cropping reduced its share, but rice accounted for 41.1 percent of the region's cropping acreage until the 1950s. Cash crops like cotton and mulberry trees are also noteworthy. The proportion of cotton and mulberry planted had been increasing, which, given the inclusion of double cropping, means that a greater proportion of cotton and mulberry were planted in the first season crops. However, these two crops made up less than 10 percent of the total acreage cultivated. This matches Li (1998) and Allen (2009b). Cotton and mulberry cultivation was small

compared to total cultivated land. As noted later, rice and cotton were grown at very close profits, making these two well-known cash crops contribute not too much as imagined to agricultural output. Since rice and cotton profits were comparable, errors in rice or cotton acreage calculations are also unlikely to affect agricultural output. Furthermore, despite the fact that the double cropping index had been increasing, the majority of the second season crops were wheat. As previously mentioned, the output value of the main crop, wheat, in the second season of double cropping was lower compared to the first-season crop with the same sowing area. This indicates that double cropping did not result in a substantial increase in output as implied by the expansion of the sowing area. The local cropping structure did change over the centuries, with cash crops becoming more important, but until the 1950s it was still dominated by rice. In other words, this reconciles the California School and its opponents: new agricultural changes were happening, but their impact in terms of improving input-output efficiency or productivity was small.

3.2.3 Agricultural output value-added

Once the acreage of each crop in the Yangzi Delta is known, the value-added of each crop and the entire agriculture can be estimated. (1) First, I will calculate the value-added of rice, the most important local crop. This requires rice acreage, yields per plot, and production cost. We already have the first two pieces of information. To determine the value-added of rice, I will concentrate on the cost of rice production in this section. (2) The second step is to determine the value-added of other crops. Ideally, we also need the preceding three pieces of information. However, yields per plot for other crops are unavailable. Thus, I follow previous studies on Chinese agricultural output (Liu, 2009; Shi, 2017) and discuss how many times more income is generated by growing other crops than rice on the same area. This method assumes that crop income differences on the same acreage were stable over time. It seems reasonable based on qualitative and quantitative evidence (Li, 1998; Shi, 2017). However, this assumption does not hold true in all cases. Over the centuries, the rise of cotton and the textile industry

it spawned had the greatest impact on the agricultural economy of the Yangzi Delta. Cotton prices shifted relatively quickly in comparison to rice prices as a result. Income from cotton farming fluctuated over time compared to rice farming because per-plot cotton yields did not change much relative to rice yields. To be more realistic, my cotton value-added calculation will account for relative price changes separately. For other crops, I assume that the difference in income from other crops relative to rice for the same acreage remained stable over time. (3) Thirdly, I will determine value-added for non-plantation industries like livestock, fishing, and forestry.

3.2.3.1 Arable farming

A. Rice

In fact, the majority of the debate about rice value-added stems from the use of soybean cake fertiliser. Both 1930s surveys (Ou, 2017 [1947]: 47-49) and late Qing Dynasty direct estimates of intermediate inputs (Shi, 2017: 153-164) agree that intermediate inputs for grains like rice account for 12-15 percent, including seed, fertiliser, machinery, and housing. However, Li (1998: 47-50, 139) suggests that intermediate inputs locally may be higher due to the fertiliser revolution supporting double cropping, which required large soybean cake imports. Allen (2009b) compares several studies and concludes that Li's estimate may be too high, especially for the Ming Dynasty before the fertiliser revolution. According to Brenner and Isett (2002), the fertiliser revolution was largely a response to double cropping's land degradation. The rise of double cropping raised the possibility that a fertiliser revolution was taking place in the area. According to surveys in 1930s, 15 percent of intermediate inputs for grain in China are reasonable, 12 percent of which are other than fertiliser (Ou, 2017 [1947]: 48). However, Ou also finds that the average total intermediate input in China reached 26 percent when considering Jiaxing farms in the Yangzi Delta, suggesting that intermediate inputs for grain production in the Yangzi Delta might be higher than the China average.

This study follows Allen (2009b) in that there was no significant local fertiliser revolution before the early 17th century, so soybean cake fertiliser was not widely used. The cost of fertiliser at the time was minimal because it was primarily made of natural manure. However, given that the average intermediate input other than chemical fertiliser in China in the 1930s was already 12 percent, and the greater intensity of cultivation in the Yangzi Delta, I set the value-added of local rice at about 85 percent of output without the large input of soybean cake (before 1620s), equivalent to Brenner and Isett (2002)'s speculation based on LI Wenzhi (1957). As the double cropping index increased from 1.4 to 1.7 (from 1620s to 1850s), local bean cake use should also increase. If we assume that bean cake was used in most of the region prior to the 19th century wars, I can get a total cost of bean cake in the 1820s of about 0.75 taels per Mu (Li, 2010b: 185). The result closely resembles what happened on the Jiaxing farms in the 1930s (Ou, 2017 [1947]: 48). Then, assuming that bean cake coverage increased from zero to 100 percent of rice cropland as the double cropping index increased from 1.4 to 1.7, we can use linear interpolation to estimate intermediate inputs for the entire fertiliser revolution period.

Another issue concerning rice value-added is the price of unhusked rice. Husked rice dominates China's rice price history. Little is known about unhusked rice. However, rice hulling is an important industrial process. Thus, when calculating agricultural output, we should use unhusked rice. In Chinese metrology, milling 1 Shi unhusked rice yields 0.5 Shi husked rice, or 60 percent of its weight (Li, 2010b: 317-320; Wu, 2016 [1985]: 329). Intuitively, 1 Shi unhusked rice may cost half as much as 1 Shi husked rice. This setting has been widely used in previous agricultural output studies (e.g., Allen, 2009b; Ou, 2017 [1947]; Shi, 2017). However, Li (2010b: 339) criticises this approach, arguing that it amounts to assuming that the only profit from the rice milling workshop is the subsidiary products of rice, i.e., rice bran and hulls, a profit that is excessively small. He estimates that 1 Shi of unhusked rice in the Yangzi Delta in the 1820s cost 1,100 Wen based on the Hua-lou producer's profit share and daily labour wages. At this time, 1 Shi husked rice cost 2,800 Wen, so Li's setting is more than 20

percent lower than the previous scholars' 1,400 Wen. Since rice was a major local product, the final agricultural output estimate would have reflected this difference. In fact, Li's calculations are not entirely based on direct historical evidence, especially since he notes that the local agricultural handbook mentions a price ratio of 1:2 for the two products per Shi unit, but ultimately does not use this figure (Li, 2010b: 340).

So, what is the truth? Two methods seem to resolve this debate. Value-added analysis for rice mills is the first. Using data from the Republican-era industrial survey, Ou (2017 [1947]: 96) discovers that in the 1930s, the share of raw materials in the output of China's 61 rice mills was approximately 84 percent. In the 1820s, 0.5 Shi husked rice cost 1400 Wen in Hua-lou, and the byproducts were 200 Wen, so milling 1 Shi unhusked rice earned 1600 Wen. Applying the 84 percent raw material share yields a cost price of 1344 Wen. In other words, 1 Shi unhusked rice would cost 1344 Wen, lower than the traditional method's 1400 Wen but much higher than Li's 1100 Wen. Another piece of evidence comes from 1930s' Wujin County price data (Chang, 1933: 214), which shows that 1 Shi unhusked rice cost 92-94 percent of husked rice it produces. If applied to Hua-lou in the 1820s, the result would be around 1300 Wen, close to 1344 Wen. The above two methods suggest that an ideal setting of 1400 Wen would overestimate local agricultural output. But it is also true that the rice mills were not very profitable. I use 1300 Wen, or about 1 Shi unhusked at 46 percent of the 1 Shi husked price, which corresponds to the common sense observations in the agricultural handbook.

Thus, if I use LI Bozhong's price data for the Hua-lou area, I can obtain a series of value-added for rice expressed in constant 1820s prices. This will be the basis for value-added calculations for other crops and industries.

B. Cotton

In 1820s' Shanghai, cotton with seeds cost 50 Wen per Qing Jin (Li, 2010b: 350) and yielded 100 Qing Jin per Mu (Li, 1998: 136), so the output value of cotton per Qing

Mu was 5,000 Wen. For the same period, rice yielded 3.4 Qing Shi per Mu and cost 1,100 Wen per Qing Shi. If the value-added of rice and cotton as a percentage of their respective outputs is assumed to be similar, then the value of cotton production on the same land would be 1.34 times more profitable than rice production. It is close to Shi's 1.1 times estimate (2017: 166-172). Shi's results are the average for China, and as he says, cotton profitability in the Yangzi Delta was higher, which fits our calculations. However, in the case of early cotton, special treatment may still be required. From the early Ming to the late Qing Dynasty, the price of rice compared to cotton and cotton cloth changed significantly. In the early Ming, when the cotton fabric industry was still developing, cotton and its products were more expensive. Cotton became increasingly cheaper in comparison to rice as the textile industry developed. If we assume an income gap of 1.34 times between rice and cotton in the early Ming Dynasty, the large long-term change in relative prices may have underestimated cotton's value-added. To investigate long-term relative price shifts, I collect rice and cotton (or cotton cloth) prices in the Yangzi Delta from the early Ming to the Republic of China.

I have gathered a sample of 372 cotton prices from various sources. Cotton prices rose significantly during the Qing Dynasty. To fully determine the cotton price in terms of rice, additional calculations are required. Next, I need rice prices. Rice price information is more reliable and consistent than cotton price information. Wang (1992)'s Suzhou rice prices from 1638-1935 are used for the period after 1638. Rice prices before 1638 are typically quoted using a 10-year price series compiled by PENG Xinwei (1965) from a database of more than 400 records. However, many of these 400+ records are thought to contain officially regulated Ming Dynasty prices and may not be market-related (Qiu, 2018: 380-384). Moreover, this information comes from different parts of China and may not accurately portray things in the Yangzi Delta. Thus, I refer to QIU Yongzhi's (2018) study of rice prices in the Ming Dynasty, in which he plots a long-term rice price series based on HU Tieqiu's (2016) collection of rice prices in the Yangzi Delta. In case Qiu's data are missing in the 1620s and 1630s, I have supplement-

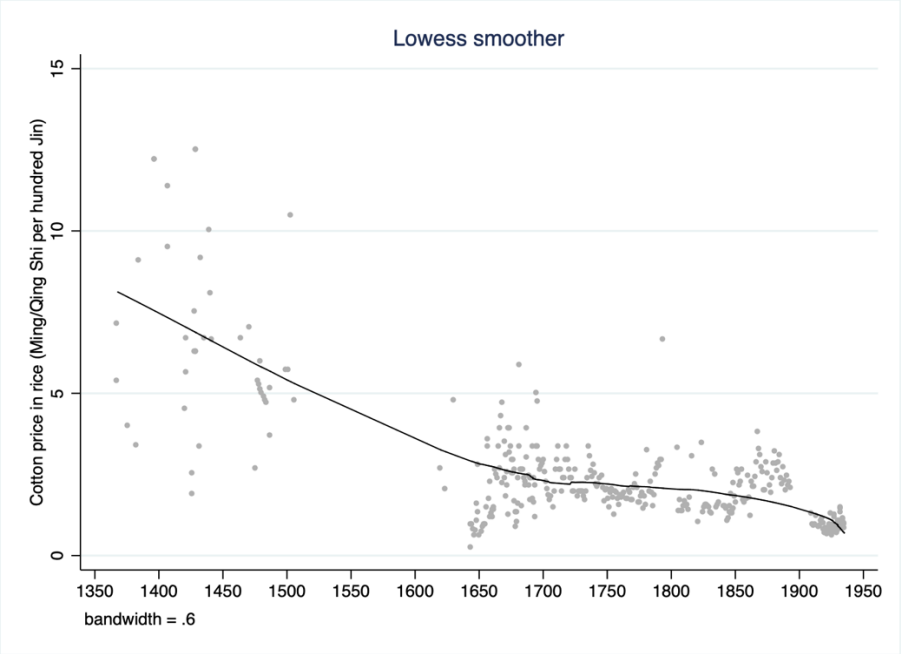

Figure 3.5 Cotton prices in rice in the Yangzi Delta, 1368-1935

Notes: Cotton prices consist of 375 observations, including the directly recorded price of cotton and the price of cotton adjusted using the price of cotton cloth, according to the transformation rule of Li (2010b: 348), i.e. 1:9 for the price of cotton per hundred Jin to white cotton cloth per Pi.

Sources: The 44 observations for the period 1368-1620 are from "Textile Prices in the Ming Dynasty (明代纺织品价格部)" (Wang, ed., 2017: 2093-2104) in *The Chinese Canon: Money and Finance Division, Economy Volume* (中华大典: 经济典, 货币金融分典). This book is a collection of extracts from ancient Chinese historical materials by category. The records are drawn specifically from *Collected Statutes of the Great Ming Dynasty* (*Da Ming Huidian*, 大明会典), *Veritable Records of the Ming Dynasty* (*Ming Shilu*, 明实录), *History of Ming Dynasty* (*Ming Shi*, 明史), *Guangxu Huating County Gazetteer* (光绪重修华亭县志), and *Ancient and Modern Book Collection* (古今图书集成), etc. The 220 pre-19th-century records of the Qing Dynasty are drawn from the *Yueshi Bian* (阅世编), *Linian Ji* (历年记) and *Yibang Lu* (一斑录), collected by WU Chengming (2001: 265).

The 49 observations of 1846-1894 come from two materials. Firstly, the 1862-1894 are derived from the prices of cotton exported from Shanghai in the customs archive compiled by Yao (2016 [1962]: 1655). The 1846-1862 are taken from Surat's cotton prices published by Sauerbeck (1886). Peng (2006: 156) finds that Surat and Shanghai's cotton prices trended in a highly consistent manner in the mid-19th century. I therefore follow Peng's approach and use the Surat cotton price trend to link the subsequent Shanghai cotton prices. Using the level of cotton prices in the Yangzi Delta in the 1840s as a benchmark, I finally obtain a cotton price series for the period 1846-1894.

The 62 observations after the 1890s come from direct records from various locations in the Yangzi Delta, namely Chang (1933), Tan (1993: 343), *Shanghai Prices History* (1998: 67), *Hangzhou Prices History* (2002: 219), and *Nanjing Prices History* (1996: 124), in which the retail price is adjusted to the wholesale price at a 10 percent discount as shown for Nanjing case.

For rice prices see the text.

ed it with 1634's prices from the *Supplementary Agricultural Handbook* (补农书) (Chen, 1958). Qiu's data are unavailable during the Hongwu period of the Ming Dynasty, so I interpolate using PENG Xinwei's trends and Qiu's 1430 prices as the benchmark.

Figure 3.5 shows sample points and LOWESS smoothed curves for cotton prices in rice. It is clear that the difference between rice and cotton profitability during the Qing Dynasty did not change much over time. But the real cotton price dropped by almost 75 percent between the early and late Ming Dynasty. Prices suggest the cotton revolution occurred in the Ming rather than the Qing. This is partly due to the rapid development of the local cotton and cotton textile industry, which may have marked the full transition from hemp to cotton in Chinese clothing. If the price of cotton in terms of rice was 100 in the 1820s, it would have been 400 in 1400, making cotton farming five times more profitable than rice. So, rather than assuming that cotton is 1.34 times the income of rice over time, I use the newly constructed price of cotton relative to rice to recapture the multiplier of income from cotton cultivation over time. Applying this data and the general intermediate inputs of 15 percent of output from early 20th century surveys, I obtain the long-term value-added of the cotton production.

C. Mulberry, wheat, rape and others

Other crops are now being discussed. Shi (2017: 176-178) claims mulberry trees are four times more profitable than rice, which is likely too high. According to other sources, the income from mulberry cultivation could be 2.2 or 2 times that of rice (Chen, 1958; Li, 1998). For this study, a more conservative estimate of two times is chosen. The intermediate input has been set to 15 percent.

Wheat yielded 23.4 percent unhusked rice per plot in the early 19th century (Li, 1998: 124) and 84 percent of the price (Li, 2010b: 340). The income from growing wheat in this manner was roughly 20 percent of that from rice. According to previous studies,

wheat intermediate input was 20 percent (Allen, 2009b; Brenner and Isett, 2002; Li, 1998: 111). This provides the added value of wheat.

Using the same method, the income from beans can be estimated to be 42 percent that of rice, based on the yields per Mu and prices provided by Li (1998, 2010b). Rapeseed farming income was equal to rice farming income. Farming income for the other cereals is not available, but because they were grown on much smaller acreages, I assume they were in the case of wheat. Other cash crops would generate twice as much revenue as rice, claims Liu (2009). The error set this way should be small since the area planted to other miscellaneous grains and cash crops was small. According to twentieth-century surveys and the aforementioned studies, intermediate inputs for these crops are calculated at 15 percent.

Thus, the arable sector's total and crop-specific value-added can be calculated.

3.2.3.2 Livestock, fisheries and forestry

Besides arable farming, there are livestock, fisheries, and forestry. We begin with the 1820s. Following Li (2010b: 161-166)'s detailed primary sources on the Hua-lou region, I set the per capita pig in the 1820s at around 0.3, which gives a total output of 2,429 Wen per capita and 2,186 Wen for intermediate inputs, resulting in the value-added of 243 Wen per capita. At a copper-to-silver ratio of 1200:1, the value-added of pigs per capita was 0.2 taels. The value-added of poultry and eggs was 0.84 taels per capita, based on similar data and methods. The fishing industry generated 0.62 taels per capita.

However, Li does not attempt to estimate the forestry industry because it was so insignificant in the region he examines. As a result, I have used survey data from the 1950s. In Huzhou, forestry made up 27 percent of the total value of the livestock and fisheries industries' output (*New Zhejiang Fifty Years Statistical Data Collection*, 2000: 546). According to this ratio, local forestry output per capita in the 1820s was 1,234 Wen. Ou

(2017 [1947]: 63-68) finds that intermediate inputs in the Yangzi Delta were 40 percent in the 1930s, giving forestry a 0.62 taels per capita in terms of the value-added.

These numbers suggest that in the 1820s, the non-plantation sector contributed roughly 2.29 taels per capita to the economy, or about 27 percent of the total agricultural sector's value-added.

In the absence of data, Perkins (1969) and Allen (2009b) assume these sectors grow with the population. But it is undeniable that the early Ming Dynasty had better livestock and forestry resources than the centuries that followed. The early Ming gazetteers record large amounts of local land used for horse breeding, but over the centuries these lands gradually became cultivated, including the officially prescribed horse breeding land. As land resources were stretched compared to the population, cattle farming became unaffordable, and one cow for six months cost nine months of rations in the early eighteenth century, according to Li (2010a: 217). In the early 15th century, Shanghai's fishing industry accounted for 20 percent of local non-agricultural taxes (Zhang, 2016 [1990]: 54). However, fishing in the Qing Dynasty appeared to have been less important for taxation. Despite reforms to the tax system, declining resource availability alongside rising populations might have contributed to a decline in the quantity of fish caught per person. Forests also experienced a significant decline in this regard. Pomeranz's (2000: 226) and Li's (2002: 249-263) descriptions of forest resources imply that there was no issue with the decline of local forest resources during the Ming and Qing Dynasties. Since natural resources were already scarce in the 1820s, assuming constant non-plantation output per capita may underestimate the importance of these sectors before the Qing Dynasty. It seems more reasonable to assume a constant share of value-added as in BGL (2018, 2021).

On the basis of the information above, the total agricultural value-added can be calculated. At this point, measuring agricultural growth is complete. The outcomes are displayed in Figure 3.6.

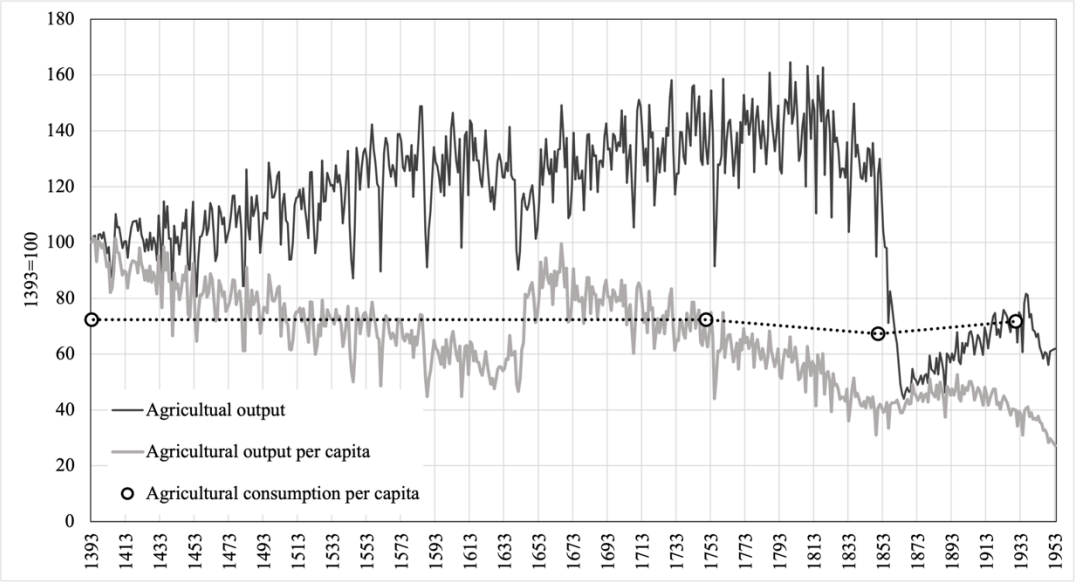

Figure 3.6 Agricultural output and consumption in the Yangzi Delta, 1393-1953

Sources: For output data, see the text. As for the consumption data, I refer to Huang (2009)'s estimates of rural household consumption in the Yangzi Delta at 1750, 1850 and 1930, with modest adjustments based on Li (2010b)'s results for Hua-lou per capita consumption. Specific details can be seen in the text.

3.3 Analysing agricultural growth: seven centuries of agricultural output and TFP

3.3.1 Agricultural output and consumption

Figure 3.6 shows Yangzi Delta agricultural output and per capita from 1393-1953. Intuitively, Philip Huang's Involution agriculture existed where total output increased but per capita output stagnated. Local agricultural output had grown steadily, except for a few population losses. Long-term population growth, however, outpaced agricultural output, leading to falling per-capita agricultural output. Ming and Qing agricultural growth rates were similar during peacetime. Growth appears to have picked up speed after 1870, as indicated by the steepening curve in Figure 3.6.

Table 3.5 Rural household consumption in the Yangzi Delta, 1750-1930
(in 1850 constant prices, taels)

	1750	1850	1930
Grain	29.3	29.3	29.3
Vegetable	5.3	4.2	5.3
Meat	1.5	1.0	1.5
Fish	0.8	0.6	0.8
Egg	0.5	0.4	0.5
Oil	1.7	1.5	1.5
Sugar	1.0	0.7	0.9
Vinegar	0.9	0.8	0.8
Firewood	4.8	4.0	4.8
Consumption per rural household	45.7	42.5	45.3
Population	22567k	34043k	20486k
Household	4513k	6809k	4097k
Total agricultural consumption	276.2m	387.4m	248.6m
Total agricultural output	266.1m	232.6m	134.8m
Gaps in production to consumption	-10.1m	-154.8m	-113.8m

Sources and notes: Consumption data is taken from Huang (2009) while population data comes from the previous chapter. Agricultural output is derived from this study using the averages of 1741-1750, 1841-1850, 1921-1930 as agricultural output for 1750, 1850 and 1930 respectively. A household is assumed to be five persons in the calculations. In addition, in the case of Huang, rural consumption is calculated for the Yangzi Delta, and therefore must have been lower than the local average; Li (2010b: 232) estimates that per capita food consumption in the Hua-lou region was about 64 taels in the 1820s, or 57 taels in the 1850' prices, which is about 1.34 times higher than in the rural areas of Huang. I have therefore used this ratio to calculate local consumption in 1750, 1850 and 1930 with the estimated rural consumption of Huang as the benchmarks.

Was local nutrition worsened by declining agricultural output per capita? The truth was probably not. As discussed in much of the literature, China's long-distance markets matured probably from the late Ming Dynasty onward. After the mid-Qing period, huge amounts of grain entered eastern China, centred on the Yangzi Delta, from the upper and middle Yangzi River and northern regions (e.g., Chen, 1990; Chuan and Kraus, 1975; Deng, 2009; Fan, 1998; Hou, 1996; Jiang, 1992; Li, 1986, 1998, 1999; Long, 2003; Wang and Hwang, 1989; Wang et al. 2014; Wu, 1995; Zhang and Liao, 2002). Industrial products like cotton, silk, printing, and others were exported from the Yangzi Delta to secure food supplies. This implies that production of the main exports should

grow at least as fast as the population. Industrial goods exports were needed to make up for the shortfall in per capita agricultural output since per capita consumption of all commodities remained constant.

Table 3.5 shows rural household agricultural product consumption from 1750 to 1930. These figures are based on HUANG Jingbin's (2009) exhaustive collection of Yangzi Delta consumption data. For comparison, I convert Huang's nominal consumption to real comparable consumption at constant prices in 1850[27]. As population grew between 1750 and 1850, average household consumption fell. The 1930s were slightly higher than the 1850s, but they had not yet recovered to the 1750s level. Despite these minor changes, per capita agricultural consumption was stable. Figure 3.6 shows Huang's estimated agricultural consumption per capita index as a dashed line and circles. Given that per capita consumption seemed very stable over time, we can depict the situation since the 15th century by assuming that consumption in the early Ming Dynasty was about the same as in the Qing[28].

Figure 3.6 shows that agricultural production and consumption in the Yangzi Delta were still balanced in the 15th century, suggesting that bilateral food and textile trade should not be significant. However, the long-term decline in agricultural output per capita suggests that the situation in the 15th century was unsustainable. And by the middle of the 16th and 17th centuries, agricultural production could no longer support local consumption, so large amounts of food had to be imported and local textiles had to be exported to complete the trade. Approximately 20 percent of the food deficit occurred during this period. This analysis supports previous research that a local long-distance grain market formed in the late 16th century. Following the Ming-Qing Transition of the 1640s, which increased land per capita, there appeared to have been no

[27] HUANG Jingbin provides 1850 prices. For price comparison with my data based on constant prices in the 1820s, I use PENG Kaixiang's (2006) Yangzi Delta price index. According to Peng, prices in 1850 were about 0.9 of those in the 1820s, indicating weak local inflation.

[28] According to Chen (1958) and Jiang and Wang (2020), the food consumption of Yangzi agricultural workers on annual contracts in the Ming Dynasty was roughly 5.5 Ming/Qing Shi of rice, compared to roughly 5-5.5 in the mid- to late-Qing Dynasty, a fairly close match.

significant shortfall in local grain for the next 100 years. However, a grain deficit emerged in the 1750s and grew until it peaked in the 1850s at nearly 50 percent of local agricultural output. This suggests that the local proto-industrialization after the 1750s was driven by the need to import grain, which necessitated the rise of the textile industry.

3.3.2 A reconciliation of the controversies: output per workday and TFP

3.3.2.1 Agricultural output per workday

What about agricultural labour productivity? Early economic historians are particularly interested in this topic. Labour productivity is critical in answering the controversies of the California School and the Involution School. In the previous discussion, one of the main questions was whether the "new things" like double cropping would increase or decrease agricultural labour productivity. The Involution School claims that with these "new things", labour input costs exceeded output, resulting in a long-term decline in agricultural labour productivity. Thus, clarifying labour productivity would help resolve this controversy. Usually, two settings are used to calculate labour productivity. The first is time-based output. In pre-modern agricultural research, this is the agricultural output per workday (Allen, 2009b). The second calculation considers output per worker. I focus on the first setting because the Yangzi Delta lacks high-quality data on occupational structure[29].

Given that we already know how many acres of crops were grown, estimating the number of hours put in by farm workers is a simple calculation. Pre-modern crop care time per unit of land was relatively constant, so agricultural labour input time could be ob-

[29] The literature on Qing Dynasty occupations has made great strides in recent years (Guo et al., 2019; Yang, 2020, 2022). Tens of thousands of samples from the Qing Dynasty Ministry of Justice (*Xing Ke Ti Ben*, 刑科题本) have been used in these studies. Guo et al. (2019) are the first to estimate China average occupational structure using these samples, gazetteers, and local government census files. Recent studies by Yang (2020, 2022) using a larger sample of judicial archives examine the occupational structure of the male labour force in various regions of China, particularly in the Yangzi Delta during the Qing Dynasty, and finds no significant changes around 200 years after the 18th century. But a stable occupational structure of the male labour force does not necessarily mean that the occupational structure of the total population would have remained unchanged.

Table 3.6 Workdays required to care for one Mu of crop

Rice	Cotton	Mulberry	Miscellaneous grains	Other cash crops	Wheat	Beans	Rape
12.5	8.7	32.3	6.7	16.0	10.0	6.8	11.4

Sources and notes: The data come from Buck (1985 [1937]: 410). For wheat I refer to Allen's data, set to 10 days. For other miscellaneous grains, for which no direct data are available, I refer to Buck's survey of dryland grains, set at 100 days per hectare, or about 6.7 days per Mu. For other cash crops I take Buck's mean values for tobacco and tea, about 240 days per hectare, or about 16 days per Mu.

tained (Allen, 2009b; Brenner and Isett, 2002; Huang, 2002; Li, 1998). Following Allen's method, I use Buck's 1930s survey of Chinese agriculture to calculate labour input time per unit of land for each crop (Buck, 1985 [1937]). It is worth noting that I have made some changes to the wheat labour input in Buck's survey. Because Buck's results are so low, I use Allen's average of 7-13 days of labour input per Mu of wheat, i.e. 10 days. However, this is only true for farming. We still lack data on the sectors other than farming that account for roughly 27 percent of agricultural value-added. Using the time spent caring for animals in Europe, Allen (2009b) has attempted to project labour time in the livestock sector in the Yangzi Delta, but there is actually very little firm data on this. No information is available either for industries apart from livestock. For the sake of simplicity, I assume that the daily output of these sectors was not dissimilar to that of farming in order to estimate the labour inputs of other sectors.

In this manner, we can combine agricultural output data to obtain agricultural output per workday, i.e. labour productivity, for the Yangzi Delta. My Yangzi Delta agricultural output per workday is shown in Figure 3.7. The fitted lines in the figure are from segmented regression (Linden, 2015), where I subjectively divide the local structural breakpoints into four historical events: 1630, 1645, 1851, and 1865. These four breakpoints are chosen to capture the Ming-Qing transition and Taiping Rebellion, which had a major impact on the local economy. Here is the specific regression equation:

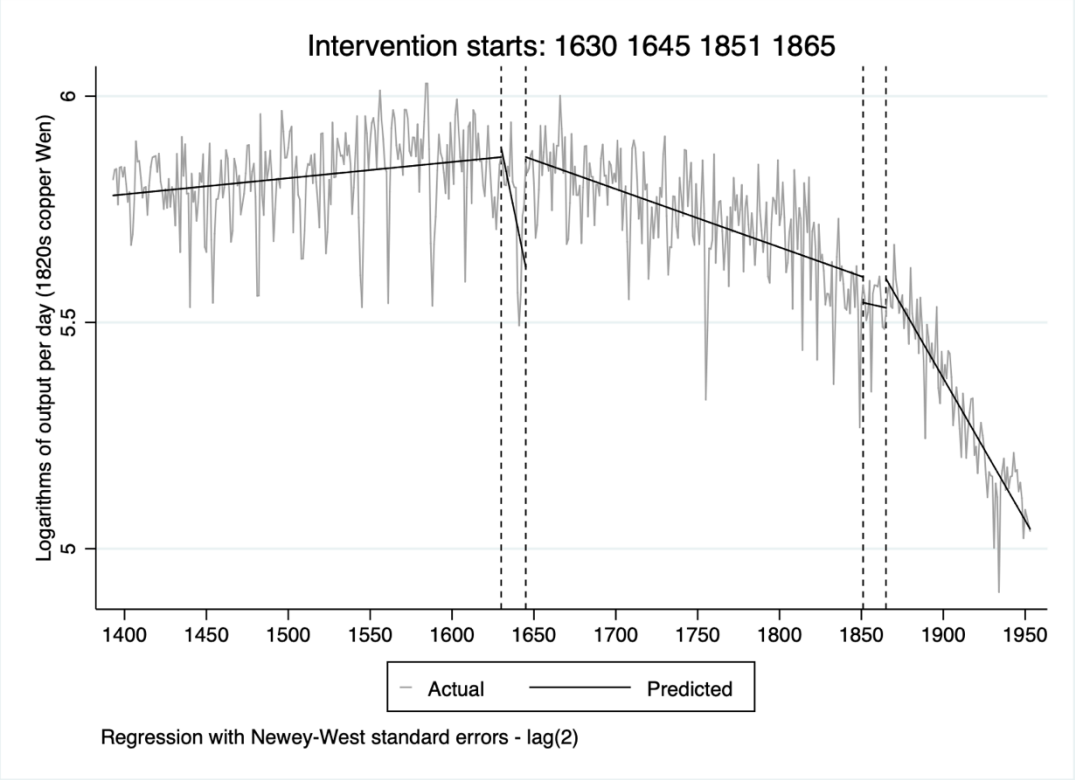

Figure 3.7 Agricultural output per workday in the Yangzi Delta, 1393-1953
Sources: see the text.

$$Y_t = \alpha_0 + \alpha_1 (t - 1393) + \sum^{m} \beta_m DU_{m,t} + \sum^{m} \gamma_m DT_{m,t} + \varepsilon_t$$

where Y_t refers to agricultural labour productivity in logarithmic form; α_0 and α_1 are used as the level values and slopes of the control group up to the first structural breakpoint 1630; *t* represents the year, while (*t-1393)* denotes the number of years away from the initial time. *m* denotes several different structural breakpoints in the equation, representing 1630, 1645, 1851, 1865, respectively. $DU_{m,t}$ represents the dummy variables for the different structural breakpoints. In simple terms, $D_{m,t}$ is equal to 0 when *t* is before a structural breakpoint *m*, or 1 otherwise. β_m is therefore used to describe the difference between the intercept after the structural breakpoint and the intercept of the previous periods. Correspondingly, it is easy to understand that $DT_{m,t}$ are the dummy variables representing the slope of (*t-1393)* after different breakpoints. ϵ_t is an AR(2) process.

Table 3.7 Segmented regression for agricultural labour productivity in the Yangzi Delta

	Coefficients	NW std. err.	T statistics	P-value
Years since 1393	0.000	0.000	3.510	0.000
DU1630	0.022	0.037	0.580	0.560
DT1630	-0.018	0.006	-2.880	0.004
DU1645	0.243	0.075	3.240	0.001
DT1645	0.016	0.006	2.620	0.009
DU1851	-0.057	0.028	-2.000	0.046
DT1851	0.000	0.003	0.160	0.875
DU1865	0.064	0.032	2.020	0.044
DT1865	-0.005	0.003	-1.780	0.076
Constant	5.780	0.012	485.250	0.000

Sources: see the text.

Table 3.7 displays the regression results. Combined with Figure 3.7, agricultural labour productivity in the Yangzi Delta showed a slight increase or no decrease during the Ming Dynasty but a sharp decrease during the Qing Dynasty. This Ming productivity increase may indicate a weak escape in the "Involution". One of the few Ming Dynasty output per capita studies shows that GDP per capita did not decline as much as in the Qing Dynasty (BGL, 2021). There was no decline in agricultural output during the Ming in the Yangzi Delta because cash crops and double cropping were not as common as they were during the Qing. This is not surprising. Double cropping and cash crop expansion were new agricultural practises, but their impact on improving input-output efficiency or productivity did not show obvious differentiation from traditional production models.

Let us now perform a more detailed calculation to determine why. We know from the previous section's value-added calculations that wheat, the most important crop in double-crop rice, and cotton, the principal cash crop, did not have a higher output value than rice for the same area of land. Even wheat had a significantly lower output value than rice. Growing wheat earned only a fifth of what rice earned in the Qing Dynasty, while cotton, a highly prestigious local crop, earned roughly 1.5 times as much. But Table 3.6 shows that wheat and rice had similar labour inputs. Even with the lowest

labour input of 6-7 days, wheat input-output efficiency was much lower than rice's. This is also true for cash crops, where labour input was high but returns were low. These crops had lower labour productivity compared to rice. Thus, the new agricultural changes did not increase labour productivity and might even decrease it.

Overall, cash crops required more labour than rice did, and double cropping utilised the same amount of labour but produced much smaller returns. As long as cash crops and double cropping did not develop too quickly, agricultural output per workday would not fall. Long-term yields per Mu increased throughout the Ming and Qing Dynasties, making labour productivity increases possible. Despite the Little Ice Age, agricultural technology appeared to have played a role in the Ming Dynasty. However, we must be extremely cautious in determining whether the "Involution" was already overcome. Agricultural output per workday increased or at least did not decrease. This is a commendable achievement in a pre-modern economy, but when linked together throughout the Ming and Qing Dynasties, it would seem to have been unsustainable. The decline of the Qing period completely erased the modest growth of the Ming period. The introduction of large quantities of cash crops, as well as double cropping, made it hard for labour productivity to increase. By 1850, labour productivity had dropped significantly from the 1400s. The stagnation in labour productivity was still present when the Ming and Qing Dynasties were considered as a whole.

Beyond peacetime, local labour productivity declined differently in two major historical events. Local agricultural productivity stabilised during the Taiping Rebellion in the Qing Dynasty. However, the late Ming appeared to have followed a different pattern. Agricultural productivity fell precipitously. Indeed, this suggests that the two dynasties' final crises might have been different. The rebellion at the end of the Qing Dynasty was more of a social issue than the Little Ice Age's impact on agricultural production at the end of the Ming Dynasty. This suggests that a climate-induced economic collapse may have caused the Ming regime's collapse. The Qing Dynasty was different in that climate was not the primary cause of the chaos at the time. This may have aided its defeat of

one of China's largest rural uprisings. Overall, looking at the labour productivity of the Ming and Qing Dynasties, there was not a labour productivity surge like the one witnessed in the British economy after the 17th century.

3.3.2.2 TFP

But it does not necessarily mean that the agricultural economy model in Yangzi was inherently "negative". In fact, the reality may be more complicated. Labour productivity is just one aspect of overall productivity. The lack of growth in labour productivity does not necessarily imply a lack of growth in total factor productivity, a commonly used indicator for assessing innovation or technology. Next, I examine the so-called "input-output efficiency" or the Total Factor Productivity (TFP) in the Yangzi agricultural economy. TFP will provide a more comprehensive assessment of the role of "new things" in Yangzi beyond labour productivity.

Capital input is often the biggest issue with direct TFP calculation. But in agriculture, the issue is more manageable. In pre-modern agricultural farming, land was more important than power and fertiliser. Livestock use was uncommon in the Yangzi Delta and throughout China (Li, 1998, 2010b; Perkins, 1969). This means that even if there is an error in the capital input calculation, the impact on the final conclusion is minimal. So what exactly happened with regard to capital input?

Assuming capital input grew in line with land growth, this produces the lowest capital bounds. This is because there is widespread agreement amongst qualitative sources that fertiliser would have been the single most important increase in capital input in the Yangzi Delta. Given the increased use of double cropping, there is no doubt that fertiliser input per plot increased over time. Since fertiliser input might be one of the fastest-growing factors for capital input in the region, the rate of growth of cultivated land should not be too problematic as a floor for capital input growth. Perkins (1969) bases his capital input bottom line on water project growth, which is slightly higher than land

growth. He contends that the slower growth of water projects may serve as a sort of lower bound when compared to inputs such as fertiliser, which were assumed to grow in tandem with population growth in his book. In order to provide wider tolerance intervals, I am continuing to use land as the lowest bound rather than water infrastructure.

The next section talks about upper bounds. When discussing the fertiliser revolution in this chapter, I also suggest that the growth of fertiliser input in the Yangzi Delta was very much related to double cropping, and that one important source driver behind double cropping was the decreasing land per capita. In other words, the increase in fertiliser was most likely intended to prevent a decline in agricultural output per capita. Then, fertiliser per capita should change little. This matches Perkins' population-based capital growth ceilings. Historical evidence shows that capital input to Chinese agriculture began almost exclusively after collectivisation in the 1950s (Zhai and Lou, 2022). It is therefore reasonable to assume that prior to this time, capital input growth in traditional agriculture was somewhere between population and land growth.

Of course, aside from the aforementioned, there is also a setting for capital input under the hypothesis that capital grew proportionally to output, that is, that the capital-output ratio was stable over time. It comes from Kaldor's (1961) "stylised facts" about economic growth, based on data from the last two centuries or so. This assumption also holds in the case of Britain from 1350-1870 (Broadberry, 2022). I will also adopt this assumption.

The land data comes from Chapter Two. When calculating TFP, I include double cropping acreage. The "ghost" land from double cropping is clearly an important land input. For capital input, I use the previously mentioned upper and lower bounds, as well as Kaldor's assumption. There is no good reference for factor shares. For comparison, I use Perkins (1969) and Liu and Hwang (1979), who set labour, land, and capital contributions at 0.6,0.2, and 0.2. Table 3.8 displays the TFP of Yangzi Delta agriculture.

Table 3.8 Growth accounts of the Yangzi agriculture economy, 1393-1953 (% per year)

	Y	L	S	K1	K2	K3	TFP1	TFP2	TFP3
1393-1500	0.16	0.06	0.02	0.07	0.01	0.03	0.01	0.07	0.05
1501-1600	0.08	0.06	0.02	0.07	0.01	0.02	-0.07	-0.01	-0.02
1601-1700	0.04	0.06	0.02	-0.05	0.01	0.01	0.01	-0.05	-0.05
1701-1800	0.06	0.09	0.04	0.08	0.01	0.01	-0.15	-0.08	-0.08
1801-1900	-0.86	-0.30	-0.10	-0.13	-0.09	-0.17	-0.33	-0.37	-0.29
1901-1953	0.05	0.40	0.13	0.21	0.10	0.01	-0.69	-0.58	-0.49

Sources and notes: For data, see the text. The labour, land and capital shares are set at 0.6, 0.2, 0.2 and the production function takes the classical neoclassical growth form. Y, L, S refer to output growth, growth due to labour and growth due to sown area, respectively. K1 refers to capital growth at the upper bound, proxied by population growth. TFP1 is lower bound TFP growth. K2 is capital growth at the lower bound, proxied by land growth, and therefore TFP2 is upper bound TFP growth. K3 and TFP3 are results from Kaldor's assumption, which states that capital input grew in line with output.

TFP growth had been negative for most of the period, regardless of the form of capital growth, indicating that there had been no substantial gains in the input-output efficiency. Traditional factors like labour and land drove agricultural growth. Local agricultural total factor productivity growth peaked in the 15th and 17th centuries. The 17th century is well understood, owing largely to the second half of the 17th century's climatic easing. As shown by the harvest grades for this chapter's four observing stations in the Yangzi Delta, gazetteers reported many good harvests in the late 17th century. However, TFP growth turned negative again after the 18th century. The 15th century might not have had much to do with the weather, at least based on the gazetteers' depiction of the local climate. The increase in crop yields per plot was, however, a relatively simple achievement during this time period. The fastest growth in rice yield per plot after 1400 might have occurred in the 15th century, not the 18th century as previously thought. No details are available on what changed in agriculture during this period, but if it was not the weather, it was probably agricultural technology or the 15th century's many good agricultural policies, such as incentives to reclaim land, tax reductions, etc. The late 17th century's agricultural growth may have been partly due to this as well. In Chinese history, a new regime usually started by implementing many pro-agriculture policies.

Despite these positives in the early 15th and early 17th centuries, the TFP's response was not particularly positive, except that it appeared to be better than in other periods. The TFP of these two friendlier periods was actually close to zero. Over centuries of agricultural development, traditional factors grew little. As agricultural output slowed during the Ming and Qing Dynasties, TFP growth would then decline. This stagnation suggests that "new things" like agricultural knowledge, farming techniques, intensification, seasonal labour input, increased crop varieties, etc. did not change local agricultural growth pattern much. In other words, these "new things" may not fundamentally differ from traditional production methods in terms of facilitating productivity improvements. This sets them apart from technological advancements in modern economic growth that significantly enhance input-output efficiency or total factor productivity (TFP).

According to Boserup (1965), population growth may lead to positive technological advancements, and thus agriculture may enter a new stage of development. Yet, population growth also has drawbacks, such as the infamous Malthusian trap. As suggested by the California School, the Yangzi Delta saw many new changes under the pressure of continued population growth, but the negative effects of population growth likely offset these positive factors. In other words, while there is nothing wrong with what the California School regards as novel, it is also true that these innovations had little positive impact on agricultural production in terms of improving productivity.

However, there is another question that needs to be addressed in depth: if these "new things" did not boost agricultural production's input-output efficiency or TFP, does their existence mean that agricultural producers in the Yangzi region were irrational? In fact, agricultural producers' decision to engage in these seemingly trivial "input-output efficiency enhancing" practices is an example of rational behaviour. Yangzi agricultural producers did follow the typical behaviour of rational producers in terms of profit maximisation (e.g., Bray, 1986; Popkin, 1979). When confronted with the prospect of a reduction in per capita income owing to population pressure, Yangzi

agricultural producers had two main alternatives for adaptation: innovating agricultural production methods (such as double cropping) or engaging in more non-agricultural activities (such as textile industry). However, studies by Allen (2009b) and Li (1998, 2010b) show that the income per unit of labour in Yangzi's textile sector was significantly lower than that in agriculture, possibly only one-fourth of the latter. The causes remain unclear now. Ma and Peng (2021, 2022) offer one hypothesis, arguing that one of the reasons could be an oversupply of labour during agricultural idle periods caused by seasonality. Whatever the reasons, we can conclude that agricultural production remained the most profitable option for individual producers in pre-modern Yangzi. On the other hand, while the "new things" that emerged in agricultural production, such as cash crops and double cropping, did not appear to have high input-output efficiency when compared to traditional rice cultivation, they did increase total agricultural output per unit of land or total household income for Yangzi peasants within a year. Despite the fact that it appears to demand more input for the same outcome, this option was sensible as long as agricultural producers made profit-maximising decisions. The rational behavior exhibited by peasant farmers in the Yangzi region can also be observed in other parts of China (e.g., Marks, 1998b; Myers, 1970; Rawski E., 1972; Rawski T., 1989). This is akin to England's so-called "industrious revolution", in which workers worked harder to increase the labour supply and earn more money in a year. In other words, maximising annual revenue had always been the major goal for both English workers and Yangzi peasant farmers.

Figure 3.8 clearly illustrates this logic. We assume that Yangzi peasant farmers did not engage in double cropping or choose labour-intensive industries such as cash crops, and that all land was used for rice farming. In this case, Yangzi farming sectors' output per capita would be 20 percent lower than in the real world over six centuries, as seen in Figure 3.8. If peasant farmers' other production activities remained constant, their annual income would fall by 20 percent. Such calculations are relatively rudimentary and do not account for the influence of other conditions, but it is reasonable to assume that intensification would enhance agricultural output as a sort of thought experiment. Just

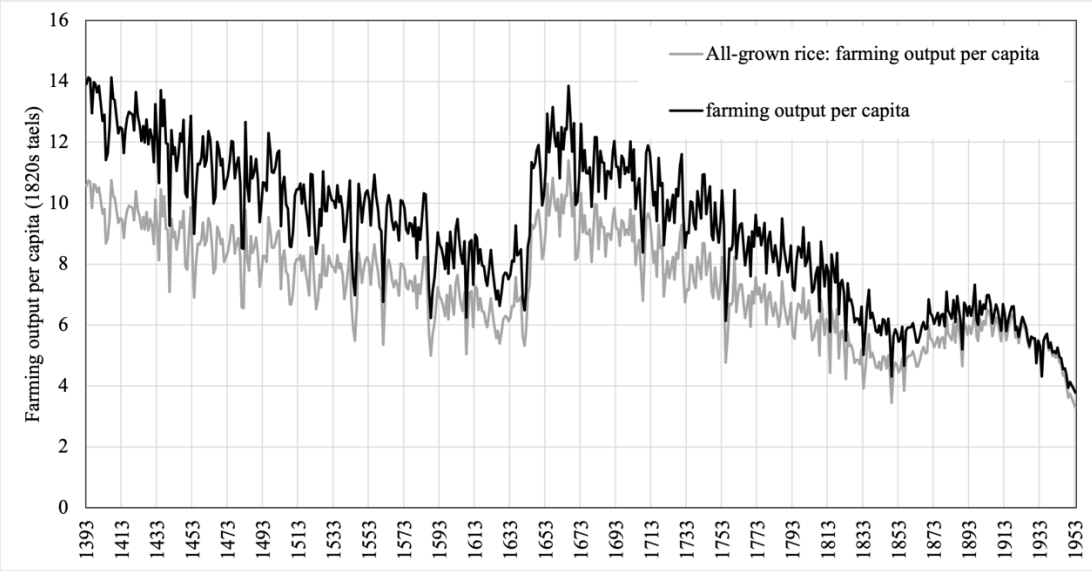

Figure 3.8 A comparison of farming output per capita under the all-grown rice scenario and the real situation in the Yangzi Delta, 1393-1953

Sources: see the text.

cultivating rice required less labour on the same land, labour productivity might be higher in this situation, making the declining trend less visible. However, no rational producer would make such a production decision if peasant farmers were concerned with increasing the total revenue. According to this viewpoint, while these "new things" did not contribute much to increasing labour productivity, they were not as worthless as the Involution School claims. In a time of limited resources, this option significantly reduced the drop in agricultural output per capita. In other words, the "new things" existed and aided in growing per capita output; it is only that their input-output efficiency or the productivity was low, resulting in the "imperfect" trend of stagnant or even declining labour productivity.

In some ways, this could be seen as a reconciliation of the California School and Philip Huang's "growth without development" story: the most important feature for Yangzi's peasant farmers was to create "new things" in order to maximise annual output to the greatest extent possible. "New things" like double cropping did help them maximise output within the resource limits of the moment. According to the California School, it had substantial importance from this standpoint. However, these "new things" contrast

from technological advances in modern economic growth, which result in significant increases in labour productivity. In the long run, relying solely on Yangzi-style innovations in agriculture may be insufficient to embark on the path of modern economic growth. To some extent, the development pattern of Yangzi resembles the narrative of the "high-level equilibrium trap" described by Mark Elvin (1973). Yangzi is neither a stagnant world devoid of vitality nor a true model of modern economic growth (a Britain-like model that aims to save labour and significantly improve labour productivity). If we evaluate Yangzi using pre-modern standards, it is evident that she had maximised output growth under pre-modern levels of resource constraints and labour-intensive technologies; for instance, the per-unit land yield was nearly at the highest level in the world before the introduction of modern fertilisers (Elvin, 1973: 307-308). Therefore, it may be quite difficult to attribute overly harsh evaluations to Yangzi model.

3.4 Conclusion

In this chapter, I examine the Yangzi Delta's agricultural development over several centuries. All objectives are geared toward obtaining a dataset of agricultural output. Thus, I study land productivity, crop variety, double cropping, value-added, and others. Once agricultural output data are available, the classical question can be answered directly. This is the famous conflict between the California School and its critics. My research shows that new agricultural technologies and methods can coexist with long-term stagnation in per-capita and per-workday agricultural output.

However, the question of involution vs. development is much broader than just the agricultural sector. Some California School scholars have recently accepted the possibility of stagnation or per capita decline in Yangzi Delta agricultural development (see Allen, 2009b; Li, 1998). As a result, they have begun to seek new methods of obtaining a picture of long-term economic growth or, at the very least, non-decline per capita. The non-agricultural sector is one major focus. If non-agricultural output per capita grows

rapidly, it can offset the long-term decline in total per capita income caused by agricultural decline. Proto-industrialisation or agricultural seasonality (Ma and Peng, 2021, 2022) might compensate for the agricultural sector's decline by developing the non-agricultural sector. Idle labour on family farms could be fully utilised to do additional textile work, increasing total annual income. This appears to be similar to British "industrious revolution", in which income was increased by increasing labour supply (e.g., Koyama, 2012; de Vries, 1994, 2008). However, all this requires that the non-agricultural sector grow significantly more than the agricultural sector, which requires a major structural change in the economy. Due to a decline in agricultural output per capita, total output per capita would decline even if non-agricultural output did not. That is, if the new changes in the non-agricultural sector that these scholars believe were efficient, we should see a dramatic structural change in the economy. Is this correct? In the next chapter, this question is examined.

CHAPTER FOUR: INDUSTRY AND SERVICES

4.1 Introduction

How did the Yangzi Delta's non-agricultural sector evolve over time? This question is crucial to understanding the local economy's growth. We know that Yangzi Delta agricultural output per capita declined over time. A significant structural change in the economy is required if we do not anticipate a decline in total output per capita. This would require steady growth in non-agricultural output per capita.

Intuitively, the Yangzi Delta appeared to have undergone a significant commercialisation process after the 14th century. For example, numerous studies describe the rapid growth of "market towns" during this period (e.g., Chen, 2017; Dai, 2017; Elvin, 1973, 1977; Fan, 1990, 2005; Fan Y., 2002; Liu, 1987; Luo, 2010; Skinner, 1977; Wang and Chen, 2017; Wang W., 1999; Yao, 2017). These towns are regarded as important indicators of the changing structure of the local economy. What should not be overlooked, however, is that the local population also doubled once. It is not uncommon for simple population growth to result in an increase in urban settlements. We should consider the total population growth when discussing local urban population growth, that is, the so-called urbanisation rates. Real structural change occurred when the "new changes", like urban population growth, which represent non-agricultural sector changes, grew faster than the population. To put it another way, the advent of "new changes" does not ensure the outcome of per capita growth. The "efficiency gains" (per capita growth) achieved must still be carefully analysed.

This chapter examines Yangzi non-agricultural output per capita and economic structure. I approach these questions in two ways. First, various non-agricultural sectors' output and urban population growth are compared with total population growth to

confirm that no sector or urban population was likely to considerably exceed total population growth. The former discusses long-term trends in non-agricultural output per capita. The latter refers to possible economic structural changes if the urbanisation rate changes are used as a proxy for economic structural changes. The essence of this approach is demonstrated in early works by Wrigley (1985) and more recent studies on historical economic growth accounting (e.g., Álvarez-Nogal and Prados de la Escosura, 2013; Malanima, 2011) by utilising variations in urbanisation rates to infer changes in the share of non-agricultural output in GDP. In other words, if the income disparity between urban and rural populations remained relatively stable over the pre-modern period, variations in urbanisation rates could reflect movements in the non-agricultural sector's share of total GDP, a phenomenon known as economic structural change. Returning to the Yangzi region, the lack of a discernible change in urbanisation rates may signal that there was a minimal long-term change in economic structure. In other words, assuming there was no significant change in economic structure, non-agricultural output growth would be in line with that of the agricultural sector, resulting in a long-term drop in non-agricultural output per capita similar to that of the agricultural sector. Second, with the qualitative and indirect evidence as the reference, I estimate non-agricultural output directly to provide precise quantitative evidence. Both discussions find that Yangzi Delta non-agricultural output growth did not exceed population growth. So while there might have been a weak trend in the structure of the economy favouring the non-agricultural sector (as long as non-agricultural output per capita grew faster than agriculture), total output per capita must have declined in the long run.

4.2 Non-agricultural development in the Yangzi Delta after the 15th century: a snapshot

4.2.1 Production of non-agricultural sectors

Table 4.1 Development of industrial sectors described by LI Bozhong, 1620-1850

Category			Output	Labour
Light industry	Textiles	Cotton cloth	50-100m Pi	1.7-3m
		Silk cloth	around four times	35-170k
	Food	Grain processing	growth in line with population	
		Winemaking	growth	
		Tea making	growth	
		Food processing	growth	
		Salt	1700: 50k ton; 1931: 37k ton	
		Oil pressing	1.4-1.55m ton	28-31k
	Clothing		growth	
	Tobacco		growth	
	Daily groceries		growth	
	Paper making		growth but slower than population	
	Printing		growth	
Heavy industry	Toolmaking		growth in line with population	
	Construction		growth but slower than population	
	Shipbuilding		0.6-6.4m taels (nominal) (1.41-6.4m in 1840s tales)	3.5-8.75k
Energy			growth but slower than population	

Sources and notes: Data are taken from information in various chapters of Li's (2010a [2000]) book. Output and labour, where no time is specified, refer to growth from 1620 to 1850. For the shipbuilding industry, Li gives nominal prices, which I have roughly translated into 1840 constant-price silver using Broadberry, Guan and Li's (2018, 2021) price index.

LI Bozhong has extensively studied the Yangzi Delta's industrial development between 1550 and 1850 (Li, 2010a [2000]). Li exhausts almost all local historical records of the industrial sector and finds that most industrial products grew from the 16th to the 19th century. However, since there is little quantitative evidence, Li's conclusions can only

conclude that these products' output was growing. Little is known about growth rate. As I just explained, population growth often leads to industrial or non-agricultural growth, which does not help us understand structural changes in the local economy. However, we can still check the situation in sectors widely considered to be growing faster. The non-agricultural sector as a whole would not be growing faster than the population if these faster-growing sectors did not significantly outpace population growth.

Table 4.1 summarises the shifts in the Yangzi Delta's industrial sector from 1620 to 1850 according to Li's book. Industries are classified into three types: light industry, heavy industry, and energy. Light industry has seven subsectors and heavy industry three. Despite Li's best efforts to find data on output changes, only five industries—cotton cloth, silk textile, salt, rapeseed, and shipbuilding—provide simple estimates. Many of these results come from Li's indirect estimates based on consumption and exports. For instance, Li assumes a constant local per capita consumption of cotton in order to estimate local consumption of cotton cloth by simply counting the population. Next, Li adds the cotton cloth consumption to cotton cloth exports estimated to get the total cotton cloth output. Additionally, certain outputs can be roughly estimated by the local labour force's size under the assumption of constant productivity. However, labourer counts are rarely available. For industries with even less information, Li can only make broad judgements about their output based on qualitative evidence. In this case, the table can only show very rough descriptions of "whether there was growth" or "how it compared to population growth". Such information is useless for long-term output data construction. But it can provide important background information on the local industrial sector during most of the Ming and Qing Dynasties.

In general, the Yangzi Delta's industrial sectors had been expanding from the Ming to the late-Qing periods. Growth in the textile industry in particular was consistent with the region's favourable reputation among its Chinese counterparts. However, Li's

survey suggests that most industries' output growth did not significantly outpace population growth. In other words, industrial output per capita likely changed little over time.

Even the rapidly growing and important local cotton industry did not outpace population growth too much. Li estimates 1.3 million cotton cloth workers in 1620 and 3 million in 1850. Li's count of Yangzi Delta's total labour force shows an urban labour force of 1.2 million in 1620 and 2.9 million in 1820, and a rural labour force of 6.8 million and 11.5 million in both periods (Li, 2010a [2000]: 326). With 1.3-3 million workers, the Yangzi Delta's cotton cloth industry was likely the largest non-agricultural industry. Thus, cotton cloth industry output largely influenced industrial sector output. Li's results show that local cotton cloth production roughly doubled from 1620 to 1850, slightly higher than the 20 to 36 million population growth he predicts. Rice milling, oil pressing, and construction were the region's second-largest industries after cotton cloth, and they grew in line with per capita demand most of the time. Given that many of the remaining industries grew at about the same rate as the population, it is likely that the industrial sector as a whole grew at about the same rate, or at least the deviations did not seem to be too great.

Shipbuilding and silk are the only sectors where output growth exceeded population growth significantly. Given the small size of these two sectors, their growth was unlikely to have a major impact on the industrial sector. The 1820s agriculture value-added was 277 million taels, as calculated in the previous chapter. Silk and shipbuilding produced 15 million and 6.4 million taels, respectively (Li, 2010a [2000]: 32, 204). The net output of the silk cloth industry was about 36 percent of the total (Ou, 2017 [1945]: 406-409), while Li (2010a [2000]: 175) estimates the Yangzi Delta's share of shipbuilding in the 1820s at 44 percent. As a result, the value-added of silk and shipbuilding accounted for 3 percent of agriculture. According to Li, economy in the Hua-lou region in the 1820s was structured so that agricultural and industrial value-added were roughly equal, so silk and shipbuilding would have accounted for no more than 3 percent of

industrial value-added. Even if we conservatively set industrial value-added at 50 percent of agriculture, these two industries would have contributed no more than 6 percent of the overall industry. Compared to cotton cloth's 25.46 million taels of added value calculated by Li, 9.2 percent of agriculture or 18.4 percent of industry, silk and shipbuilding had little impact. It is also worth noting that, at a time when most industrial industries were expanding, another industry, the hemp textile industry, was contracting. This industry, which might have provided daily clothing for many Yangzi Delta residents in the early Ming Dynasty, nearly vanished in the late Qing Dynasty. This industry declined because cotton replaced hemp in everyday clothing. Given this clothing change, the textile sector would have grown much slower. In sum, it appears that we can rest assured that local industrial growth did not significantly outpace population growth and might not fall too far below it, either.

The services sector has little information and is less clear-cut than the industrial sector. However, output growth rates should be similar to population growth since most pre-modern services sectors were heavily dependent on population growth (BGL, 2018, 2021; Broadberry et al., 2015). Since trade, commerce, and other parts of the services sector were highly correlated with agriculture and industry, growth rates in those sectors could limit services sector growth. This means that the service sector's growth was likely to be below the population growth. Given that the share of the service sector in the pre-modern period was generally no less than that of the industrial sector, there is a high likelihood that output growth in the Yangzi Delta's non-agricultural sector did not exceed or was even lower than population growth. Thus, output per capita for the economy as a whole appeared unlikely to rise in the long run.

4.2.2 Economic structural change: urbanisation rates

We can also look at evidence from structural changes in the economy to support these conclusions. Urbanisation rates as long been used as a proxy for economic structural change (e.g., Álvarez-Nogal and Prados de la Escosura, 2013; Malanima, 2010;

Wrigley,1985). If the urbanisation rates does not change, the economic structure probably may not either.

4.2.2.1 Defining cities in Chinese history

However, what constitutes a city and how to define urban population have always been complex topics. Although there appears to be a somewhat vague consensus that a "city" is generally a densely populated settlement with a large population, predominantly non-agricultural, and a high diversity of non-agricultural occupations (de Vries, 1984: 10-13), the concept of "city" in different countries and regions is often not exactly the same. In general, within the aforementioned consensual concept, there are roughly two different perspectives for defining a city. One is population-based, whereby a settlement with a population exceeding a certain threshold is considered a "city". The other perspective focuses on occupational structure and emphasises a settlement where the majority of residents are engaged in non-agricultural occupations (Chao, 2006: 2). In practice, these two definitions can be highly ambiguous in different countries or regions. For instance, in terms of population size, the standards can range from 2,000 to 10,000. The consequences of different definitions may significantly affect conclusions regarding urbanisation rates or may have almost no impact at all, as it depends entirely on the share of different-sized cities within a region (Allen, 2000; Xu, van Leeuwen and van Zanden, 2018, XLZ thereafter). As I will mention later in the text, in the Yangzi Delta, the urbanisation rates obtained using the 2,000 or 10,000 thresholds may differ only slightly. In other words, the small cities in the Yangzi region during the Ming and Qing Dynasties did not seem to have a large population. The criterion of the share of the non-agricultural population can also lead to unpredictable results. For example, defining a "city" based on a share of non-agricultural occupations as either 50 percent or more than 90 percent may yield completely different outcomes. The former may include many areas that are not quite like "cities", while the latter may be too "urban". Even defining "cities" based on population and occupational structure is already the least controversial. If we consider more complex criteria such as market networks, defence, legal centres, etc., it

may become impossible to compare urbanisation rates across different cultural regions of the world. For instance, CHAO Kang argues in his renowned research on urbanisation in China that, based on Max Weber's description of European cities, one could even argue that China has had no cities in its history (Chao, 2006: 1).

However, even if we consider only population size and the share of non-agricultural population as criteria for defining a city, the "cities" identified based on these criteria in China and Europe do not appear to be the same. Compared to Europe, the biggest challenge for the calculation of urbanisation rates in China is that there has never been any official or legal definition of a city. When comparing the definitions of cities in China and Europe, XLZ points out that "[I]n contrast to Europe, where cities were clearly defined in both legal and geographical terms, in China this was not the case... In China, unlike Europe, no legal designation of the city as a separate entity existed. Originally, in China cities were built for, and serve as administrative and military centers."

In general, geographical units depicted in historical publications in China often originate from the central government's administrative design. The system of prefectures and counties, established during the Qin Dynasty around the 2nd century BCE, laid the foundation for the basic administrative regions in China for approximately 2,000 years. Under this system, there was initially a capital administrative region as the seat of the central government. The next level of administrative units were generally provinces, each with a regional capital where the provincial government was located. Below the provinces, there were prefectures or counties (sometimes the provinces directly governed the counties, but during the Ming and Qing dynasties, there was an administrative unit called a prefecture between the province and the county). Similarly, these administrative units had their own seat of government. The lowest level of centrally appointed officials was generally at the county level. Although there were some administrative units below the county level, for a long time they did not have officials sent by the central government. In the pre-modern design of administrative regions in China, there

were generally 1,000-2,000 counties nationwide. Counties were the smallest units among the various levels of administrative units in China, with centrally appointed officials, but each county usually had tens of thousands of people scattered over a large area, residing in central districts, peripheral areas, and smaller dispersed settlements. Therefore, it seems that we cannot compare counties as individual "settlements" to Europe. In other words, considering the fact that pre-modern China had a population of over 60 million and a maximum of 2,000 county-level administrative regions, if we define "cities" based on counties as the basic settlements combined with population size, then almost all counties in China would be considered "cities". However, it is evident that such a definition is not helpful for understanding the essence of urbanisation. Moreover, there doesn't seem to be a unified definition of how to divide the smaller settlements within counties. For example, below the county level, there are sometimes population settlements referred to as "Tu (图)" or "Zhen (镇)", and of course, these "Tu" or "Zhen" areas may also contain several smaller settlements, such as villages. Clearly, we cannot take villages, which may have only a few hundred people and represent extremely small-scale settlements, as the basic units of settlement.

Hence, following the approach pioneered by Skinner, Chinese demography historians often define "cities" in China by adhering to this treatment, wherein the seat of government in each administrative level is generally considered a "city", while other areas outside of these regions are labeled as rural unless they have special large-scale non-agricultural settlements such as market towns (meeting the criteria of having a non-agricultural population share exceeding half or 70 percent and a population size of 1,000 or 2,000 or more) (e.g., Cao, 2000, 2001, 2018, 2022; Chao, 2006; Elvin, 1973, 1977; Skinner, 1977; XLZ, 2018). This definition essentially encompasses two layers of meaning. First, it defines all seat-of-government locations as "cities". Secondly, it employs occupational structure as the main criterion for determining whether settlements with a certain population threshold outside of these administrative centres can be classified as "cities".

The setting of the first layer of meaning primarily stems from the fact that the locations of local governments were clearly defined by the authorities. One example of this is that city walls surrounded the small areas where the majority of local governments were located for a very long time. Another manifestation is evident in the administrative design of the central government, where these locations of local governments were given different designations than other areas. For example, in gazetteers, we can find distinct terms such as "Fang (坊)" and "Li (里)" with the former primarily referring to the areas where local governments were located, while the latter often encompassing other regions. Generally, the residents in these locations of local governments consisted overwhelmingly of non-agricultural labourers. Farmland and agricultural populations within the city walls were very scarce. The substantial non-agricultural population inside these city walls relied heavily on support from agricultural sectors outside the region to survive. From this perspective, these locations of local governments, which are typical "cities" as defined in Chinese demography history research, are very similar to cities in Europe, especially Western Europe, although Chinese "cities" show a stronger administrative centre characteristic.

However, the greatest divergence in defining cities between China and Europe lies in the areas beyond the locations of administrative centres. Specifically, at a lower level than the county-level seats of government, there were actually areas that can be referred to as "cities", such as the mentioned market towns. These market towns also served as major economic and commercial centres within their regions. Although they might lack the presence of centrally appointed officials and might not function as defence or legal centres, these areas are characterised by a significant concentration of non-agricultural populations. As a result, Chinese demography historians have defined these areas as the lowest level of cities. The hierarchical definition of cities in China thus results in the use of population thresholds for calculating the "urban population" that commonly range from 1,000 to 2,000 individuals, which is entirely different from the commonly used thresholds of 5,000 to 10,000 individuals in Europe. This is because the population size of most market towns is below 5,000 individuals. In other words, the design of

China's urban criteria appears to aim at inclusivity, ensuring that settlements with a substantial share of a non-agricultural population are not excluded from the definition of cities. Consequently, the minimum population threshold for defining a "city" becomes quite small. In contrast to some European cities where more than one-third of the population may engage in agriculture, the share of non-agricultural population included in the definition of urban population in China is likely to be higher. In most cases, the share of agricultural population in urban populations above the level of market towns was very low, sometimes even below 5 percent, based on occupational surveys of urban populations in the early and mid-20th century (Jiang, 2013; Population Statistical Compilation of the People's Republic of China, 1988) as well as scattered evidence from the Qing Dynasty (XLZ, 2018; Xu, 1998a, 1998b). In fact, Li (1998: 22-24; 2010b: 45) even disregards the non-agricultural population in urban Yangzi populations. The share of non-agricultural population in market towns with a population size of around 1,000 or 2,000 is mostly around two-thirds, and at the minimum, it would exceed 50 percent[30].

In other words, in the second layer of China's urban definition, cities are not defined solely based on the population size of settlements. Therefore, it cannot be assumed that China's urbanisation rates, calculated based on settlement size, would be lower than those of Europe. A study by LU Weidong (2015) reveals significant differences in the national urbanisation rates when using different criteria, including settlement size and occupational structure, respectively, for regions below the county level. For instance, if a threshold of 1,000 residents is used, the average urbanisation rates for several provinces in northwest China after the 19th century would be 53.6 percent. However, considering a criterion that includes settlements with a population of over 1,000 and a majority non-agricultural population, the average urbanisation rates for the same regions could be around 10 percent or even lower. Therefore, while China's urban population

[30] The reason for choosing 50 percent as the bottom is primarily due to the lack of formal occupational surveys in pre-modern China, but various scattered evidence and modern surveys indicate that the share of the non-agricultural population in those renowned commercial and industrial centres (market towns) is at least above 50 percent, which is acceptable to some extent.

definition takes into account both settlement size and occupational structure, it clearly leans towards defining cities based on occupational structure. This means that even if scholars attempt to adjust China's urban definition to the commonly used European standard of 10,000 residents, the resulting urbanisation rates would likely be incomparable to those in Europe. In XLZ's (2018) study on urbanisation rates in China from the 11th century to the early 20th century, they first calculate urbanisation rates following the aforementioned definition of Chinese cities established by Skinner and then attempt to adjust settlement size to the "European standard" of 10,000 residents. They find that the urbanisation rates in the Yangzi Delta region hardly decrease after this adjustment, only declining by 2-4 percent, while the previously calculated rates are approximately 19-25 percent. However, the overall urbanisation rates for China drop from 7-12 percent to 4-5 percent with this change in criteria. Yet, such adjustments merely involved excluding smaller settlements from the original urban definition. This inevitably results in lower "urbanisation rates" when based on a population threshold of 10,000 residents. However, if one strictly adheres to a population size criterion of over 10,000 residents without specifically considering occupational structure, the resulting "urbanisation rates" could be higher, as attempted by Lu as mentioned earlier. The challenge, however, is that such adjustments may be difficult to implement in pre-modern contexts because, as mentioned earlier, the definition of "settlement" is challenging in the Chinese context. Additionally, due to the lack of finer-scale government population statistics, we cannot determine the population size of each specific "settlement" beyond the government seats, even if we provide a definition of "settlement". Therefore, the definition of urbanisation rates by Chinese population historians is essentially a compromise based on the availability of historical materials. This defined urbanisation rates can be understood as a cautious approach that considers the population of government seats and well-known non-administrative commercial or market centres outside these seats as "urban population". In other words, to some extent, it leans towards the information displayed by the occupational structure.

In summary, the lengthy explanation above regarding the definition of urbanisation rates in China indicates that, due to its unique cultural background and data availability, China's urban definition may not lend itself well to direct comparison with Europe. The absolute values obtained under the two definitions do not appear to measure exactly the same thing. One possible comparison is to include only those uncontested "cities" in the calculation. For example, XLZ also conduct another extreme adjustment by comparing only the population share of China's and Europe's primate cities. They find that such a calculation of the "urbanisation rates" shows China to have had a much higher value than Western Europe before the 18th century. It was not until the 17th century, which aligns surprisingly with the Great Divergence timing discussed by my research, that China lagged behind Western Europe. However, this approach has obvious limitations as it overlooks small but rapidly developing cities. Therefore, overall, cross-national comparisons between China and Western Europe in terms of urbanisation rates require further careful consideration in the future.

However, despite the differences, the definitions of cities in China and Europe actually share more similarities than differences. They both fundamentally reflect the geographical clustering of regional economic activities, particularly non-agricultural activities. Therefore, while the urban definitions in China and Europe may have significant differences that make it difficult to compare absolute values, considering longitudinal comparisons within the same country or economy may be appropriate. In other words, although China's definition of urbanisation rates differs from those of Europe, the "urbanisation rates" in the context of China can reflect meaningful economic structural changes over several centuries. Based on the previous explanation of calculating China's urbanisation rates, it is evident that China's "urban population" is more inclined towards the non-agricultural population (although not entirely equivalent to the non-agricultural population), thus making it more capable of reflecting long-term changes in economic structure to some extent, assuming a stable difference in labour productivity between agriculture and non-agriculture. Therefore, this definition, although deviating from conventional or European definitions, does not hinder the analysis in this

chapter. Of course, it should be noted that this type of "urbanisation rates" has limitations, as it may not capture the economic structural changes resulting from the development of proto-industry in small settlements, similar to the case of the Tokugawa periods in Japan (Bassino et al., 2019). This point will be taken into consideration when analysing the economic structural changes using the urbanisation rates in the Yangzi Delta later on.

4.2.2.2 Urbanisation rates in the Yangzi Delta

Yangzi Delta urbanisation is generally agreed upon. LI Bozhong's early investigation is consistent with those from CAO Shuji's work (XLZ, 2018). As I mentioned in Chapter Two, Cao's work forms the basis for virtually all of the current consensus estimates of China's population in the literature; in this respect, it is as influential as Wrigley and Schofield's English population history. Cao' 2000 and 2001 books on Chinese population studies detail urban population situation from the Ming to the Qing Dynasties, but they do not clearly describe urbanisation rates. In 2018, his unpublished manuscript provides a table with prefectural-level urbanisation rates in China from 1393-1910.

It is unfortunate that Cao's reconstructed benchmark years for urban population are much fewer than his population data. Cao presents urbanisation rate figures for only four years: 1393, 1580, 1776, and 1910. His database presented ignores many wartime urbanisation rates. However, he also discusses possible wartime urban population changes. Based on Cao's descriptions of population losses during the war and related historical records, it is possible to estimate urban populations before and after the war (XLZ, 2018), albeit crudely compared to his four benchmark estimates. In this way, urban populations for both peacetime and non-peacetime benchmark years can be approximated. Note that Cao defines Chinese urban population as settlements with 1,000 or more non-agricultural people. XLZ have changed Cao's urban population criteria to 2,000. My study recalculates the urban population using Cao's original data and XLZ's adjustment method.

Table 4.2 Urban population and urbanisation rates in the Yangzi Delta, 1393-1953

Year	Urban population thousand	Urbanization rates percent
1393	2,102	19.0
1420	3,065	23.7
1421	2,365	19.3
1580	4,825	22.1
1630	6,038	23.0
1644	4,050	20.0
1645	3,500	22.8
1776	4,717	19.0
1851	6,836	20.0
1865	1,913	15.9
1893	2,382	17.0
1910	2,721	17.4
1936	7,724	34.7
1953	9,861	39.1

Sources: see the text.

In comparison to Cao's original figures, XLZ's recent exploration of urbanisation in China from 1100 to 1900 clearly yields more usable figures. In fact, XLZ's work is still based on Cao's original data. But they have carefully analysed Cao's data and supplemented it with much new evidence from gazetteers and new research to make necessary corrections. XLZ's results clearly outperform Cao's 2000 and 2001 results. However, XLZ does not appear to have referenced Cao's 2018 manuscript's 1910s results. When building the Yangzi Delta's urbanisation data, I rely on both Cao (2000, 2001, 2018) and XLZ (2018). Given that both Cao and XLZ have aspects that are not as strong as the other, I apply the criterion of whose study has cited more and newer materials to determine which figure is better when there are conflicts between Cao and XLZ results. To get continuous data, interpolation methods are needed. I assume that the urban population always increased during peacetime periods, so log-linear interpolation can be applied to the interval between the benchmark years.

The data construction details are as follows. (1) For the Ming Dynasty, XLZ has added new materials to Cao's original data and made corrections. Thus, I refer to their

urbanisation rates estimates for 1393, 1630, and 1644 to calculate the urban population. (2) I use Cao's urban population growth rate from 1393 to 1580 to calculate the urban population in 1580. (3) The decline in urban population that occurred when the Yongle emperor relocated the capital to Beijing in 1421 must be considered. I extrapolate to 1421 using 1580-1630 growth. Removing Cao's (2000: 307) migrant population yields 1420's urban population. (4) The situation after the 1645 war is calculated using Cao's (2001: 23) population loss. (5) For 1776, 1851, and 1893, I use XLZ's urbanisation rates combined with Cao's population data to get the urban population. (6) For 1910, which was not covered in Cao's 2000 and 2001 books, I use his 2018 urban population estimates. He calculates the 1910 urbanisation rates using the number of shops in the 1910s as well as the 1950s census. (7) For the 1910s, XLZ also provides an estimate for 1918. However, I will not be using the 1918 data from XLZ. The data for that year came from a survey of Western missionaries in early 20th-century China (Stauffer, 1922), mostly from self-reports and interviews with local county officials. It is likely that most of the data came from the 1910 national census. Despite the high quality of the data collected by these missionaries, the survey is clearly likely to be an underestimate compared to the 30 percent urbanisation rates obtained from high-resolution military maps in the 1930s (Jiang, 2013). For the ROC period, I prefer Jiang's (2013) high-resolution map results. (8) Jiang's (2013) detailed explorations are also used for the 1950s. Table 4.2 shows my final Yangzi Delta urbanisation data.

4.2.3 Summary

Urbanisation rates show a long-term stagnation picture. If urbanisation rates changes can be seen as a proxy for economic structural changes, the long-term economic structure might be stagnant. The consequences of structural stagnation in the economy might be even more dire than those of per capita non-agricultural output stagnation. If the economic structure remained unchanged, non-agricultural output per capita would decline at the same rate as agricultural output per capita. In other words, the results of the first part of this section's discussion of non-agricultural output per capita and the second

part's discussion of urbanisation can be used as upper and lower bounds on the Yangzi Delta's non-agricultural output per capita growth trend. Therefore, the growth of output in non-agricultural sectors in the Yangzi region should fall between population growth and agricultural output growth.

But there is another issue. The Yangzi Delta's urbanisation rates may not reflect its economic structure. Proto-industrialisation in rural areas would cause the urbanisation rates to underestimate the economic structural changes (e.g., Bassino et al., 2019; Palma and Reis, 2019; Saito, 1983; Saito and Takashima, 2016). This means that if urbanisation rates remain constant over time, the share of local non-agricultural output must rise. However, this does not affect our assessment of Yangzi Delta non-agricultural output per capita growth. Our qualitative analysis indicates that the ceiling for non-agricultural output growth in the Yangzi region is likely to be approximately the same as population growth. In this scenario, the aforementioned issue may only raise the lower bound estimate for the range of non-agricultural output growth, but it should not affect the upper limit estimation. Therefore, it is reasonable to assume that non-agricultural output growth in the Yangzi region was higher than that in the agricultural sector but unlikely to exceed population growth.

Thus, we can draw some conclusions about Yangzi non-agricultural output per capita. That is, non-agricultural output per capita should grow at a rate slightly lower than or equal to population growth in the long run, making it impossible for total per capita income to remain constant or increase in the long run.

4.3 Growth in industry and services: a direct calculation

4.3.1 Industry

Li's detailed description of Yangzi industrial development aids in the formation of a broad intuitive judgement about local industrial growth. The above estimates are

preliminary, but they give us a good sense of where we stand; in most cases, local population growth rates served as a good proxy for local industry growth rates. Based on this reference system, I estimate industry and services output directly.

Before I discuss the industry, I need to lay out the criteria I use to categorise it. In historical national accounts, industry is usually divided into metals and mining, manufacturing, and construction (BGL, 2018) or metals and mining, textiles and leather, and other industries (Broadberry et al., 2015). Depending on the region's materials, these criteria may vary. Since some of the Yangzi Delta's traditional industrial sectors, like metals and mining, were so undeveloped, the criteria for industrial sectors may need to be adjusted. Three categories make up Li's (2010b) Hua-lou industry. The first category of industry is the so-called independent "artisans", who are small-scale individual producers in the manufacturing sector. Second are textiles. The third type of industry is large-scale manufacturing, which includes rice milling, oil pressing, winemaking, cloth dyeing, shipbuilding, salt, construction, and bricks. Classifying industry into large-scale and small-scale sectors is a common practise (Broadberry and Korchmina, 2022). The Yangzi Delta had many individual producers and can be discussed separately. On the other hand, the textile industry was a one-of-a-kind regional industry that had a distinctive growth pattern and standing in the economy. In addition to that, there were producers who worked on a large scale. Therefore, I follow Li's classification of industries. Due to the information and data I have, though, I will talk about the small-scale manufacturing industry first, then the large-scale manufacturing industry, and finally the textile industry.

4.3.1.1 Artisan manufacturing

In the Yangzi Delta, as Li says, independent artisans were common. These were typically self-employed individuals who provided essential services to city dwellers through the application of specialised expertise. Although they could be classified as manufacturing, these people were often distinct from large-scale businesses, not

seeking profit but simply to support their families (Li, 2010b: 82). I agree with Li's idea that the output of this group of artisans grew in line with population, especially the urban population. Based on urban population data and Li's estimate of 2.48 taels of silver per urban population in the 1820s, I can calculate the artisan sector's value-added output in constant 1820s prices for the entire period.

4.3.1.2 Textiles

Cotton, silk, and hemp textiles dominated the Yangzi Delta textile industry. In the Yangzi Delta, the textiles industry, especially cotton, was large and transformative, such as the famous switch from hemp to cotton fabrics. The significant involvement of women in cotton weaving cannot be overlooked. Most Yangzi Delta households had women who wove cotton in the early 19th century. Local proto-industrialization began in this industry. All of this makes the textile industry appear very unique. It makes sense to treat textiles as a separate sector in the Yangzi Delta.

A. Silk cloth

The Yangzi Delta was a major silk cloth production centre in China. During the Ming and Qing dynasties, local silk fabrics were exported extensively to China and abroad (Fan, 2016). Silkworms reared on mulberry trees provide the raw material for the production of silk cloth. As a result, I can speculate on the production of silk fabrics in the Yangzi Delta based on the cultivation of mulberry trees. In the previous chapter, I obtain a detailed production value for mulberry cultivation. I set the growth of silk cloth output in line with the output of mulberry trees. The production value of silk cloth in the Yangzi Delta in the 1820s was 15 million taels (Fan, 2016: 308). The value-added of silk cloth production was approximately 36 percent of the total production value (Ou, 2017 [1947]: 405-408). By combining these data, I can generate a series of value-added for silk fabrics at constant 1820s prices.

B. Cotton cloth and hemp cloth

However, calculating other textile industries' value-added can be difficult. In the cotton cloth industry, not all cotton was used to make cloth. A portion of the cotton was used for everyday purposes, such as fillings for winter garments and quilts, among others. Cotton production could be used to infer cotton cloth production if the proportion of cotton used to produce cotton cloth did not change significantly. During the Ming and Qing Dynasties, however, the Yangzi Delta experienced a famous change in clothing material. In other words, from the early Ming to the Qing Dynasties, the proportion of cotton output used to produce cotton cloth increased. This makes it difficult to calculate cotton cloth using cotton output. According to Huang (2009: 151), less than 80 percent of cotton output in the 1750s was used for weaving. Although it was profitable to process most cotton into cotton cloth, it is likely that a large proportion was not turned into cotton cloth before the 17th century, especially in the 14th century. While it is difficult to say whether the "husband and wife plough together" advocated by LI Bozhong was popular in the late Ming, there is no doubt that it was prevalent in the early Ming. This suggests that by the end of the 14th century, only urban labour produced cotton cloth. Thus, most cotton was not processed into cotton cloth during this time. Hemp cloth was used for a lot of people's everyday clothing. In this case, cotton cloth output estimates based on cotton fields may be overstated. The Republic of China era is a different story. Cotton cloth output estimates based on cotton fields were also underestimated as the Yangzi Delta imported cotton.

I employ a methodology similar to that of BGL (2018, 2021). It presupposes that the textile industry in the pre-modern grew in line with population. In the Yangzi Delta, the rest two sectors of the textile industry most likely appeared as follows: (1) Cotton textile output grew slightly faster than population. (2) The hemp textile industry shrank significantly. In the early Ming Dynasty, many locals wore hemp cloth, but by the mid-Qing Dynasty, the industry had almost disappeared. (3) Cotton and cotton cloth prices fell significantly relative to rice, reflecting the substitution of cotton for hemp cloth at a time when there were few technological changes in the textile industry. If the hemp textile industry's decline is ignored, cotton cloth output growth will exceed population

growth. However, if the hemp textile industry is taken into account, the aggregation output growth of cotton and hemp cloth will slow. Because the shrinkage of the hemp sector was primarily due to cotton cloth's replacement, he aggregation output growth will not be significantly reduced. In other words, given the substitution of cotton cloth for hemp cloth in everyday clothing, it is reasonable to consider the two industries as a whole. As a result, we can assume that the rest textile industry in the Yangzi Delta grew in line with population during the Ming and Qing Dynasties. This corresponds to Li's (2010a [2000]) observations on the textile industry. Despite being the fastest growing, the cotton cloth industry did not outpace population growth by much. Given the gradual demise of the hemp textile industry, the combined output of the two industries should not exceed the population growth.

Western technology and modern factories boosted Yangzi Delta textile production in the early 20th century. According to the data in the previous chapter, cotton cloth prices relative to rice also fell during this period. Urbanisation rates significantly accelerated after 1910. To reflect the growth of the cotton textile industry in the Yangzi Delta during this period, I set the aggregate of the rest industries to grow in line with the urban population after 1910. Subsequent analysis confirms that this corresponds to historical facts.

The next step is to compute the value-added. I cannot use Li's 1820s textile output per capita data to calculate Yangzi Delta's textile industry value-added because Li's Hualou region only produced cotton cloth in the textile industry. However, Huang (2009: 141) states that 75 percent of Yangzi Delta's cotton output was used to make cotton cloth in the 1820s, so I can use cotton as the raw materials to calculate cotton cloth's value-added. Because the hemp textile industry nearly vanished during this time period, I only count the output of the cotton cloth industry as the output of the aggregating textile industry in the 1820s. According to Li (2010b: 348-350), seed cotton to plain cotton cloth value increased by a factor of three, while the value-added of plain cotton cloth production was 67 percent (Li, 2010b: 168). Then I can calculate the cotton cloth

sector's value-added output in the 1820s, using these data and Chapter Three's agricultural results. I can obtain the final value-added series for the entire period of the merged cotton cloth and hemp industry in constant 1820s prices by using the benchmark value-added of the 1820s as a basis, combined with the previously mentioned pre-1910 population growth and post-1910 urban population growth.

The value-added of the textile industry is the aggregation of the above three industries. According to my calculations, the average value-added of the textile industry in the Yangzi Delta from 1393 to 1953 is approximately 29 percent of the value-added of the entire industry. This share increased from roughly 26 percent in the early Ming period to 30 percent in the 1820s and then to 42 percent in the 1930s, reflecting the growing importance of textiles in the industrial sector. Other evidence supports this. According to Li (2010b), Hua-lou's textile contribution to industrial value-added in the 1820s was 30 percent. *The Newly Shanghai Gazetteer, Volume III* (2005: 1872), shows that the local textile industry formed 50 percent of all industrial production value in the first half of the 20th century. As a result, my estimates capture this structural change and are consistent with historical data.

4.3.1.3 Large-scale manufacturing

A. Food processing

Food processing industries, such as rice milling, oil pressing, and winemaking, were closely related to agriculture. But the agricultural output from the previous chapter may not be enough to estimate these sectors' output in the Yangzi Delta. Since the mid- to late Ming Dynasty, local food imports were common (e.g., Deng, 2009; Fan, 1998; Isett, 2007; Jiang, 1992; Li, 1998; Long, 2003; Wu, 2001; Xu and Wu, 1985). As mentioned in the previous chapter, local agricultural output was no longer enough to support daily agricultural consumption, but food consumption per capita did not change (Huang, 2009). The large amount of imported food makes it hard to tell how much of the food processing industry, especially complex ones like oil pressing and winemaking, was

done outside the region. Given the small changes in per capita consumption of these products, I consider the other food processing industries to be growing in line with the population. This is consistent with previous estimates of China's food processing industry output (BGL, 2018, 2021). According to Li (2010b: 183), the food processing industry in Hua-lou produced 2.77 taels per capita in the 1820s. I take this figure and multiply it by the Yangzi population to get food processing value-added output at 1820s prices.

B. Construction

Li divides the 1820s Hua-lou construction industry into ordinary dwellings, commercial, and public buildings (Li, 2010b: 176-182). According to Broadberry et al. (2015) and BGL (2018), the construction output usually grew in line with population. But using regression, Xu et al. (2017) discover that housing in China is actually highly correlated with timber quantity. Per capita timber holdings actually decreased due to ecological degradation caused by population growth during the Ming and Qing Dynasties (Zhang, 2021). Li (2010a [2000]) also confirms that building materials in the Yangzi Delta were scarce from the Ming to the Qing Dynasties. Thus, in the Yangzi Delta, construction output growth should not have exceeded population growth. However, since the Yangzi Delta had a timber shortage and imported a lot of timber from the upper Yangzi River, I set the following growth trends for the construction sector: (1) For ordinary dwellings, I agree with Xu et al. (2017) that its sectoral output grew in line with that of the timber, and thus forest, sector. As a result, I derive this sector from the calculations for the agricultural sector in the previous chapter. According to Li, in the 1820s, the average value of ordinary dwellings per capita in the Hua-lou region was 1.44 taels of silver (2010b). Using this information, I can generate a series of output for ordinary dwellings at constant 1820s prices. (2) Commercial, industrial, and public buildings were generally thought to meet the needs of urban residents and thus followed up with urban population growth. When calculating construction output, BGL (2018, 2021) also adjusts for urbanisation. Given that the Yangzi Delta's substantial imports of building materials tend to prioritise urban construction, I expect commercial, industrial, and public

buildings to grow in line the urban population. In the 1820s, the value of commercial, industrial, and public buildings per capita was 2 taels. Construction added approximately 25 percent to the value (Li, 2010b: 182). Thus, I aggregate the two series to derive the construction industry's value-added output at constant 1820s prices.

C. Miscellaneous large-scale manufacturing

For the rest miscellaneous large-scale manufacturing, there is insufficient direct evidence to estimate output in these industries. However, it is acceptable to treat it as growing in line with population in this case. I detail Yangzi Delta non-agricultural industry growth in the first part of this chapter. Most non-agricultural industries growth did not significantly outpace population growth. Despite its reputation in the Yangzi Delta as a vital and rapidly expanding industry, the cotton textile sector grew at roughly the same rate as the region's population. I therefore set the growth of the remaining large manufacturing industries to match population growth.

In calculating the weights for the 1820s, Li's data show a value-added output per capita of 1.07 taels for these remaining industries. I have yet used Li's data, though. This is because the categories of the residual industries from Li do not correspond to the overall situation in the Yangzi Delta. These industries in the Yangzi Delta were not entirely consistent with Hua-lou. As a result, using Li's data to calculate the value-added weights for the 1820s benchmark may be biased. I refer to Huang (2009: 307-308) for the per capita consumption levels of these residual industries in the entire Yangzi Delta in the mid-19th century. According to Huang,, per capita consumption of these residual industries in the mid-19th century was around 0.58 taels. It was 0.64 taels at 1820s prices, according to price data of Peng (2006). This estimate should be conservative and not overestimate the residual industries' value-added. I can then calculate the value-added output of the remaining miscellaneous large-scale manufacturing for the entire period using the 1820s population and per capita data.

4.3.1.4 Industry in 1937-1945

The calculations above are for long-term trends and may not accurately reflect the Japanese occupation period of 1937-1945. During this time, the Yangzi Delta's industry suffered greatly. The local non-agricultural sector grew rapidly from the late-19th century, with the establishment of many modern factories and financial institutions. These industries were more reliant on trade and globalisation, making them vulnerable to negative shocks. During the Japanese invasion, the local non-agricultural sector was not immediately and severely affected. Instead, as nearby industrial firms moved to Shanghai in search of institutional protection, the existence of the Shanghai Concession caused a historically unprecedented boom in local industry and commerce in 1940. However, with the outbreak of the Pacific War, the Japanese army occupied the Shanghai Concession. Local industry and commerce declined dramatically from 1940 to 1946 as a result of the loss of institutional protection and also an Allied trade blockade. This period saw less population loss than the Ming-Qing Transition and Taiping Rebellion. Thus, if the changes in industrial output during this period are calculated using the method described above, the too-small population loss is insufficient to account for the massive non-agricultural sector shrinkage at this time.

Although detailed industrial output data for this period are not available, I can use the industrial electricity consumption index (Fang, 2018) as a proxy variable for the industrial output index. Since 1908, industrial electricity consumption in the Shanghai area was well documented. However, Shanghai's electricity consumption index may only be a proxy for Yangzi Delta industrial output from 1937 to 1945. One reason for this is that Shanghai was the most industrially developed region in the Yangzi Delta, but it did not represent the entire region. Shanghai's industrial development was likely faster than Yangzi Delta's. Thus, the long period following 1908 was clearly distinguishable between Shanghai and the Yangzi Delta as a whole. However, when the war broke out in 1937, most of the local businesses relocated to Shanghai in search of safety, as I will explain in Chapter Five. During this time, Shanghai was home to most of the Yangzi

Table 4.3 Industry estimation measures

Sector	Measures
ARTISAN MANUFACTURING	Population
TEXTILES	
Silk	Mulberry production
Cotton and Hemp	Population before 1910; urban population after 1910
LARGE-SCALE MANUFACTURING	
Food processing	Population
Construction	Dwellings: forestry (agriculture); commercial & public buildings: urban population
Other	Population

Sources: see the text.

Delta's industry. Shanghai was thus able to represent the Yangzi Delta. Another reason is that in the first half of the 20th century, China's industrial development transitioned from handicrafts to modern manufacturing, and not all businesses used electricity. As more and more businesses in the industrial sector started to use electricity, it is clear that electricity consumption would then grow faster than industrial output in the long run. By the 1930s, this trend had stabilised, so industrial growth and electricity consumption growth were similar. Thus, from 1937 onward, industrial electricity is a better proxy for industrial output. Qualitative sources describe dramatic industrial sector fluctuations during World War II, which matches the changes in industrial electricity consumption (e.g., Fang, 2018; Tian, 1948; Xu and Huang, 1998). Large economic fluctuations in a short period of time caused by the effects of a world war were observed in European countries as well (Maddison Project, 2020). So, for the industrial sector, I use the direct estimation method described above to obtain pre-war long-term trends, and then use the pre-war results as a benchmark to interpolate using the Shanghai Electricity Consumption Index compiled by Fang (2018) to obtain a series of industrial value-added in the Yangzi Delta during WWII.

4.3.1.5 Summary

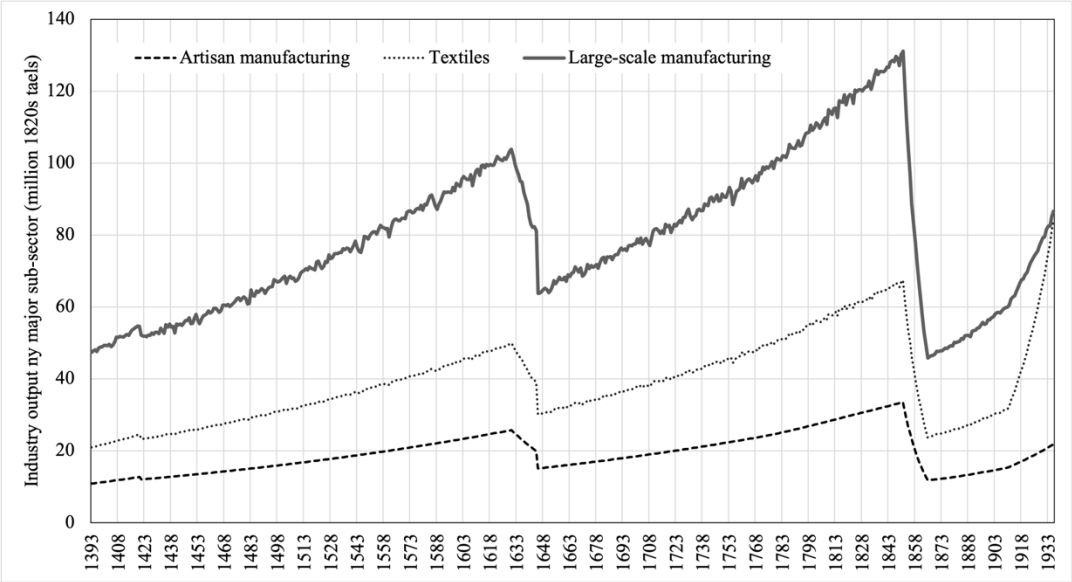

Figure 4.1 Industry output by major sub-sector in the Yangzi Delta, 1393-1936 (million 1820s taels)

Sources: see the text.

Table 4.3 summarises the industrial estimation methods. Figure 4.1 shows the three industry subsectors' value-added series. Because many of my estimates are actually dominated by population growth, overall industry grew more in line with population. This, however, has no bearing on the precision of my estimates. Earlier in this chapter, I have discussed in detail the development of industry in the Yangzi Delta. Even the growth of the famous textile industry, which produced the most local surplus, did not outpace population growth so much. As a result, my industrial estimates are generally reasonable. As many revisionists believe, the industrial share would rise because industry grew faster than agriculture.

4.3.2 Services

For the calculation of services, I use the Broadberry et al. (2015) classification, which includes government services, commercial and financial services, and housing and domestic services. In historical national accounting, this is the more commonly used standard.

4.3.2.1 Housing and domestic services

First, I begin my calculations with higher-quality data on housing and domestic services, which Broadberry et al. (2015) and BGL (2018) argue was usually consistent with population growth. In the 1820s, housing and domestic services net output was around 1.58 silver taels per capita in the Yangzi Delta, according to Li (2010b: 197). By combining the population data, I can obtain a series of housing and domestic service outputs.

4.3.2.2 Government and commercial and financial services

However, there is little data available for the Yangzi Delta's remaining service sectors, namely government services and commercial and financial services. One hypothesis states that government services, as well as commercial and financial services, primarily served agricultural and industrial production activities. The most important government services in the Yangzi Delta, such as policing, legal, and postal services, primarily support agricultural and industrial activities. In comparison to agricultural production, which was mostly self-sufficient, the production of industrial goods traded on the market might benefit more from government services. A similar story could be told about commerce and finance sector. According to BGL (2018), the growth of Chinese commerce was measured by the proportion of agricultural and industrial output traded into the market. They estimate that 17 percent of Chinese agriculture entered the market in 1840, whereas all industry was expected to enter the market. As a result, I proceed to calculate government services, commercial and financial services in this manner. Yangzi Delta agriculture was likely more marketable. However, in the absence of data, I use Wu Hui's (1998) 20 percent of China average for the late Qing Dynasty to account for agricultural production in market in the Yangzi Delta. This may be true to some extent in the Yangzi situation. According to my agricultural data, all cash crops in the Yangzi Delta accounted for roughly 20 percent of agriculture. There would be no problem with this setting if all cash crops were traded in the market.

Table 4.4 Services estimation measures

Sector	Measures
Government, commercial and financial services	Agricultural and industrial production
Housing and domestic services	Population

Sources*:* see the text.

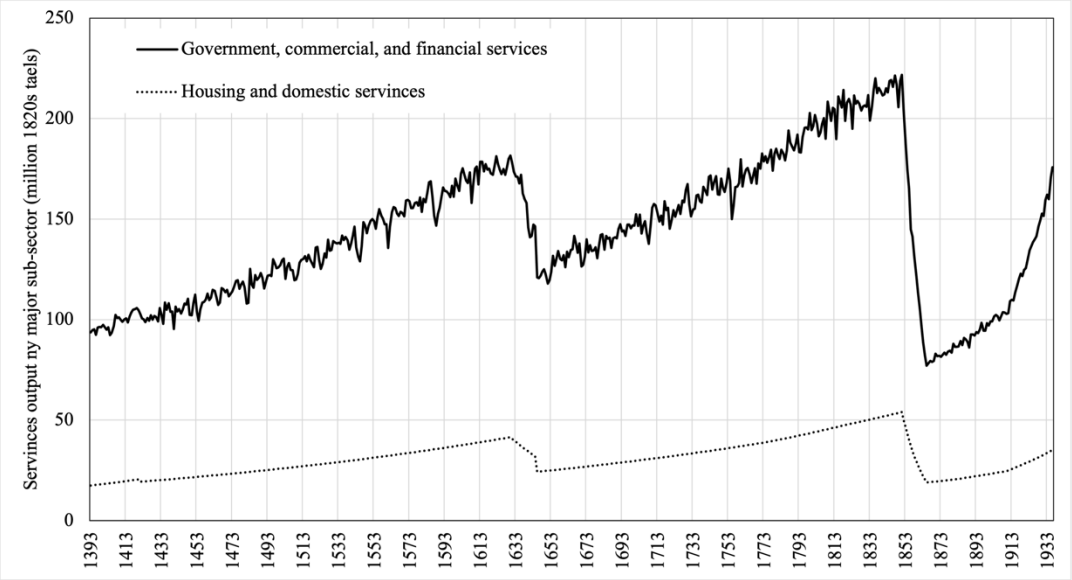

Figure 4.2 Services output by major sub-sector in the Yangzi Delta, 1393-1936 (million 1820s taels)

Sources: see the text.

When this setting is applied to 1820s Hua-lou, we find that the weighted figures calculated for 20 percent agriculture and 100 percent industry are roughly 1.29 times the output of these two service sectors in Hua-lou. Thus, using the agricultural output from Chapter Three and the industrial output from the previous section of this chapter, and the Hua-lou ratio, I can finally calculate the Yangzi Delta output series for services other than housing and domestic services. Overall, this calculation appears to be quite arbitrary. Other evidence supports its plausibility. According to Li (2010b: 197), the share of housing and domestic services in the total services sector in Hua-lou was 18 percent. My calculations for the services sector show that housing and domestic servi-

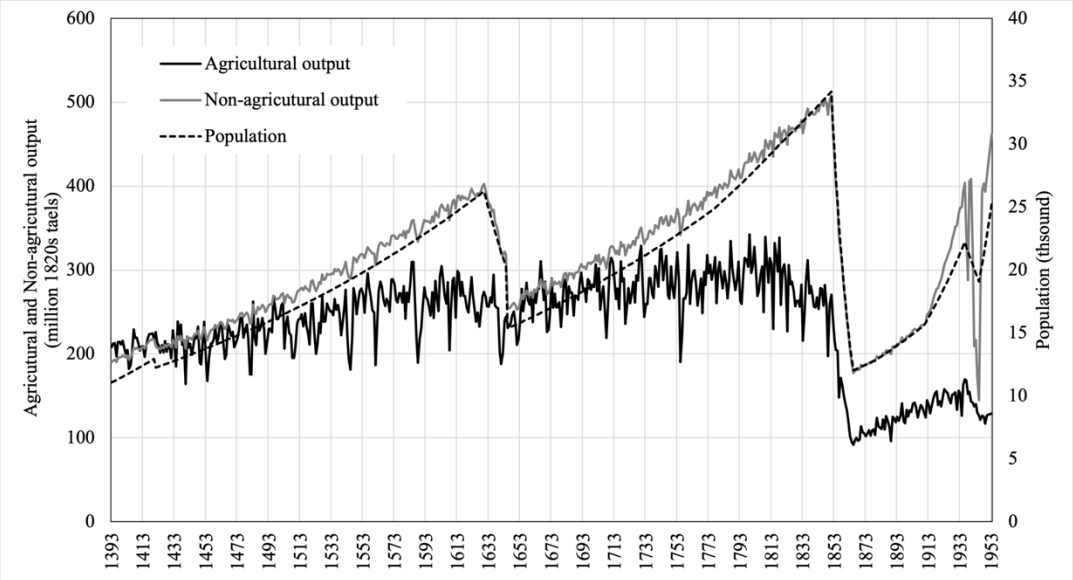

Figure 4.3 Output of agricultural and non-agricultural sectors and population in the Yangzi Delta, 1393-1953 (million 1820s taels)

Sources: see the text.

ces made up 16-19 percent of total services from 1393 to 1953, with an average of 17.8 percent, which is consistent with Li's findings.

4.3.2.3 Summary

Table 4.4 summarises the industrial estimation methods. Figure 4.2 depicts the Yangzi Delta's services growth. Service growth mirrored industry growth. This pattern of growth would eventually lead to a consistently higher share of the services sector relative to the agricultural sector. The higher output of services relative to industry is also consistent with the findings of Yang's (2022) occupational structure.

4.3.3 Non-agricultural output

Figure 4.3 compares agricultural and non-agricultural output in the Yangzi Delta to population. Overall, non-agricultural output grew at a rate very close to, but slightly less than, that of population. In the long run, local non-agricultural output per capita slightly declined, but better than agriculture. As a result, the economy underwent structural changes, with the agricultural sector's share declining over time. But let us return

to our central question in this chapter. If non-agricultural output per capita growth was insufficient to offset the decline in agricultural output per capita, it would imply that the economy's overall per capita growth was declining in the long run. Unfortunately, data show that non-agricultural output growth in the Yangzi Delta did not offset the decline in agriculture.

4.4 Conclusion

The main task of this chapter remains arithmetic, namely calculating the Yangzi Delta's non-agricultural or industrial and service output. My relentless and even seemingly verbose account stems primarily from the fact that non-agriculture data are not as solid and reliable as those for agriculture. As a result, I hope that the discussion in this chapter takes into account, as much as possible, readers with a variety of perspectives, both supportive and critical of the historical GDP calculations. I attempt to investigate the development of the Yangzi Delta's non-agricultural sector using all available qualitative and quantitative evidence. For readers familiar with the historical GDP approach, a comprehensive overview can help them understand my quantitative calculation procedure. For those who still doubt the historical GDP approach, I hope they will focus on "structural change in the economy of the Yangzi Delta" rather than details of output calculations. That is why I do not begin this chapter with a direct calculation of output. I believe that even readers who disagree with the historical GDP approach will likely not disagree with the assumption I made at the beginning of this chapter: "if we were to expect no decline or even an increase in the long-term trend of total output per capita at a time when agricultural output per capita was falling, a sizable increase in non-agricultural output per capita was required."

When we concentrate on this issue, the rest falls into place. In other words, the local industries with increasing output per capita were the sources of growth for the Yangzi Delta's non-agricultural sector and even the economy as a whole. If per capita growth

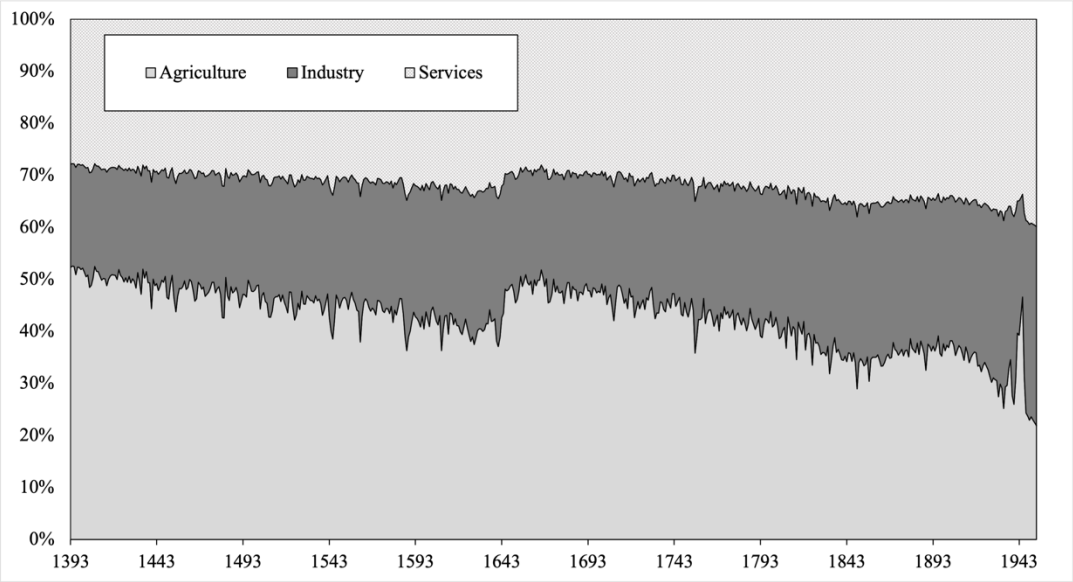

Figure 4.4 Economic structure in the Yangzi Delta, 1393-1953

Sources: see the text.

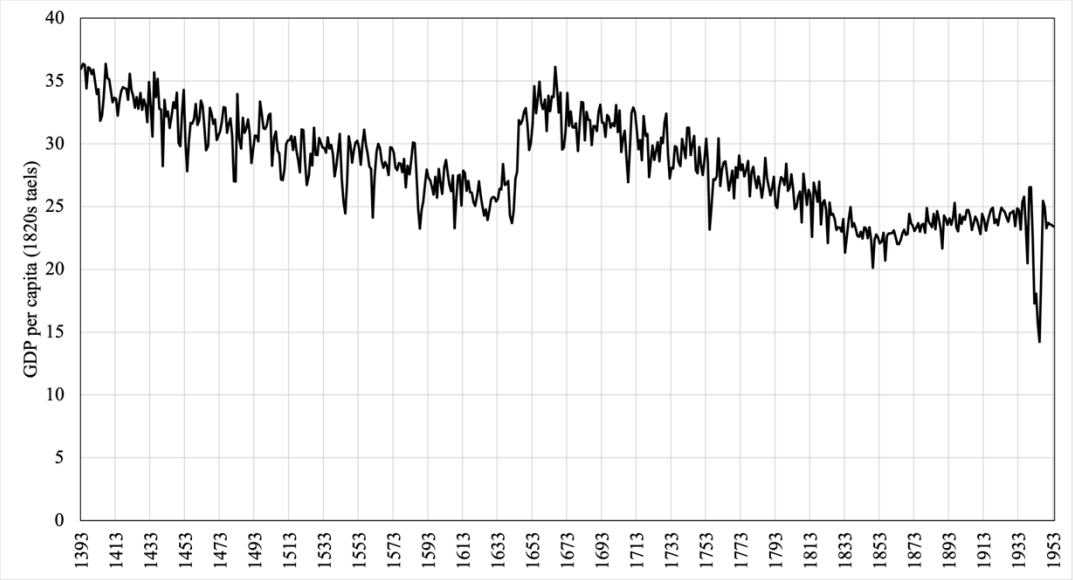

Figure 4.5 GDP per capita in the Yangzi Delta, 1393-1953 (1820s taels)

Sources: see the text.

in the most promising industries remained low, local non-agricultural output per capita might not either. Finally, it appears that this is my conclusion. The textile industry was the most active local non-agricultural sector, and we saw it grow not much faster than

the population. However, there is no evidence that the textile sector accounted for a large share of the non-agricultural sector, so other industries that grew almost in line with the population would have swallowed up the new textile sector changes. Overall, the Yangzi Delta's economic structure gradually improved, with agriculture's long-term share declining, but not sufficiently to avoid a decline in GDP per capita. Figure 4.4 depicts long-term structural changes in the Yangzi Delta economy. Agriculture's share was falling. Given the long-term stagnation of urbanisation rates, it is obvious that the so-called proto-industrialisation explained the economic structural changes during this period. This is also considered "new changes" by the California School. However, as with the agricultural sector, these new changes did not result in an increase in total output per capita. In other words, there is nothing wrong with the emergence of "new things", but their economic performance must be evaluated. The mere appearance of something does not imply that it had a significant impact.

Figure 4.5 depicts GDP per capita in the Yangzi Delta. Even with significant economic structural changes, it is clear that growth in the non-agricultural sector was insufficient to compensate for the decline in agricultural output per capita. This eventually results in a long-term decline in GDP per capita. It is important to note, however, that the aggregation of agricultural, industrial, and service output is a volume aggregation in constant 1820s prices. This means that relative price changes across sectors are thought to have no effect in this case. This is primarily due to a lack of price data. In pre-modern China, however, this treatment makes sense. Most Chinese GDP estimates have used this method. Data on prices in various sectors from the 19th and 20th centuries show no trend change in the ratio of prices in various sectors, even in the early 20th century when the economic structure changed significantly (Chen, 2003; Ma and de Jong, 2019). This is the average situation in China. This is also true for prices in Shanghai, China's most developed city. In fact, the greatest relative price change over the centuries was in cotton. It is largely due to a long history of cotton being used as the primary everyday clothing material. Cotton price changes have been considered in my agriculture chapter. Thus, relative price changes do not affect my agricultural output calculations. The

biggest problem in the non-agricultural sector is the cotton textile industry. However, as previously stated, the substitution of cotton for hemp cloth implies a two-pronged trend of growth and decline. As a result, combining cotton and hemp cloth into one sector should not significantly alter relative prices. Therefore, we can calculate GDP by aggregating sector estimates.

PART II: ANALYSING ECONOMIC GROWTH

CHAPTER FIVE: GDP AND GDP PER CAPITA: SEVEN CENTURIES OF ECONOMIC PERFORMANCE IN THE YANGZI DELTA

5.1 Introduction

The GDP series can be built from the agricultural and non-agricultural output series from previous chapters. This new data allows us to discuss a local economic growth process from the end of the 14th century to the mid-20th century for the first time in the literature. Was the Yangzi Delta one of China's most developed regions? Over the centuries, did the economic growth process remain constant or did it go through various stages? Since the "Opening Eyes to the World (睁眼看世界)"[31] in the 19th century, had local economic growth changed? What impact did the West have on local development? We can also examine whether the Yangzi Delta's economy matched Malthusian predictions. Also important is whether Boserupian agricultural development and Smithian growth originated locally. We discuss each topic in turn in the following sections, specifically "describing economic growth" and "modelling economic growth".

[31] This well-known description, familiar to most Chinese people, originated from WEI Yuan (1794-1857), a renowned scholar in 19th-century China who was dedicated to introducing Western knowledge to China. Wei's depiction referred to LIN Zexu (1785-1850), a prominent official at the time. Lin's anti-opium campaign in 1839 is believed to have possibly played a role in triggering the First Opium War. Additionally, he edited a comprehensive geographical encyclopaedia that provided information on the geography, history, and politics of countries beyond China. Subsequently, the phrase "睁眼看世界" became one of the most commonly used expressions in various Chinese history textbooks to describe the situation of China in the 1840s. It is also frequently cited by Chinese government leaders when discussing modern Chinese history.
https://language.chinadaily.com.cn/a/201510/27/WS5b20bd3ea31001b825721105.html

5.2 Describing economic growth: a bird's eye view of economic growth

5.2.1 Was the Yangzi Delta China's most developed region?

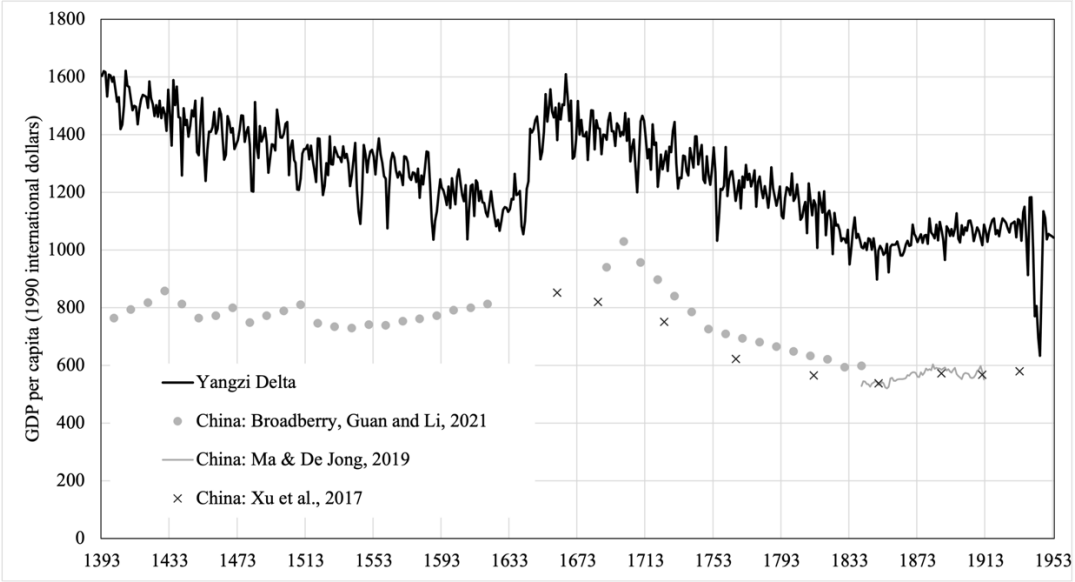

Figure 5.1 GDP per capita in the Yangzi Delta and China, 1393-1953
(1990 international dollars)

Sources and notes: The Yangzi series is taken from this study. See the last two chapters for details. For China's GDP data: decadal data from 1400-1840 come from Broadberry, Guan and Li (2021); annual data from 1840-1912 are derived from Ma and de Jong (2019); nine benchmark years' estimates between 1661-1933 (1661, 1685, 1724, 1766, 1812, 1850, 1887, 1911, 1933) are taken from Xu et al. (2017).

Yangzi Delta economic output can be calculated by adding agricultural and non-agricultural output from Chapters Three and Four. As mentioned in Chapter Four, such aggregation is a sum of volume indices based on relative prices in the 1820s due to the lack of sector-specific price data. However, because pre-modern China's economic structure changed so little, it is understandable that relative prices between sectors did not change much over time (e.g., Allen et al., 2011; BGL, 2018). Chapter Four's urbanisation rates show that the Yangzi Delta's urban population share stayed at 20 percent for centuries. The cotton-based cotton textile industry was likely the sector with the greatest relative price change in the Yangzi Delta. Yang's (2022) occupational structure data confirm this: the occupational structure of the male labour force remained virtually

unchanged over time during the Qing Dynasty. This implies that the female-dominated cotton textile industry was the primary driver of change in the Yangzi Delta's economic structure. This is also supported by the price change of cotton relative to rice in Chapter Three. The change in the relative price of this sector, which is likely to have the greatest impact on the aggregated results, has been accounted for in both agriculture and non-agriculture calculations. Thus, based on the above, I can aggregate output results from Chapters Three and Four to get the total output or GDP.

Let us start by looking at the GDP per capita for the Yangzi Delta, which spans seven centuries and a total of 561 years in Figure 5.1. For comparison, I convert it to 1990 international dollars. Translating Chinese silver-denominated GDP into 1990 international dollars requires purchasing power parity comparison prices. The good news is that since I use the same local currency as LI Bozhong in the 1820s, I can easily use Li and van Zanden (2012)'s price conversion coefficients to convert 1820s silver prices into 1990 international dollars. In my study, one 1820s tael of silver was worth 44.55 in 1990 international dollars[32].

Figure 5.1 shows Yangzi Delta GDP per capita and recent estimates of China average GDP per capita. The Yangzi Delta had a much higher GDP per capita than the rest of China, and this disparity remained relatively constant[33]. In other words, pre-modern China's regional economic inequality might not have varied much. So, can the Yangzi

[32] According to Li and van Zanden (2012), the Dutch GDP per capita in 1823-1829 was 1.86 times that of Hua-lou, whereas the Dutch GDP per capita in 1990 international dollars is 1998 at this time (Smits, Horlings and van Zanden, 2000; van Zanden and van Leeuwen, 2012). Thus, Hua-lou GDP per capita of approximately 24.107 taels is equivalent to 1074 in 1990 international dollars.

[33] It is important to note that in 1700, the GDP of China, as presented by BGL, experienced a temporary increase, which appears somewhat inconsistent with my estimation for the Yangzi region and the long-term trends suggested by Xu et al. This inconsistency is primarily due to the population data provided by BGL, which shows a decline from 1690 to 1700. One possible explanation is that there might have been some lasting negative effects, such as epidemics, following the conclusion of the Revolt of the Three Feudatories (1673-1681), which ravaged half of China (Solar, 2021b). However, the issue is that there is little qualitative evidence indicating such a severe impact on China's population after the end of this rebellion. BGL population data is taken from the population series of Maddison (1998: 169), which was based on the original work of Liu and Hwang (1979). However, Liu and Hwang do not provide an explanation for this population decline in the official population records. Therefore, BGL's population data for 1700 needs further confirmation from additional evidence in the future. Nonetheless, this issue does

Table 5.1 GDP per capita relative to China average, 1390-1930 (China = 100)

	Yangzi Delta this paper	Hua-Lou LZ	Macro YD Ma	Yangzi Delta BG	China wealthiest BG	China poorest BG
1400-1620	172.5			158.2	143.9	57.8
1690-1839	164.9	179.0		165.8	124.7	56.0
1840-1909	184.1					
1910-1936	188.2		174.2			

Sources and notes: (1) My calculation of relative GDP is based on the Yangzi Delta data estimated in this study divided by the average of China's GDP for the corresponding period. For Chinese GDP data from the 1390s to the 1840s, I refer to BGL (2021). For data from the 1840s onwards, see Ma and de Jong (2019) and Xu et al. (2017).

(2) The third column is the situation of Hua-Lou, two counties in Shanghai, 1823/29, calculated by Li and van Zanden (2012) (LZ series in the table). They discover that the region's real GDP per capita during this time period is 53.8 percent that of the Netherlands. According to the Maddison Project, the Netherlands' per capita GDP was 1998 in 1990 international dollars. Therefore, Hua-Lou should be around 1074 in 1990 international dollars. The China average was set at 600 dollars (BGL, 2018).

(3) The third column is the so-called Macro-Yangzi from Ma (2008). The Macro-Yangzi defined by Ma far exceeds the area in my research. The territory of Ma includes another 9 prefectures outside my definition, while the population was also more than twice the Yangzi Delta in my research.

(4) The fourth to sixth columns are Broadberry and Guan (2022) regional GDP benchmarks (referred to as the BG series in this research). They estimate four-year GDP (1400, 1580, 1770, 1850) in eight Chinese regions. In the fourth column, I use their data mean as the Yangzi Delta situation. In the fifth column of the BG data, "East Central China" in 1400, 1580, and 1770 and "Southeastern China" in 1850 were China's richest regions. In the sixth column, I calculate China's least developed regions' relative GDP per capita over time. According to their findings, "North China" was the poorest region in China in 1400, 1580, and 1850, while "Northwest China" was the poorest in 1770.

Delta be considered one of China's most developed regions? This question may be about the Great Divergence topic. If there were more developed regions in China than the Yangzi Delta, the Yangzi may become less important in the topic. But this question has not been satisfactorily answered by previous studies. According to wage research, Beijing, China's capital, and Suzhou, the Yangzi Delta's star city, had similar daily wages. However, this does not prove the same for GDP.

not affect the Yangzi Delta. The Yangzi region was not directly involved in the rebellion, and there is no evidence suggesting a population decline in the Yangzi region during this period.

Numerous studies have examined pre-modern China's regional economy (e.g., Elvin, 1977; Huang, 1985, 1990; Li, 2007; Marks, 1998b; Rawski E., 1972; Skinner, 1977). However, there is currently little research on regional GDP in pre-modern China. Broadberry and Guan (2022) are the only authors presently delving into this subject. Based on their estimates of GDP for several large regions (about three provinces for one region in their study), the Yangzi Delta appeared to be significantly richer than the China average, especially given that other rich regions, such as southeast China, had long been only about 1.3 times the China average for GDP per capita. This finding is consistent with the Yangzi Delta's economic importance in China, as previously agreed upon in the literature (e.g., Pomeranz, 2000; von Glahn, 2016).

Table 5.1 compares regional GDP per capita to national average. My calculations of Yangzi per capita income compared to China are in the second column. The third column shows Li and van Zanden's (2012) 1823/29 estimates for two Yangzi counties. The fourth column is from Ma (2008), whose Yangzi Delta territory is larger than mine and has more than twice the population. Ma's definition includes many undeveloped mountainous areas, so his income per capita should theoretically be lower than mine for the Yangzi Delta. The last three columns are from Broadberry and Guan (2022), based on four benchmark years' estimates. Due to a lack of data, their Yangzi Delta estimates are indirect. For example, they set the per capita cultivated land and grain yields for the Yangzi Delta as an average of the three provinces of Anhui, Jiangsu, and Zhejiang. But the results of their calculations are not very different from the results of my direct calculations.

My findings match other related studies. We can agree that the Yangzi Delta was at least 1.7 times the average Chinese per capita income and one of China's richest regions. It is also interesting to note that the Yangzi Delta's economic position in China did not appear to improve from the Ming to the Qing Dynasties, despite many "new things" like the spread of cotton and other cash crops and the gradual rise of the textile industry. This suggests that other Chinese regions developed faster, reducing regional inequality.

It is consistent with the facts about Ming-Qing population growth and economic development. The reclamation of new regions such as Sichuan, Yunnan, and the Northeast prevented Ming and Qing China's economy from becoming overly concentrated in one geographical centre. But from the 1910s to the 1930s, Yangzi per capita income increased to 1.8 times China average. This is most likely due to the introduction of Western technology and the emergence of modern factories beginning in the mid-19th century, which distinguishes the Yangzi Delta from other parts of China. The rise of Shanghai is the story of this. After becoming a Treaty Port city, what was once an ordinary prefecture in the Yangzi Delta quickly became the economic centre of the entire China.

For over 500 years, Yangzi GDP per capita outperformed China average. This does not, however, mean that the Yangzi Delta's position as the richest is unrivalled. Pre-modern capital cities were often prosperous. Broadberry and Guan (2022) estimate that Northern Song Dynasty capital Kaifeng had 2.1 times the China average GDP per capita. It is necessary to discuss the realities of the capital region in terms of regional comparisons because, for a large portion of the 15th to 19th centuries, the Chinese capital was not located in the Yangzi Delta.

Let us look at a brief history of China's capital since the 10th century. Kaifeng was China's capital during the Northern Song Dynasty (960-1127). The Jurchen in northeast China defeated the Northern Song regime in 1127, resulting in more than a century of political fragmentation until the establishment of the Yuan Dynasty (1271-1368). Beijing became the Yuan Dynasty's capital. After the Yuan was replaced by the Ming, the capital of China was moved from Beijing to Nanjing, also in the Yangzi Delta, for over half a century under the first three Ming emperors (1368-1420). From 1420, when the Yongle emperor returned the capital to Beijing, to 1927, Beijing was the capital of the unified Chinese regime. It was not until 1927 that Nanjing temporarily regained its status as China's capital.

The Yangzi Delta's GDP per capita during 1400-1420, when it was China's capital, was 1.91 times the China average. From the 10th century to the 14th century, China's capital was not as prosperous as it was during the Northern Song Dynasty. After 1927, the Yangzi Delta regained capital status with a GDP per capita 1.88 times the China average. However, due to the early adoption of the Western model, the Yangzi Delta was growing rapidly by this time. This implies that when Beijing was the capital in the early twentieth century, it might not have had such a high relative GDP per capita. So, it is clear that the economic status of the capital regions of the unified Chinese regime got worse over time.

China's peripheral economies developed over centuries. Many parts of Sichuan, famous for its food and population, were still barren in the 10th century. Yunnan and Guizhou in the southwest were even tribal civilisations for a long time. At the time, China's densely populated areas were primarily in the North China and along the lower reaches of the Yangzi River. With the nationwide wars in the end of the Yuan Dynasty, North China had lost its former glory. The war had left many areas nearly uninhabited. Population surveys from the early Ming Dynasty paint a very clear picture of this (Cao, 2022). By this time, southern China had become the country's economic centre, and many previously unexplored southwest regions were becoming more densely populated. The well-known events of the early Ming Dynasty, the Southern and Northern imperial Keju examinations, show that the northern regions' human capital was already far behind that of the southern ones[34]. During the two centuries of peace that followed, not only did the north's economy begin to recover, but the south's periphery was also developing. Regional inequality in China was intuitively decreasing. As the population grew in the Qing Dynasty, many "ghost lands" were explored, including the traditional nomadic settlements. Overall, it makes sense that China's capital's economic status was

[34] Because the final 51 candidates accepted for the 1397 imperial civil service examinations were all southerners, the Hongwu emperor separated the subsequent southern and northern examinations in order to select candidates based on different criteria. Although political factors are suspected to have played a role in this event, there is no doubt that in the early Ming Dynasty, the examination results of northern candidates would have lagged behind those of southern birth.

declining. It is therefore reasonable to assume that Beijing's GDP per capita as China's capital from 1420 to 1927 was probably around 1.7-1.8 times the China average, slightly higher than that of the Yangzi Delta. The wage study, which claims that wages in Beijing were slightly higher than in Suzhou in the Yangzi Delta (Allen at al., 2011), could also be correct.

What could this mean? Does this imply that the Yangzi Delta was not the most developed region in China, but rather the capital region? The answer may not be so obvious. The last column of Table 5.1 shows the per capita income of China's poorest regions. Northwest China (Shaanxi and Gansu) and North China shared the title of the poorest (Hebei, Shandong, Shanxi, and Henan). North China, where China's capital was for most of its history, was the poorest region in three of Broadberry and Guan's (2022) four benchmark years. Is it possible that Hebei province, where China's capital was located, was significantly richer than the other three North Chinese provinces? Yes, mostly. Most of Hebei's cultivated land per capita, grain yields, and urbanisation rates were higher than North China's, according to Broadberry and Guan (2022)[35]. However, we cannot say that Hebei was extremely developed because its economic performance was not significantly better than that of Jiangsu in East Central China. Despite having 2-3 times the cultivated land per capita of Jiangsu, grain yields in Hebei were only 20 percent of Jiangsu. In this context, it is possible that the per capita agricultural output

[35] In the framework proposed by Broadberry and Guan, per capita GDP can be divided into two components: per capita agricultural output and per capita non-agricultural output. Per capita agricultural output is approximately equal to the product of grain yields and per capita cultivated land. Therefore, if the product of these factors is low in a region, it may indicate a low per capita agricultural output. In the absence of direct evidence, they suggest that the comparison of per capita non-agricultural output between two regions can be approximated using the urbanisation rates. According to the description in Chapter Four regarding the relationship between urbanisation rates and economic structure, higher urbanisation rates may indicate a higher share of non-agricultural output in the economic structure, indirectly suggesting better development of the non-agricultural sector. However, this does not necessarily imply that per capita non-agricultural output is higher. Therefore, comparing per capita non-agricultural output may not be as straightforward or easily understandable as comparing per capita agricultural output. However, it is not within the scope of this study to discuss whether the framework proposed by Broadberry and Guan is correct. I have merely used their framework as a starting point for a tentative discussion on whether per capita GDP was high in Hebei. To reach a conclusion, I have also considered direct estimates of Hebei's GDP from other studies. Details can be found in the main text. In summary, grain yields and per capita cultivated land can assist in comparing the agricultural aspects, while the urbanisation rates can aid in comparing the non-agricultural aspects of two regions.

in Hebei might be lower compared to Jiangsu. As for the comparisons of the non-agricultural output per capita, for the most part, the Heibei urbanisation rates were also lower than in Jiangsu. If we consider Jiangsu's per capita income to be roughly 1.4 times the China average, Hebei might just be at the China average income level. Caruana-Galizia and Ma (2016)'s study on Chinese provincial GDP estimates supports this possibility. Of the three benchmark years they provide, only 1912/1918's provincial GDP is directly estimated. The other two are projected by regression. In 1912/1918, Hebei had a directly calculated GDP per capita of 506 in 1990 international dollars, while Jiangsu had 853 and the China average was 586. Even in the two extrapolated years (1873 and 1893), Hebei's income per capita was only about 1.19 and 1.35 times the national average. It is worth noting that China's capital was still Beijing at the time. If we consider that Beijing, the capital, was about 1.7-1.8 times the China average, then serious regional inequalities might arise in Hebei, where Beijing is located. In other words, the capital's development may be largely due to some artificial political status, implying that this economic prosperity might not be self-sustaining. More importantly, Beijing was simply a city with a small territory. It had one to three million people during the Ming and Qing Dynasties. The highest peak over 2,000 years might be in 1928, with only four million people (Gao, 2014: 490)

All of this suggests that Beijing is not a particularly appealing international comparison option. Based on the above discussion, I am inclined to think that the capital's per capita income might be slightly higher than that of the Yangzi Delta (if the capital is set at 180, the Delta at 170, and the China average at 100), but given Beijing's small size and the fact that the Yangzi Delta's star cities, such as Suzhou and Shanghai, always had higher incomes than the Delta average, Beijing's economic status as the capital did not appear so impressive. As a result, it is reasonable to believe that the Yangzi Delta was, to some extent, one of China's most developed regions. As the capital, Beijing's per capita income was probably 1.8 times the national average during the Ming and Qing Dynasties, which could serve as an upper bound for the Chinese regional economy. Therefore, in the following international comparisons, I believe the Yangzi Delta can

represent China's most economically developed region. This is the same situation as Holland for the Netherlands: the Netherlands has a much larger territory and population and is frequently included in international comparisons rather than Holland.

5.2.2 Growth process I: trend and breaks

Let us now look at the Yangzi Delta's economic growth process and trend over the centuries. As econometric techniques improve, the literature has a rich history of decomposing economic growth trends and cycles (Mills, 2009; Mills, Diebolt and Haupert, 2016). However, due to the various limitations of each model, I do not intend to cover all modelling approaches to the Yangzi Delta's growth. For brevity, this section only presents preliminary results from simple arithmetic methods, as done in the British economic decomposition study (Broadberry et al., 2015; Crafts and Mills, 2017). Exploring structural breaks in time series is also a part of trend analysis, which is technically divided into two parts: setting subjective breaks and automatically detecting potential breaks based on data patterns. The goal of this section, however, is not to find every statistically possible break. My focus is on some major structural breaks in history.

The results in Figure 5.1 are actually quite intuitive. The Yangzi Delta's economic growth process can be divided into "peacetime" and "non-peacetime" periods (as judged by major wars, disasters, and population losses). Three peacetime periods are 1393-1630 (Ming), 1645-1850 (Qing), and 1865-1936 (late Qing and Republic of China). Three non-peace periods are 1631-1645 (Ming-Qing Transition), 1851-1865 (Taiping Rebellion), 1937-1945 (Japanese Invasion). Thus, I discuss the economic growth trend in the Yangzi Delta along these divides. In chronological order and according to Figure 5.1's growth trend, I have divided what follows into pre-1850 and post-1850. Pre-1850 includes two periods of peace and one period of non-peace. Post-1850 includes one period of peace and two periods of non-peace. Because there is less time after 1945, I will end my discussion there.

Table 5.2 Mean annual growth rates in the Yangzi Delta, 1393-1953

Year	Mean annual growth rate (%)					
	Agriculture	Industry	Service	GDP	Population	GDP per head
1393-1550	0.15	0.35	0.30	0.24	0.36	-0.12
1551-1630	0.05	0.34	0.29	0.20	0.36	-0.16
1393-1630	**0.12**	**0.35**	**0.29**	**0.22**	**0.36**	**-0.14**
1631-1645	**-1.01**	**-3.33**	**-2.86**	**-2.16**	**-3.58**	**1.42**
1646-1800	0.15	0.36	0.32	0.25	0.38	-0.13
1801-1850	-0.27	0.37	0.27	0.10	0.42	-0.32
1646-1850	**0.05**	**0.37**	**0.31**	**0.22**	**0.39**	**-0.17**
1851-1865	**-6.94**	**-6.96**	**-6.95**	**-6.95**	**-6.94**	**-0.01**
1866-1910	0.79	0.61	0.63	0.68	0.58	0.10
1911-1936	1.01	2.28	1.94	1.74	1.36	0.38
1866-1936	**0.87**	**1.22**	**1.11**	**1.07**	**0.87**	**0.20**
1937-1945	**-3.28**	**-14.23**	**-9.31**	**-8.32**	**-1.70**	**-6.62**

Sources: see the Chapter Two, Three and Four.

5.2.2.1 Pre-1850

A. Peacetime

Table 5.2 shows the mean annual growth rates of agriculture, industry, services, GDP, population, and GDP per capita over time. Let us start with the centuries before the 1850s. In the Yangzi Delta, the 1393-1630 period of the Ming Dynasty and the 1645-1850 period of the Qing Dynasty were times of peace[36]. These two periods had similar

[36] However, it is important to note that there was not complete peace throughout China during most of the two dynasties. Military actions in border regions were prevalent for much of both dynasties' durations. During the Ming Dynasty, frequent wars occurred near the military defences against the Mongols and Jurchens in the north. Prolonged conflicts also took place in southwestern regions such as Yunnan. In the mid-16th century, conflicts with pirates along the southeastern coastline reached their peak. The Qing Dynasty, on the other hand, engaged in both external and internal warfare for much of its existence. The emperors Kangxi, Yongzheng, and Qianlong spent nearly a century eliminating the Dzungars and expanding China's territory into Xinjiang. Additionally, the issues of secret societies and piracy in the mid-

growth patterns: sectoral output and GDP grew slowly and steadily, but GDP per capita fell by 0.13 percent and 0.17 percent due to faster population growth. An interesting fact is that from 1801-1850, total agricultural output showed a decline. Almost all of the GDP growth came from the non-agricultural sector. As I previously stated, the deterioration of the climate caused by volcanic eruptions in South East Asia might have been a significant underlying cause. The long-term decline in land productivity was the direct cause.

B. Non-peacetime: Ming-Qing Transition

The situation was different during the non-peace period. The first population drop in the Yangzi Delta occurred in 1630. Population loss occurred as the plague spread from the north. After the Ming government was overthrown and the slaughter began, a second wave of population loss occurred. The Yangzi Delta's Ming-Qing Transition period was likely to have begun in 1630 and ended in 1645. On a national level, however, the Ming-Qing Transition likely lasted much longer. In 1644, the Manchus of Liaoning in northeastern China crossed the Great Wall and entered mainland China. As a result, China's warfare reached a climax. Warfare between poor peasants and the government had been going on for many years in the preceding decades, but it was not until 1644 that it became a nationwide war. Warfare raged for decades during the Ming-Qing Transition period. When the defeat of the last Taiwanese regime to oppose the new Manchu rule is considered, the Ming-Qing Transition period might have lasted as long as 40 years, until 1684. China's population might have dropped by over 33 million during this time (Cao, 2018).

Despite the infamous "Jiading Three Massacres (嘉定三屠)" and other massacres in the Yangzi Delta region, large-scale warfare lasted only about a year. After the Qing army drove the last remnants of the Ming regime out of the Yangzi Delta region, peace was quickly restored. Despite occasional small-scale armed conflicts, the local

Qing period also led to numerous military conflicts. Further details on the wars during this period can be found in *A Chronology of Warfare in Dynastic China* (2003).

economy and population were largely unaffected. Between 1630 and 1645, the Yangzi Delta's average annual population growth rate was around -3.58 percent. This population loss was second only to the Taiping Rebellion two centuries later in local history. Despite GDP declining, GDP per capita was growing at 1.42 percent per year. Such growth would have been incomprehensible in peacetime in pre-modern times. However, if the increase in income is due to an increase in resources per capita as a result of population loss, it is a common outcome, also known as the Malthusian phenomenon.

Agriculture's growth explains this. According to the data in Chapter Two, the disruption of 1644-1645 resulted in approximately 24 percent of the local population loss but only 13 percent of the loss of cultivated land, implying an abrupt upward change in per capita cultivated land, a typical Malthusian phenomenon. The benefits of the sudden increase in cultivated land per capita lasted for a long time afterward. Early Qing gazetteers show that local cultivated land recovered to pre-war levels around the 1660s, but the population did not recover until the mid-18th century. Although the primary cause, this Malthusian-style explanation does not yet tell the whole story. Moderating climate and rising land productivity might also help. Readers familiar with Ming history may recall that the Little Ice Age of the late Ming Dynasty devastated the local economy. The negative impact of the climate was a major reason for a wave of peasant revolts across China in the early 17th century.

Massive natural disasters and reductions in grain production plagued the region in the five years preceding 1644. "Great famine", "cannibalism", and "streets full of starving people" appear in many gazetteers. As I mentioned in Chapter Three, gazetteers exaggerate what happens in an unusually local harvest year, or "recording the anomalous rather than the normal", but these descriptions do suggest that the climate in the decades before 1644 was likely very unfavourable. After 1645, when the Qing Dynasty replaced the Ming, few similar records were kept. Gazetteers even describe "Great harvests" sometimes. According to the rice yield in Appendix D, the average amount of unhusked rice per Mu in 1640-1644 was 410 Jin, rising to 511 Jin in 1645-1650, a 25 percent

increase. Of course, the gazetteer editors might have feared the Manchus and concealed as many bad agricultural years as possible to demonstrate the new regime's superiority. But we can also confirm these records by comparing rice prices. According to Wang (1992)'s first-hand rice price data, the average price of rice in 1640-1644 was 3.34 taels per Shi, while the price in 1645-1650 was 2.77 taels. If we extend the period to 1645-1660, the price would have been even lower, at 2.44 taels.

According to the preceding discussion, the structural increase in GDP per capita in the Yangzi Delta 1644-1645 resulted from a number of factors, including a significant increase in cultivated land per capita, as well as an increase in grain yields per plot. The wage study also supports the increase in GDP per capita. Recent studies by de Zwart and van Zanden (2018: 218)[37] and Liu (2022) both confirm a structural increase in real daily wages in the Yangzi Delta over this period. The increase in real wages reported by de Zwart and van Zanden (2018) is primarily due to a drop in prices. Their nominal wages barely change. Of course, this is due to the fact that their nominal wage data is assumed to be unchanged and is extrapolated from data from the late 17th and 18th centuries. The actual situation at this time is better captured by Liu's data. According to Liu's data on engraver wages in the Yangzi Delta in the 17th century, there was an increase in nominal wages in the labour market during the Ming-Qing Transition period, while prices fell at the same time, resulting in a jump in real wages. In any case, there is no question that per capita income rose structurally or on trend during this period.

5.2.2.2 Post-1850

A. Non-peacetime: Taiping Rebellion

The next phase's story appears to be more sophisticated. Figure 5.1 shows that Yangzi Delta GDP per capita stopped declining between 1850 and 1936. The peace after the Taiping Rebellion did not change this trend. For the first time in several centuries, the

[37] De Zwart and van Zanden (2018) actually uses a subset of the data from the famous Allen et al.'s wage project (2011). Although this subset of data did not appear in Allen et al.'s 2011 article, it is shown by one of the authors, van Zanden, in his collaborative book.

Yangzi Delta's population and GDP per capita grew almost simultaneously between the late nineteenth and early twentieth centuries, according to Table 5.2. Since the 1840s are considered China's first entry into the modern world system, it is reasonable to assume that external knowledge and technology contributed to the growth. But there is a problem: the famous Taiping Rebellion broke out between 1851 and 1865. This marked the end of the old pattern and the start of the new one. So my story for the period after the mid-nineteenth century begins with the Taiping Rebellion.

The Taiping rebellion was led by Guangxi peasants who believed in a modified form of Christianity, and it was the largest uprising in centuries. Nanjing was captured by insurgents in 1853 and became the capital of the new regime centred on the Yangzi Delta. This regime lasted only 12 years under the Qing government's frenzied nation-wide repression. However, the rebellion sparked decades of conflict between various forces across China, resulting in the deaths of approximately 73 million people (Cao, 2001, 2018, 2022).

How was Taiping's Yangzi Delta economy? The chaos disrupted the economy as a whole, with severe population loss and land desolation (Li, 1957: 146-174). "Either about ten miles of land was not cultivated, or there was no smell of cooking smoke in the village." ZENG Guofan, the chief counter-insurgency commander at the time, once said (Li, 1957: 157). Yet what about per capita situation? According to Ma and de Jong (2019), China's per capita income did not decline significantly during this period. Table 5.2 confirms it: this phenomenon was applicable to the Yangzi Delta region as well. There was still negative annual growth in per capita income during this time period, but it was only 0.01 percent, which is better than the more than 0.32 percent annual decline seen in the previous 50 years. There was little change in the per capita situation as the size of the economy and the population both decreased. Wages did not appear to have changed significantly either. Jiang and Wang (2020) are the only sources we have for wages in the nearby area during this time. They collect annual wages for a village in the Yangzi Delta's neighbouring Zhejiang region from 1836 to 1870. The Taiping army

harassed this area, but annual wages remained stable. This evidence is from a marginal area and may not represent the region as a whole. However, when combined with GDP results, it appears that per capita income during the Taiping Rebellion should have been a nearly constant trend.

The difference in impact between the Taiping Rebellion and the Ming-Qing Transition could be attributed to the duration of the disruption. Ming-Qing Transition in the Yangzi Delta was completed soon. The aggressive massacres carried out by the Qing army were primarily responsible for the population loss here. Soon after the new regime took power, there was peace. Local officials reported land barrenness in the 1650s, suggesting land loss was greater on the northern bank of the Yangzi River, but no such records existed in the Yangzi Delta (Fang, Jing and Wei, 2007: 27-47; Wang et al., 1991: 228-247). But during the Taiping period, massive population losses in the Yangzi Delta were accompanied by massive land destruction. After the Rebellion, the local governor MA Xinyi reported severe land and population losses in the Yangzi Delta in the 1850s. Another local magistrate, LIU Kunyi, reported in 1899 that after more than 30 years of peace in Xinyang County, Suzhou Prefecture, there were still 100,000 Mu of uncultivated land (Li, 1957: 158-161). My calculations show that cultivated land per capita was 1.4 Mu before the war and 1.5 Mu after the war, which is negligible compared to the Ming-Qing Transition periods. The continuing disruption destroyed both population and the economy.

B. Peacetime: 1865-1936

Following the war, the Yangzi Delta's economy appeared to have entered a new and unprecedented pattern. Table 5.2 shows that between 1866 and 1936, the Yangzi Delta's GDP and population grew simultaneously, resulting in 0.2 percent GDP per capita growth. Cultivated land per capita changed little during the war, but because it was much easier to restore cultivated land than to reproduce the population, population growth was slower than cultivated land growth. Cultivated land per capita reached 2.2 Mu by 1936. In other words, this was very much another form of Malthusian

phenomenon, where land grew faster than population, allowing per capita resources to continue to increase for a short period after the war. If this is the case, population growth will outpace the land again after the land is fully restored, repeating the Malthusian story. However, I do not see it as a Malthus-style increase in per capita income comparable to the Ming-Qing Transition periods. One important reason is that the changes in the Yangzi Delta were likely to be self-sustaining. According to Table 5.2, dividing the period into 1866-1910 and 1911-1936 reveals that both population and GDP grew in both periods. However, GDP grew at a faster rate relative to population in the second period. This is primarily because the non-agricultural sector grew much faster than agriculture. Thus, economic structural change accelerated during this time. This is most likely related to China's full embrace of the world during this period.

After the Second Opium War (1856-1860), the Chinese government actively introduced Western technology, resulting in the famous Westernisation Movement. Electric and steam-powered factories were built (Chang, 2010 [1969]; Du, 1991, 2019). More importantly, the establishment of many Western-style hospitals and schools aided urbanisation and industrialisation (Bai and Kung, 2015). Local urbanisation increased from 16 percent in 1865 to 35 percent in 1936. According to Table 5.2, the average annual growth rate between 1866 and 1910 was 0.10 percent, while the rate between 1910 and 1936 was 0.38 percent, which is lower than the more optimistic 1.10 percent annual growth rate estimated by Ma (2008) for the period from post-World War I to the early 1930s[38]. Compared to the negative annual growth rates of around 0.15 percent in peacetime over the past few centuries, this growth is significant.

[38] Ma's local growth rate estimates for the period from World War I to the 1930s are largely based on Rawski's (1989) China-wide estimates. Rawski's estimates may overestimate agricultural growth compared to direct data on non-agricultural sectors.

Rawski's use of Buck's retrospective wage survey of agricultural sectors to assess agricultural output per capita drives agricultural sector growth. However, Buck's estimates of national agricultural wages are not based on direct records, and many retrospective surveys are likely to be flawed. More importantly, Rawski does not explain why he does not use Buck's price indices to calculate real wages. He instead uses the price index for Wujin County, Jiangsu Province, and then the nominal agricultural wages for the entire country to study the real wage trends in agriculture. But when I divide the Wujin price index by Wujin nominal agricultural wage, the real agricultural wage decreases slightly. Buck's own price indices, when combined with his nominal wages, indicate a decline in real agricultural wages in China between 1910 and 1930. Since local agriculture was in a period of frequent disasters, it is hard

Technology might not have been the sole cause of economic growth. Western institutions brought in by the Treaty Port system might have protected private property rights and helped develop physical and financial markets (Ma, 2008, 2019). Furthermore, the emergence of large amounts of foreign direct investment, which is frequently associated with so-called Western shocks, cannot be overlooked. Although agricultural land productivity continued to decline after the mid-19th century (Chao et al., 1995; Jiang and Su, 1993), the increase in per capita cultivated land, combined with new thinking, investment, and even lifestyles, may have allowed the Yangzi Delta to achieve a simultaneous increase in population and GDP, which may have been the first opportunity for the local economy to enter the modern economic growth trajectory.

C. Non-peacetime: Japanese Invasion

In 1937, the Japanese Invasion ended this slow but steady growth. At the end of 1937, Japanese troops occupied Nanjing, China's capital, and committed a six-week massacre. This was preceded by the Battle of Songhu in Shanghai, east of Nanking, with a total of over one million troops on both sides. In the first half of 1938, Japan controlled the Yangzi Delta. The Yangzi Delta did not return to Chinese control until 1945, when Japan surrendered. Nanjing regained control as China's capital in May 1946, but was occupied by communist forces in April 1949 during the Chinese Civil War (1946-1949).

Indeed, while local wars were short-lived in the decades since 1937, prolonged political instability and frequent regime changes were fatal factors in interrupting previous sustained growth. The manner in which governance was carried out during the war had a

to understand how it grew rapidly. Indeed, according to Zhai and Lou's (2022) most recent calculations of average agricultural output per worker in China during this period, agricultural output per worker and output per capita in China would have declined.

Although Ma realises that Rawski's estimate of agricultural growth in this period may be overestimated, he still assumes that local per capita agricultural output increased. Considering that agriculture's share was not low in China in this period, even if the growth rate of the non-agricultural sectors was not in question, the overall GDP per capita growth based on Rawski must have been overestimated. According to my direct calculations, agricultural output per capita in the Yangzi Delta was falling, so the agricultural growth rate should not have been as high as Ma believes.

serious negative impact on the local economy. Unfunded banknotes were issued, and financial institution assets were misappropriated. Japan imposed control and confiscation on industrial enterprises and regulated all public infrastructure. 211 Chinese-owned factories were forcibly occupied in Shanghai by 1940. A common tactic employed by occupiers during the war was the coerced purchase of bulk commodity like grain and cotton in large quantities (Party History Research Office of Shanghai Municipal Committee, 2016: 13-18).

The non-agricultural sectors suffered a severe decline. When the Pacific War began in 1941, the Japanese occupation of the previously protected Western Concession resulted in a sharp decline in industry and services. In fact, when Japan first invaded the Yangzi Delta, a large number of industrial enterprises relocated from elsewhere to seek protection in the concessions, resulting in industrial output in Shanghai in 1940 being higher than in 1936 (Fang, 2018). The financial sector flourished as well, with bank deposits in the Concession reaching 60 percent of total Chinese deposits in 1939. (Xu and Wu, 1993: 441). However, when Japan violated the Concession's protection and the Pacific War disrupted shipping and trade, the entire non-agricultural sector fell precipitously. The most serious damage occurred in 1945, when Shanghai, China's industrial centre, virtually ceased most industrial activity. Throughout WWII, the local economy was devastated. GDP per capita growth in the Yangzi Delta was -6.62 percent, while GDP growth averaged -8.32 percent per year. Growth in all three major sectors lagged behind that of the pre-war period, and the average annual growth rate of non-agriculture became the lowest in history, less than that of the Taiping Rebellion. It was not until the end of the Japanese invasion that the average annual growth rate of local GDP per capita began to look normal. After the Japanese left, the economy quickly recovered. But things were also not looking good. China's civil war erupted in less than a year, in 1946. To deal with the fiscal deficit and military spending, hyperinflation erupted and the monetary system nearly collapsed during this period. Shanghai prices increased 1,158-fold from September 1946 to August 1948 (Zhao, 2016). The Second World War and

the subsequent unstable environment clearly put an end to decades of new growth patterns in the Yangzi Delta.

5.2.3 Growth process II: understanding the short-lived attempts to achieve modern economic growth

The previous section summarises local economic growth trend and breaks. If we look at peacetime economic growth in different periods, it appears clear that the local economy exhibited a different pattern of growth around 1865. The local growth pattern can be divided into pre-1865 and post-1865 if we ignore the three war periods. The former represents a traditional development pattern in which economic growth was slow and per capita income declined with population growth. After the 1860s, growth pattern changed. Although weak, it looks modern as population and GDP grew simultaneously. What caused the post-1865 change? How can we understand the transition from traditional to modern? Clarifying the Yangzi Delta's almost first non-negative GDP per capita growth process may aid in understanding how the region should transition to a modern economic growth path.

Despite the significant decline in land productivity and the enormous downward pressure on per capita income during this period, the ultimate growth rate of per capita GDP in the Yangzi Delta exceeded that of previous centuries. This implies the existence of new forces influencing the process of economic growth. As previously stated, the most noticeable positive change in comparison to previous centuries appeared to be the introduction of Western technologies and institutions during this period. More specifically, decomposing the changes in per capita GDP into periods of growing and shrinking aids in comprehending the underlying narrative. In accordance with Broadberry and Wallis (2017), the process of economic growth exhibits numerous positive or negative fluctuations. Among these fluctuations, the negative ones, namely the frequency and rate of change during economic downturns, might be more crucial than the positive ones, denoting the rate of change during economic upturns, in steering an economy

towards sustained long-term growth in per capita GDP. Broadberry and Wallis notice that the primary driver of overall economic growth in Europe since the 19th century might be a reduction in both the frequency and rate of change of shrinking years—periods characterised by declining per capita GDP—by comparing variations in the European economies from the 13th to the mid-20th centuries. In essence, Europe's example does not imply that the occurrence and rate of change during growing years are insignificant in the process of economic growth; rather, it emphasises the importance of reducing the frequency and rate of change of negative fluctuations, that is, shrinking years, for the entire economic growth trajectory. Achieving long-term increases in per capita GDP becomes feasible when these "negative fluctuations" are curtailed in terms of both frequency and rate of change.

Table 5.3 shows the results of applying this framework to the Yangzi Delta's economic growth process. Notably, when compared to previous periods, there was a discernible reduction in the rate of change during shrinking years within Yangzi economic growth process since 1865. Another new development after 1910 is a decrease in both the rate of change and frequency of shrinking years. This supports Broadberry and Wallis' contention that reducing the frequency and rate of change during shrinking years at the same time could facilitate long-term growth in per capita GDP. Consequently, the "new phase" of Yangzi economy after 1865 can also be attributed to the amelioration of "negative fluctuations" during the process of economic growth.

What factors transformed and contributed to Yangzi's better control of these "negative fluctuations" in comparison to earlier centuries? Broadberry and Wallis summarise various variables that impact "negative fluctuations" in their framework, including proximate causes (technology, structural change, population dynamics, and wars) and ultimate causes (institutions). In other words, identifying and addressing these factors that could lead to "negative fluctuations" in the economy may help steer the economy towards a path of long-term overall growth. However, due to lack of data, conducting a detailed analysis similar to that in Europe for the Yangzi economy poses challenges.

Table 5.3 Growing and Shrinking of GDP per capita in the Yangzi economy, 1394-1936

		1394-1630	1645-1850	1866-1910	1911-1936	1866-1936
Frequency	Growing	0.44	0.49	0.47	0.54	0.49
	Shrinking	0.55	0.51	0.53	0.46	0.51
Change rate	All years	-0.14	-0.11	0.11	0.38	0.21
	Growing	4.57	4.70	3.40	2.96	3.22
	Shrinking	-3.89	-4.73	-2.78	-2.63	-2.73
Contribution	All years	-0.14	-0.11	0.11	0.38	0.21
	Growing	2.02	2.30	1.59	1.59	1.59
	Shrinking	-2.16	-2.41	-1.48	-1.21	-1.38

Sources and Notes: The Yangzi Delta data, see the text. Frequency refers to the proportion of growing and shrinking years in GDP per head over a fixed period. The Change rate refers to the average change of GDP per head over a fixed period for all years, the growing years and the shrinking years, respectively. The definition of contribution comes from Broadberry and Wallis (2017) : frequency of growing years times rate of change plus frequency of shrinking years times rate of change.

Nonetheless, a preliminary review suggests that the primary impetus behind the mitigation of "negative fluctuations" in the Yangzi economy might be the introduction of "new institutions" from the western world, which will be analysed in depth next. The specific discussions are as follows:

A. Technology

Broadberry and Wallis framework suggests that technological progress is one of the proximate reasons for reducing "negative fluctuations" in the process of economic growth. The most noticeable new change in the Yangzi Delta since 1865 is the introduction of Western technology. It was not until the late 19th century that the government took the lead in technology transfer, which resulted in a major rise of new technologies. According to DU Xuncheng's (1991, 2019) and ZHANG Yufa's (1987, 1988a, 1988b, 1989) studies on modern enterprises utilising steam engines or electricity, many such enterprises began to emerge in the mid-19th century. After the 20th century, the growth rate of these modern enterprises increased even more. While this does not strictly prove that the introduction of new technologies had increased, a consensus

observation is that, at least since the mid-19th century, both the Yangzi Delta and China as a whole had seen the influx of numerous "new technologies" from the West, such as steam engines, electricity, and railways. As a result, it is reasonable to suppose that technical transfer from the West during this period could help to reduce unfavourable oscillations in the Yangzi economy. We cannot, at least for the time being, deny this point in our discussion (although subsequent computations on TFP demonstrate that the impact of these "new technologies" on TFP growth was minimal, we cannot dismiss the fact that these Western technology were indeed imported).

B. Structural change

Structural change here refers to the fact that a decline in the share of the agricultural sector, which usually has a high frequency and magnitude of shrinking, may have contributed to the overall decline in economic shrinkage. From 1865 to 1935, the Yangzi Delta's economic structure underwent significant change. This period saw a rise in the non-agricultural sector's share of the economy, as evidenced by the findings presented in the preceding chapters. However, this growth occurred mostly after 1910, and the economic structure did not improve significantly before 1910 compared to the period before 1865. That is, economic structural changes in the first decades after 1865 were not supposed to improve situation in reducing the economic shrinkage.

C. Demographic change

The logic behind the assumption that demographic change can lessen "negative fluctuations" in the economy stems from Malthusian theory (Malthus, 1970 [1798]). Birth and death rates, as well as changes in land resources, can have a short-term impact on per capita GDP fluctuations (Broadberry and Wallis, 2017). In other words, short-term growth in population is a force that causes the economy to experience a "negative fluctuation", whereas improved land availability is a force that causes the economy to experience a "positive fluctuation". Achieving low population growth and high land growth suggests a reduction of the negative consequences of Malthusian theory's per

capita resource decline, potentially reducing and lowering "negative fluctuations" in economic growth process.

Returning to the Yangzi region, after 1865, per capita land in the local economy increased, particularly between 1865 and 1910. The "Malthusian-style negative pressure" during this period was reduced in comparison to several centuries before to 1865. Therefore, the risk of experiencing an economic "negative fluctuation" was greatly reduced as a result of the reduced economic pressure on per capita resources brought about by this Malthusian logic. However, the comparative analysis of population growth rates presented in Table 5.2 indicates that population growth in Yangzi accelerated after the mid-19th century. This suggests that the primary reason behind the alleviation of per capita resource constraints was the faster growth of land rather than a decline in population growth. In other words, no population-related changes appeared to have directly contributed to the favourable changes in per capita resources. But as demonstrated in the framework proposed by Broadberry and Wallis, the relative increase in land can also be considered a form of "demographic change" because it effectively alleviates the pressures of Malthusian logic through changes in land availability. According to this viewpoint, the Yangzi economy did better in terms of "demographic change" between 1865 and 1936, which could be one of the reasons for suffering less "negative fluctuations". However, Table 5.3 reveals that the degree of "negative fluctuations" in the Yangzi economy was substantially smaller between 1910 and 1936, both in terms of frequency and rate of change. Per capita land resources were not as favourable during this period as they were between 1865 and 1910. This means that, unlike between 1865-1910, among the several factors leading to the lowering of "negative fluctuations" in the Yangzi economy, "demographic change" was no longer a crucial part. There must have been other reasons that also had an important sway after 1910.

D. Warfare

The logic that warfare affects the economy's "negative fluctuations" is intuitive. A secure environment safeguards long-term growth in the economy and eliminates

"negative fluctuations". However, the phenomena of "reduced negative fluctuations" after 1865 in the Yangzi economy was highly unlikely to be attributed to a decrease in warfare. This is because, following the Ming-Qing Transition in the mid-17th century, the period from the mid-19th century onwards was marked by another nationwide political turbulence extending over a century.

Compared to the mostly peaceful period before 1850, situation in local politics and warfare worsened after the late 19th century. Despite no major local wars, the political environment worsened from 1865 to 1927. The Taiping Rebellion weakened Qing central government control over local communities. The Southeast Mutual Protection Incident (1900–1904) (东南互保)[39] shows that a strong local force broke away from central government control. Shortly after, in 1911, a coalition of primarily southern provinces declared political independence from the Beijing government in what became known as the Xinhai Revolution (辛亥革命), effectively ending the Qing Dynasty. The political instability of the Republic of China period became more acute following the fall of the Qing. The political climate was very hostile during this period, with major wars like the 1927 Northern Expedition (国民大革命) led by the Kuomintang-dominated Guangdong government to unify China and other local warlord skirmishes. Although there were no prolonged military conflicts like those in pre-modern Europe, this peace, marked by warlordism and a hostile political environment, was actually worse than before 1850s. In other words, the overall political environment and warfare during this period was actually worse than the previous peacetime periods of both the Ming and Qing Dynasties, which hardly helps to explain the decline in economic shrinkage at this time.

Overall, technology, structural change, and demographic change all played a role in reducing the Yangzi Delta's economic shrinkage between 1865 and 1936.

[39] The central government publicly supported the Boxer Rebellion (义和团) in 1900, which sought revenge on the West. Fearing local exposure to the northern retaliation, ten provinces along the south-east coast declared that they would not accept the central government's orders.

Technological and demographic change likely dominated 1865-1910. In the period 1910-1936, it was all three, resulting in a simultaneous reduction in the frequency of shrinkage and the rate of change of the shrinking years.

What fundamental changes occurred in the Yangzi Delta prior to the 1850s that caused the aforementioned factors to differ from the past? The answer is the introduction of Western "things". (1) The structural changes that occurred after 1910 could actually be attributed to the high rate of sectoral output growth caused by the establishment of a large number of new enterprises. The introduction of Western technology was in fact the driving force behind these enterprises. (2) Demographic change was largely driven by structural change. This is because GDP growth outpaced population growth to a large extent, owing to structural changes in the non-agricultural sector, particularly during a period when the agricultural sector was heavily influenced by climate. (3) The introduction of Western institutions into the Treaty Ports, or what Broadberry and Wallis refer to as the ultimate causes, is what had, on the other hand, continued to allow the new technology to take hold. (4) In short, these causes interacted, and the common denominator behind them can be considered technology and institutions, i.e. the "new things" brought by the West.

So, which was more significant in those "Western things" for reducing economic shrinkage during this period: technology or institutions? Let us first perform a rough growth accounting. According to the above, from 1865 to 1936, GDP grew 1.07 percent per year, labour 0.87 percent, and land 1.40 percent. To calculate total factor productivity, we need capital growth rate. I will give a rough conjecture first. From 1910 to 1930, China's fixed capital growth rate was at least 1.4 percent per year (Rawski, 1989: 260). But even using the 1.4 percent growth rate of the average Chinese bottom line as the bottom line for capital growth in the Yangzi Delta from the 1910s to the 1930s far exceeds my previous estimates of agricultural capital growth (Figure 3.8, Chapter Three). To some extent, this is understandable. In fact, total capital growth in the early twentieth century was primarily driven by the non-agricultural sector (Rawski, 1989:

Table 5.4 Growth accounts of the Yangzi economy, 1866-1936 (% per year)

	GDP growth	Due to Labour	Due to Land	Due to Capital	TFP growth
1866-1936	1.07	0.52	0.28	0.61	-0.34

Sources and notes: For data, see the text. The labour, land and capital shares are set at 0.6, 0.2, 0.2 and the growth rates are 0.87 percent, 1.40 percent, 3.07 percent. The production function takes the classical neoclassical growth form.

260). In the 1930s, Shanghai absorbed half of China's business FDI. FDI growth in China averaged 4.3 percent per year, compared to 8.3 percent in Shanghai (Keller and Shiue, 2020, 2022; Ma, 2008). Much of the investment in the Yangzi Delta went into non-agricultural sectors. This ensures that overall capital growth outpaced that of the agricultural sector. Overall, we should have little difficulty assuming an annual growth rate of 1.4 percent as the lower bound for capital growth in the Yangzi Delta.

But after that, I also make an effort to estimate capital growth. This attempt is predicated on the assumption that capital revenue as a share of GDP remains constant. If this assumption holds, then the growth rate of capital is roughly equivalent to the growth rate of GDP (capital revenue) minus the growth rate of the rate of return on capital, based on the accounting equation that the total amount of capital multiplied by the rate of return equals capital revenue. From 1873 to 1932, interest rates in the Shanghai local financial market grew by about -2 percent annually (Kong, 1988: 478-481), while my data suggests that Yangzi Delta GDP grew by 1.07 percent, implying that local capital grew by 3.07 percent. If we assume a common form of 0.6, 0.2, and 0.2 for the shares of labour, land, and capital, then the TFP growth rate is -0.34 percent per year, implying that the three traditional factors can explain all local economic growth. Even without trusting the capital calculations, a TFP of 0 requires a capital growth rate of 1.34 percent per year. This is also less than the previous lower bound. In other words, if total factor productivity growth needs to be positive, capital growth must be less than this figure. However, this capital growth rate implies almost no decline in the local rate of return to capital. It was not the case in Shanghai; over this time, the interest rate in Huizhou, a nearby city, also significantly decreased (Chen, Peng and Yuan, 2016). Although

interest rates cannot be fully equated with returns to capital, with the development of local financial markets after the nineteenth century (Ma, 2019; Ma and Zhao, 2020; Palma and Zhao, 2021), the long-term decline in rate of return on capital should not be questioned.

This means that TFP's contribution to Yangzi economic growth after 1865 might be much smaller than previously thought. While it is true that economic growth in this period entered a new paradigm relative to itself, it was still primarily driven by the traditional three factors, especially capital. But does this mean that technology were unimportant? It is difficult to provide a cautious answer, at least in this case. While capital growth was significant, the investment process itself contributes to technological progress, particularly in the early stages of industrialisation. However, if we consider technology as input-output efficiency improvements, also known as TFP, it is clear that technology might not have been as important in this period. This is counter-intuitive, especially since technological diffusion barriers were much lower in this period. In the 1930s, Shanghai's streets were filled with the newest Western items and innovations. However, if this "efficiency gains" in economic growth were not significant, it is possible that these new technologies were not well utilised despite being introduced.

As a result, institutional considerations are thought to be more important in explaining the reduction of "negative fluctuations" during this time than others. What, exactly, are these institutions? How may "negative fluctuations" be reduced? These questions may go beyond the scope of this research. Better data for empirical research may be required to clarify these issues. Nonetheless, it may be useful to provide a rough discussion here. While this may not produce a clear answer, it can still be useful in understanding the institutional changes that occur throughout this time. From the mid-19th century, when China formally began to introduce Western institutions on a wide scale, until the 1930s, Chinese society, economy, and politics witnessed enormous transformations (Deng, 2012). Fundamental institutions such as the imperial system and the method of selection

for officials underwent considerable changes. Clearly, identifying and analysing each institutional change in detail is outside the scope of this study. As a result, I will quickly discuss some significant institutional changes that occurred after the mid-19th century.

(1) To begin with, the abolition of the imperial system in late 1911 was one of the most fundamental political institutional revolutions in Chinese history. The Xinhai Revolution brought an end to the imperial system, which had existed for thousands of years. There were subsequent brief attempts at imperial restoration, such as the notorious but failed restoration actions of YUAN Shikai, the first president of democratic China, who had a penchant for the imperial system, and the empire established by the last emperor of the Qing Dynasty, which lasted for over a decade with the support of Japanese military forces in the 1930s. These restoration efforts, however, were virtually universally rejected by various political groupings in China and swiftly devolved into farces. Although it is still debated whether the 1911 revolution completely eradicated the imperial system and its ideology from China or whether China truly transitioned to a democratic system, it is undeniable that any efforts to restore the imperial system then had been called into question. The imperial system has definitely lost favour with the majority of Chinese political parties and the general population.

The importance of the shift from an imperial to a democratic regime for economic growth is a popular topic in social science literature. The most apparent conclusion is that democracy limits monarchy and so limits rulers' "extraction" of economic profit from the public. Centralised regimes may favour the financial interests of a limited elite. Thus, if the elimination of imperial system can provide a favourable environment for investment and innovation, as well as better safeguard the property rights of wealth holders and other economic participants, it may help alleviate economic uncertainty. Despite not directly addressing the specific political system, numerous studies have discussed similar logics theoretically or empirically (e.g., Acemoglu, Johnson, and Robinson, 2005b; Acemoglu, Naidu, Restrepo and Robinson, 2019; North, 1981, 1990; North and Thomas, 1973; North and Weingast, 1989; North, Wallis and Weingast, 2009;

Ogilvie and Carus, 2014). While the economic impact of the transition from an imperial to a democratic system is currently debated, if this change can promote the formation of institutions that protect property rights and contracts, its role in reducing economic uncertainty is certainly worth considering. However, there is still no agreement on the economic implications of the end of the imperial system in China and the Yangzi region. The economic impact of this institutional reform could be quite complex, but at least we can see some progress from a political standpoint. For example, the Qing Dynasty's famed political speech censorship, known as "Literary Inquisitions (文字狱)", harmed political diversity significantly (Xue, 2021)[40]. Following the collapse of the imperial system, many independent political groupings arose, seemingly broadening the scope of political participation (Zhang and Li, 1999). If increasing political participation can help formerly marginalised groups voice their concerns and preserve their property and innovation, it could be one of the causes for the lessening of negative economic fluctuations during this period. However, more extensive analysis is required in the future. I can only offer an analytical viewpoint and do not intend to deliver definite results.

(2) Another notable institutional change was the termination of the civil service examination system (*Keju*, 科举) in 1905. The change in this system, which had been used to select officials for roughly 1,400 years, could be another explanation for lowering economic uncertainty during this period. Many studies have demonstrated that civil service examination systems promote social mobility and human capital accumulation (e.g., Ho, 1962; Chen, Kung and Ma, 2020). But another perspective contends that despite these advantages, the examination's emphasis on Confucian classics actually restricted China's ability to invest in human capital in ways that would have accelerated technological progress. Many intellectual elites spent years studying Confucian philosophy, which appeared unrelated to the scientific revolution. If this argument is correct,

[40] Because the Manchu rulers lacked confidence in their legitimacy, they were very sensitive to the rhetoric of many Han Chinese intellectuals in China. These Han Chinese intellectuals' views were interpreted as political satire or an attack on the Manchu rulers. As a result, many people were imprisoned for voicing their views. Even some individuals who made utterances that had no political significance were also deemed to be ridiculing the rulers and were punished.

it could help explain late imperial China's technological stagnation (Lin, 1995). When the civil service examination system was abolished in 1905, "new-style schools" and novel methods of choosing officials were introduced. Students' educational material grew beyond conventional Confucian philosophy to include subjects such as physics, chemistry, engineering, medicine, and others, which became the new research fields chosen by the intellectual elites of the time. During this time, a slew of "Western-style" scholars appeared. According to this viewpoint, the termination of the civil service examination system prompted the "knowledge modernisation" of China's intellectual elites. The ramifications of this change may include not only direct technological progress but also, more crucially, future Chinese officials gaining information on scientific governance that their predecessors lacked. Possession of scientific knowledge for government management and the provision of public services could be one of the reasons for the weakening of the "negative fluctuations" during this time. My data, in particular, suggest that after 1910, the "negative fluctuations" in the Yangzi region were substantially weaker than between 1865 and 1910, which could be attributed to changes in the civil service knowledge system. However, as with the economic consequences of the imperial system's termination, validating such accounts falls outside the scope of this study, so I cannot infer that the abolition of the civil service examination system must reduce economic uncertainty. Nonetheless, it is a possibility to some extent.

(3) The Treaty Port System, the third form of institutional change, occurred earlier. This new system, strictly speaking, brought not just institutional changes to China. The Treaty Port System, which served as a symbol of China's opening to the world, initially debuted in China in 1843 (Yan et al. (eds.), 1955: 41-48). By 1930, around 105 cities had been opened to foreigners as trading ports. These ports not only had an impact on China's economy as trade centres, but they also served as windows for China to continuously embrace "new things" from around the world. Foreign direct investment (FDI), new technologies, Western goods, ideas, publications, and even Westerners themselves entered China through these cities. Shanghai, in particular, stood out as a representative port city, once becoming China's economic centre and similar in terms

of prosperity and modernisation to major metropolises globally. Empirical data (e.g., Jia, 2014) has confirmed the positive influence of this system on China's economy to some extent.

So, what are the institutional consequences of this system? There were huge residential areas for foreigners known as concessions in many major treaty port cities. These places not only served as foreigners' residential areas, but they were also ruled by foreign legal systems, especially the well-known extraterritoriality (治外法权). For example, British and French concessions in Shanghai implemented British common law and French civil law, respectively. Different legal systems did, in fact, had a major impact on these regions' economic development (Levine, Lin, Ma and Xu, 2022). Furthermore, the impact of these concessions stretched beyond their respective boundaries and had a large impact on the adjacent areas under Chinese government administration. In this respect, the concessions and the Treaty Port system served a standard institutional protection function, guaranteeing the protection of private property and the enforcement of contracts. For example, when the Beijing government announced in 1916 that the Bank of China and the Bank of Communications would suspend paper note and silver redemption due to a fiscal crisis, the Shanghai branch of the Bank of China, with the support of Western legal and financial organisations in Shanghai, refused to carry out this order and continued the paper note and silver redemption business. Due to Shanghai's more reputable atmosphere, China's financial industry and capital quickly migrated there (Ma, 2019). As I have stated, similar scenarios occurred during the Japanese Invasion period. Despite the fact that the Yangzi Delta was at war from 1937 to 1941, Shanghai's industrial and commercial sectors witnessed extraordinary growth. This was not due to any additional contributions from Japan, but rather to the relocation of numerous firms in the Yangzi Delta to Shanghai to avoid the effects of the Japanese war. The Shanghai concessions contributed to the unexpected rise of Shanghai's industrial and commercial sectors during the war years. However, with the Japanese seizure of the Shanghai concessions in 1941, Shanghai's industrial and commercial sectors fell rapidly. This plainly demonstrates another example of property rights protection brought about through

concessions. During China's warlord era, the Treaty Port system and its concessions effectively provided institutional protection, allowing the Treaty Ports and their surrounding areas to maintain a certain level of autonomy and independence, avoiding economic fluctuations caused by an unstable political environment. As a result, this is most likely one of the causes behind the Yangzi economy's decreased frequency and rate of change of negative economic fluctuations after the mid-19th century.

Of course, there were numerous other key institutional changes in China after the mid-19th century that may also help explain the reduction of economic fluctuations, such as the customs system. This system was handled by foreigners and operated independently of the tax system of the Qing government. The customs system's independence prevented embezzlement by the Qing administration, earning it a high reputation. As a result, for a long time, tariffs were high-quality collateral assets for the government's public debts, ironically assisting the Qing government in alleviating serious fiscal challenges. Additionally, fiscal decentralisation emerged as a significant transformation in China after the mid-19th century. The financial crisis brought upon the central government by the Taiping Rebellion was largely alleviated through increased levels of local autonomy and fiscal decentralisation. With greater fiscal flexibility and the influence of Western power at this time, local governments exhibited a series of uncooperative behaviours towards the central government, as exemplified by the previously mentioned Southeast Mutual Protection Incident. Recent empirical studies indicate that the consequences of this fiscal decentralisation might have influenced China's economy to some extent (Deng, 2021). The increased local autonomy potentially generated regional competition and decisions that no longer strictly adhered to the central government's interests, resembling a scenario akin to pre-19th century Europe as conceptualised by Rosenthal and Wong (2011). The shift from centralisation to decentralisation might have led to new changes in the local economy, weakening the occurrence of "negative fluctuations". However, it is important to note that this speculative assertion is crude in nature and requires rigorous empirical evidence for confirmation. Here, I am merely presenting a possible analytical perspective.

I cannot evaluate the influence of all institutional changes in a single research, but the examples above illustrate the potential role of institutional changes over this period. In other words, we have grounds to believe that these institutional improvements, mostly due to the Western shock, did, to some extent, help to minimise the unfavourable aspects of China's economic growth process. The Yangzi Delta, being the region with the largest treaty port city, was probably more severely affected than other places in China.

In any case, the Western shock might have affected local growth in terms of reducing shrinkage or the "negative fluctuations" through institutions, investments, and technology. It is difficult to discuss institutions, investments, and technology separately. Many things are highly correlated. There is no doubt that the Yangzi Delta experienced unprecedented growth during this period, but growth accounting shows that the traditional three factors (labour, land, and capital) still contributed nearly all of the GDP growth. In other words, the path to modern economic growth was still in its early stages, and it was still a long way from the more critical stage of economic growth driven by input-output efficiency improvement.

5.3 Modelling economic growth: Malthus, Boserup, and Smith

We now have a clear picture of the Yangzi Delta's economic growth process over several centuries. Then, could this be depicted in some models? This is at the heart of the debate between the Involution and California Schools. The former sees the Yangzi Delta's economic growth as a classic pre-modern model, a Malthusian story. The latter believes it is self-sustaining economic growth, free of the Malthusian story. In this part, I talk about the Malthusian, Boserupian, and Smithian models as they apply to the Yangzi Delta.

5.3.1 Was the Yangzi Delta in a Malthusian trap?

This section attempts to discuss a well-known subject, the Malthusian trap. Was the Yangzi Delta economy in a Malthusian trap? However, it is not universally agreed that China would follow this very common pattern of growth seen in pre-modern economies (e.g., Lee and Campbell, 1997; Lee and Wang, 1999; Liu, 1992). There are two opposing viewpoints on the Yangzi Delta in particular: one supports the Malthusian model (e.g., Brenner and Isett, 2002; Cao and Chen, 2000; Chen and Cao, 2003; Huang, 1990), while the other opposes it (e.g., Lee and Wang, 1999; Wang and Lee, 2002; Li, 2003; Pomeranz, 2000). Both sides have found information that appears to support their points of view in a large number of historical narratives. The lack of a reliable per capita income figure fuels the debate. The region's economic performance was a mystery for quite some time. Was it an involution or a revolution? I do not intend to differentiate between the specific arguments of these two points of view in this section. I will simply try to answer this question using the data gathered in this study.

The Malthusian model is commonly used to explain the relationship between population and per capita income in the pre-modern world. The main idea is that population growth will outpace resource (or land) growth, resulting in per capita income reaching the subsistence floor. The unique aspect of the Malthusian model is a closed feedback loop between population growth and per capita income, whereby shocks to income will result in an increase in the birth rate and a decrease in mortality. Population growth will accelerate as a result. Rapid population growth will then reduce previously increased per capita income until the population stops growing. Even pre-modern economies could not be fully Malthusian. Early Malthusian escapees include England and the Netherlands. But this simple logic linking population and per capita income did happen many times throughout history. Following the Black Death, a number of traditional European economies followed a Malthusian growth path (Madsen, Robertson and Ye, 2019).

The following is a mathematical form commonly used in empirical literature to describe the Malthusian trap (e.g., Crafts and Mills, 2009; Lee and Anderson, 2002; Pfister and Fertig, 2020):

$$y_t = A_t X_t^{\theta} P_t^{-\theta} \tag{5.1}$$

$$b_t = a_1 + \beta_1 y_t + e_{1t} \tag{5.2}$$

$$d_t = a_2 + \beta_2 y_t + e_{2t} \tag{5.3}$$

$$P_t = P_{t-1}(1 + b_t - d_t) \tag{5.4}$$

where y_t denotes per capita income, P_t denotes population, X_t denotes various inputs to the production function such as land or capital, and A_t denotes things other than traditional inputs such as technology, institutions, or human capital. Furthermore, θ refers to the Cobb Douglas production function's output elasticity on rest inputs other than population. The letter *t* stands for time. In fact, equation (5.1) is the transformed version produced by dividing the population by both sides of the traditional Cobb-Douglas production function. Different production functions can be modified in the same way. For the sake of brevity, I use the Cobb-Douglas form here. In the literature, equation (5.1) can alternatively have the following forms:

$$w_t = c_t - \alpha l_t \tag{5.5}$$

where w_t is the real wage; l_t is labour supply, which in many literatures approximates population; c_t is labour demand, which is sometimes used as a proxy for technology; and α is the coefficient, which is typically thought of as the elasticity of wages against labour supply. However, I have no plans to use this format. On the one hand, the per capita income I use is GDP per capita rather than pay per capita. In fact, per capita GDP includes non-labour income, which is more representative of the real world. On the other hand, equation (5.5) can be calculated from the first derivative of the population from the Cobb-Douglas function of equation (5.1), therefore there is no fundamental difference. To be more consistent with the description of this study, I choose the form of equation (5.1).

The settings listed above are for the production side. Equations (5.2) (5.3) (5.4) define the population reproductive proecess. b_t is the crude birth rate, β_1 is the preventive check coefficient, a_1 is the long-term factors impacting fertility, such as changes in culture or reproductive behaviour, and e_{1t} is the temporary short-term shock to fertility. The story of mortality is stated in Equation (5.3). d_t denotes the crude death rate, β_2 the positive check coefficient, a_2 the long-term factors influencing the death rate, and e_{2t} the transitory short-term shock influencing mortality. The process of population expansion is depicted in Equation (5.4). It is worth noting that immigration does play a significant role. However, for the sake of brevity, the following explanation assumes that immigration is fixed or has little impact. Such assumptions have no bearing on the overall logic of the story.

In equilibrium, if per capita income improves, the birth rate in equation (5.2) increases while the death rate in equation (5.3) declines, resulting in an increase in the population growth rate. As a result, the population in equation (5.4) grows proportionally. Returning to equation (5.1), the outcome is that if other elements, like as land, capital, or technology, do not keep pace with population increase, per capita income will eventually fall until population growth catches pace with the rise of other inputs. In other words, equation (5.1) conveys the so-called Malthusian tale, which states that if population growth outpaces resource availability, any gain in per capita income would be ephemeral. It depicts the connection between population and per capita income. If, in the long run, we want both population and per capita income to increase, this means that other inputs, such as resources and technology, must expand at a faster rate than population in order to avoid the Malthusian trap. One of the underlying assumptions is that there may be a long-term limit to the increase of land or capital, such that only sustainable progress in technology will allow other factors impacting output to outstrip population.

In terms of how the population grow, whether it satisfies the Malthusian preventive or positive check is not the most important factor. It is rare to fulfil both the preventive check and the positive check, but this just means that β_1 or β_2 equals zero. It just slo-

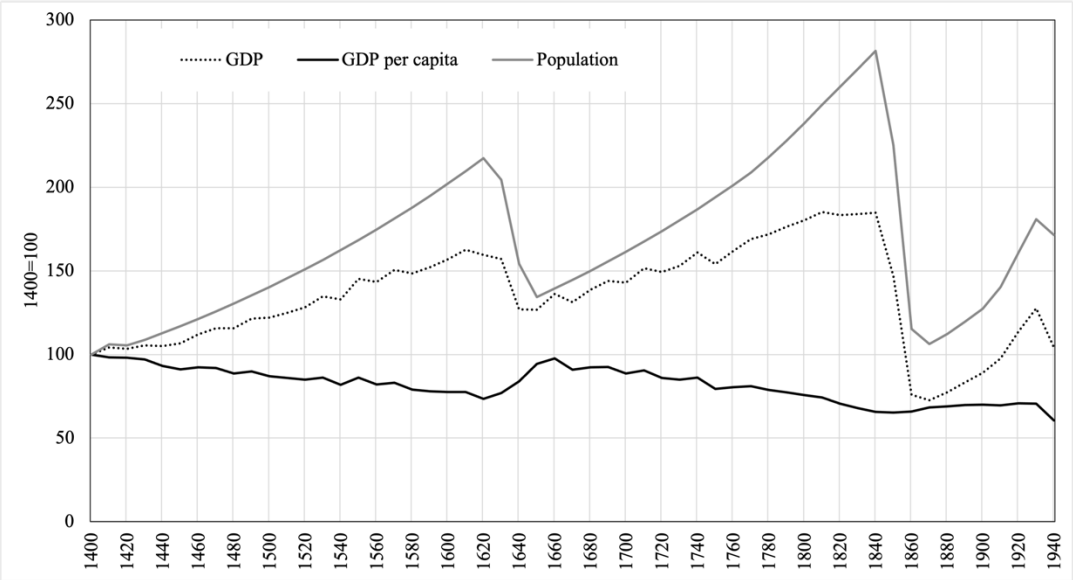

Figure 5.2 GDP, population and GDP per capita in the Yangzi Delta, 1400-1940 (averages per decade, 1400=100)

Sources: Appendix E.

ws the Malthusian feedback mechanism, resulting in a minor influence of income on population growth. However, as long as we assume pre-modern technology or resource growth to be finite and human preference for reproduction to be a normal condition of affairs, equation (5.1) will eventually serve to demonstrate the Malthusian trap. In other words, this is consistent with the core Malthusian idea that population rises geometrically, food supply or resources grow arithmetically, and resources or income per capita diminish with time. Then, as soon as we see an increase in both population and per capita income, we can conclude that the economy is no longer a Malthusian model. Back to Yangzi, the Yangzi Delta lacks birth and death data, making it difficult to test the Malthusian preventive and positive checks. This, however, has no bearing on whether the Yangzi Delta was caught in a Malthusian trap. Even if the preventive and positive checks were not always fully satisfied, as long as there is a long-term or sustainable simultaneous increase in population and per capita income, it can be considered to be out of the Malthusian trap (Broadberry et al., 2015; Clark, 2005). We only need to look at the relationship between population and GDP per capita.

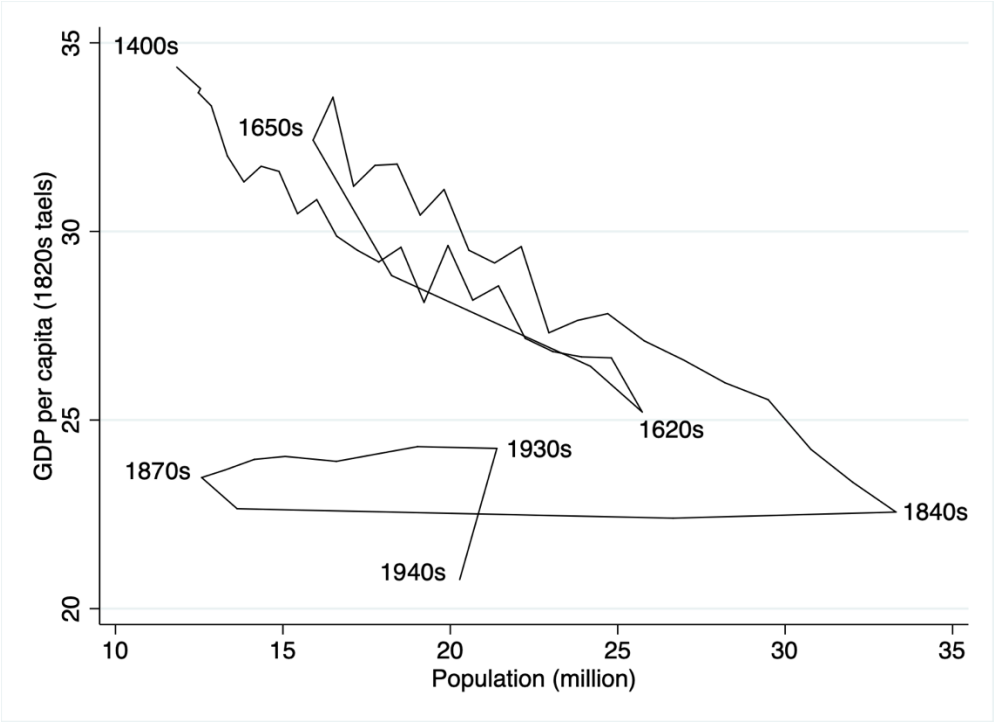

Figure 5.3 Chronological relationship between GDP per capita and population, 1400-1940 (average per decade)

Sources: Appendix E.

Was the Yangzi Delta caught in a Malthusian trap? According to the above analysis, the local economy seemed to fit the Malthusian model of "population growth swallowing up economic growth" before the mid-19th century. While the population increased, the GDP per capita fell. For the first time after 1865, GDP per capita was positively correlated with population growth. Figure 5.2 shows the Yangzi Delta's decadal average population, GDP, and GDP per capita. Long-term population growth clearly exhibited an inverse relationship with GDP per capita. This relationship lasted until the late 19th century.

Figure 5.3 depicts the relationship between population and GDP per capita in chronological order. Local population and per capita income were negatively correlated throughout the Ming and Qing Dynasty. Land or resource growth was too slow to offset population growth's negative effects on per capita income. The temporary rise in per capita income, like the Ming-Qing Transition, also followed a Malthus-like model. The

inverse relationship lasted until the Taiping Rebellion in the mid-19th century. There was no change in per capita income because the Taiping destroyed the population and land to the same extent. Until the 1870s, economic growth in the Yangzi Delta followed the a Malthus-like model, with population growing faster than GDP. In contrast to the California School, it may adhere to what Philip Huang refers to as the Involution model. After 1870, things changed. Population and per capita income increased simultaneously for the first time. Is this, however, proof that the local economy totally escaped the Malthusian trap? Perhaps not. Despite the fact that population and GDP per capita were no longer inversely related during this period, the Yangzi Delta was still far from Clark's (2005) strong positive relationship when Britain escaped the Malthusian trap. One can only say that the pre-1870 Malthusian mechanism changed. GDP per capita growth was slow and barely above stagnation.

Population growth that swallowed up most upward economic shocks put the Yangzi Delta's economy in a Malthus-like model until the 20th century. However, per capita income did not stagnate as predicted by the classical Malthusian model. Long-term per capita income decline in the Yangzi Delta suggests that the Malthusian closed-loop effect may be weak here. That is, the Malthusian reproduction mechanism of "poorer, more deaths; richer, more children" failed due to a missing preventive or positive check mechanism. Birth and death rates may be needed to test this hypothesis. Some intuitive tests can be made despite the poor quality of Chinese data in this area. Peng and Hou (1996) examine male vital data from a Yangzi Delta commoner household. They find that male mortality rates were strongly correlated with rice price fluctuations, but birth rates were not. This may indicate that Malthusian positive checks are more important in the Yangzi Delta and explain the demographic feedback mechanism's insignificance. In other words, because the deterioration in economic conditions did not cause the birth rate to fall, the upward correction from the birth rate was so weak that it could not prevent further declines in per capita income. However, conclusions about the Malthusian model of population reproduction based on imperfect Chinese micro-evidence may need to be treated with caution.

Can we now conclude that the Yangzi economy's growth pattern corresponds to the Malthusian model? The answer might not be so simple. Although our empirical data demonstrate that the Yangzi region's population and per capita GDP did not enjoy simultaneous long-term increase, particularly before the 1870s, this is insufficient evidence for labelling the Yangzi economy as a "Malthusian economy".

(1) As previously stated, testing a typical Malthusian model necessitates data on birth and death rates because population reproduction is one of the most significant mechanisms in the Malthusian model. Population reproduction that does not conform to the Malthusian model (preventive or positive check) has no effect on the emergence of simultaneous population and GDP per capita growth, but this is clearly no longer a typical Malthusian economy. And the previous paragraph's discussion demonstrates that the Yangzi Delta's population reproduction pattern did not suit the preventative or positive check story perfectly.

(2) Second, and more crucially, a typical Malthusian model frequently predicts that long-term per capita income will remain at a subsistence level. In other words, the so-called positive check will lead to population decline as long as per capita income falls below the subsistence level. However, there is little indication that the Yangzi region's per capita income was sustained at such a low level. In international comparisons, the frequently accepted subsistence level is 1 international dollar in 1990 per person per day, or 400 international dollars in 1990 per capita GDP. Even during the period when China average GDP per capita was at its lowest, Chinese GDP per capita was much greater than this criterion (BGL, 2018; Ma and de Jong, 2019; Xu et al., 2017). Furthermore, the Yangzi Delta's per capita GDP was significantly greater than the national average.

(3) Third, the typical Malthusian model frequently implies that increases in per capita income due to technological advancements will be swallowed by population expansion,

ending in complete stagnation in economic development. However, my account of Yangzi agriculture in Chapter Three reveals several labour-intensive advances that have occurred over centuries in the face of continuous population growth. Although these innovations did not enhance input-output efficiency or labour productivity considerably, the absence of these "new things" would have resulted in a 20 percent reduction in per capita income for Yangzi peasant farmers. This suggests that there is no evidence that population increase completely swallowed technological progress in the Yangzi region. Furthermore, in the 1870s, the entrance of more "new things" from the West resulted in a steady and gradual concurrent growth in population and per capita GDP in the Yangzi Delta, which is far from typical of a Malthusian model.

To summarise, there was a long-term lack of synchronised growth between population and per capita GDP in the Yangzi Delta, which corresponds to the key beliefs of the Malthusian model. However, upon closer inspection, the Yangzi economy differs in many ways from the traditional traits of a Malthusian system. It might be loosely referred to as a developed Malthusian economy. To be more rigorous, I am inclined to adopt Mark Elvin's concept of the "high-level equilibrium trap" to characterise the Yangzi Delta's economic growth process. It refers to a situation in which developed labour-intensive technologies contribute to a sustained increase in population density and the maintenance of a relatively high level of per capita income, while the trend of per capita income growth remains flat, accompanied by a scarcity of capital-intensive technologies. The scenario in the 1870s is a good example of this. As previously discussed, the Yangzi economy entered a new period of weak concurrent growth in population and per capita GDP following the 1870s. This marks the beginning of the move from the "high-level equilibrium trap" paradigm to the modern economic growth or industrialisation model. As a result, the "high-level equilibrium trap" economy appears to be located somewhere between the slower economic development of a typical Malthusian model and the quicker economic growth of a modern economic growth model. The sections that follow will help to enhance my judgement of the Yangzi economy's "high-level equilibrium trap" characteristics.

5.3.2 Was there a Boserupian agricultural revolution?

The Yangzi Delta had been trapped in a Malthus-like model for centuries, but this does not necessarily imply that there was no change in the local economy. As I discuss in Chapter Three, double cropping, soybean fertilisation, cattle rearing in agriculture (Li, 1998, 2010b), seasonality of labour or the Chinese style "industrious revolution" (Ma and Peng, 2021, 2022), and well-performing market integration were notable features of the local economy (Pomeranz, 2000; Shiue and Keller, 2007). Economic pressures caused by population growth might also create new opportunities for growth. Similar changes in agriculture with progress in labour-intensive technology are often referred to as Boserupian Growth (Boserup, 1965), whereas the explanation that population growth promotes market development through the division of labour is commonly referred to as Smithian growth (Kelly, 1997). To some extent, there are two forces in population growth that influence economic growth, namely the pros and cons.

So did Yangzi agriculture undergo the so-called Boserupian revolution, characterized by the emergence of labour-intensive agricultural innovations in response to population growth and the downward pressure on per capita income, also known as the so-called intensification concept? My detailed discussion on agriculture in Chapter Three demonstrates that Yangzi agriculture did not experience complete stagnation; numerous agricultural innovations did emerge alongside population growth. These "new things" did contribute to an overall increase in total income for local peasant farmers. From this perspective, we can consider Yangzi agriculture to align with the growth pattern proposed by Boserup.

However, I also identified limitations in this development pattern in Chapter Three. In reality, the various innovations in Yangzi agriculture had limited effects on improving input-output efficiency or productivity. This suggests that this pattern has a ceiling on productivity growth compared to the "explosive" productivity growth witnessed after the Industrial Revolution in Europe. From this standpoint, it is likely that Yangzi pattern

might not be able to support its transition into a modern economic growth model similar to Europe, particularly without external interventions. Although this assertion may appear somewhat unproven or too definitive, at the very least, the innovations in Yangzi agriculture did not have demonstrated a "revolutionary" increase in labour productivity. In other words, the growth resembling the Boserupian pattern observed in Yangzi agriculture may not be perfect or sustainable.

As a result, we should evaluate Yangzi agriculture' growth pattern with caution, recognising its contribution to increasing per capita income while avoiding overestimation of its role in propelling Yangzi towards a path of modern economic growth characterised by sustained labour productivity growth.

However, when assessing the influence of this Boserupian-style growth in Yangzi agriculture on productivity, care is advised. In Chapter Three, I discovered that there was essentially no long-term growth in Total Factor Productivity (TFP) in local agriculture using a growth accounting methodology. One difficulty is that my estimate of capital growth was really sloppy. In this section, I thus fully respect the available evidence and relax the assumptions in my calculations as much as possible.

Then, rather than using Total Factor Productivity, I calculate the input-output efficiency of agricultural growth using only population and land data (hence, Multifactor Productivity or MFP). To maximise MFP growth, I do not even use double-cropped lands in my land factor. My land input is the size of the cultivated land without double cropping, while my labour input is workdays. When double-cropping, fertilisers, irrigation, and other factors come into play, they will all be clearly displayed in the MFP. Figure 5.4 shows the results of the calculations. For the sake of brevity, I use data from a 10-year averages. Labour and land shares are still 0.6 and 0.4. This is reasonable if land rents reflected marginal production. Indeed, in the following discussion, I have relaxed this assumption without affecting the final conclusions.

Labour and land explained most agricultural output until 1750 because input and output indices were broadly consistent. This bleak outcome is also visible on the MFP line, where output is divided by input. MFP appeared to have increased slightly or not declined significantly during the Ming dynasty, which is consistent with the findings of my agricultural TFP calculations in Chapter Three. That is, agricultural input-output efficiency might have increased during the Ming Dynasty. This increase was unsustainable, and by the Qing Dynasty MFP was clearly declining. Even after 1750, the continuing decline in MFP caused a divergence between the input and output series. Inputs had begun to outstrip outputs in comparison to the situation prior to 1750, implying a steady decline in agricultural MFP after 1750. This also corresponds to my TFP estimates. Although the calculations in this section have been relaxed compared to Chapter Three, and I have tried to show the role of those new changes beyond labour and land, the calculations still do not support the idea that these new changes could significantly affect agricultural growth in terms of input-output efficiency. As I concluded in Chapter Three, progress in double cropping, fertiliser, irrigation, etc. cannot be denied, but it is clear that these developments did not increase production as much as expected.

Relaxing labour and land share assumptions does not change the above conclusions. Because land grew more slowly than labour most of the time, the growth of labour productivity and land productivity followed two distinct patterns. If we assume an extreme scenario in which one of labour or land contributes nothing to output, i.e. the share is zero, then labour productivity and land productivity are the most pessimistic and optimistic cases of MFP or TFP. In the worst case, when land is completely useless, the labour productivity index can represent new technologies and methods, showing a continuous downward trend. When labour does not enter the production function, land productivity can reflect the most optimistic technological progress scenario: there was some modest growth before the Qing Dynasty, likely due to intensive technologies.



Figure 5.4 Agricultural output, input, multifactor productivity, labour productivity and land productivity, 1390-1950 (averages per decade, 1390=100)

Sources and notes: Agricultural output data, see Appendix E. Inputs data are from agricultural labour and cultivated land. The shares of labour and land were set to 0.6 and 0.4, which in line with Liu and Hwang (1979) and Perkins (1969). Agricultural labour inputs data comes from Chapter Three. Land data is taken from Chapter Two. MFP refers to multifactor productivity, that is, output divided by weighted inputs. All variables are set to 100 in 1390.

However, after the mid-Qing period, even such optimistic calculations must admit that agricultural production was indeed much less efficient than before. In the real world, land could not supply 100 percent of agricultural inputs. As a result, the situation would only worsen.

To a large extent, there is reason to believe that agriculture in the Yangzi Delta did not make as much technological progress in terms of improving input-output efficiency as might be expected. In other words, the progress shown in the literature is either a minor contribution or the result of some effort to avoid decline in per capita output. For now, and in light of Chapter Three, we can argue that these technological improvements might have only kept per capita situation from falling sharply. In other words, the benefits of this growth process in the Yangzi Delta characterised by Boserupian traits should not be overstated. It has clear advantages and disadvantages.

5.3.3 Was there a Smithian economic growth?

Smithian growth and Boserup's emphasis on agriculture differ slightly. While both emphasise population increase as a possible source of technical innovation, Smithian growth focuses on the implications of population growth on labour division and market expansion. Indeed, as previously stated, Smithian growth may have similar results to Boserupian growth in the Yangzi Delta. To some extent, qualitative evidence suggests that Smithian growth traits, such as proto-industrialisation and the rise of market towns, were present in the Yangzi region. However, economic outcomes like the improvement of market integration and input-output efficiency seemed minor.

I will then briefly discuss pertinent empirical findings. Due to the difficulty in getting division of labour data, explicitly testing Smithian growth is difficult. However, evidence from market integration may help us comprehend Smithian growth in the context of the Yangzi region to some extent. To begin, empirical evidence about market integration may not fully align with the Smithian model outcome presented by the California School. This pessimistic scenario is supported by Gu and Kung's (2021) Chinese grain market study. In their paper, population growth hinders market integration, especially in food exporting regions. Although the negative correlation for non-grain export locations is not statistically significant, the coefficient remains negative, or at least does not show a positive role for population in market integration. It cannot be said that they have reversed Smithian growth in pre-modern China, but it is sufficient to suggest that the negative side of population appeared to be greater, at least in terms of markets. Their research also claims that market integration in the Yangzi Delta deteriorated between 1736 and the mid-19th century, when the local population was at its fastest pre-modern level. The real increase in market integration did not occur until the late 19th century. After 1890, price adjustment in the Yangzi Delta doubled in a decade. One of the best direct records of Chinese economic history is the data on the price of grains. Not only Gu and Kung, but other studies using this data have reached similar conclusions from different perspectives (Bernhofen, Eberhardt, Li and Morgan, 2017).

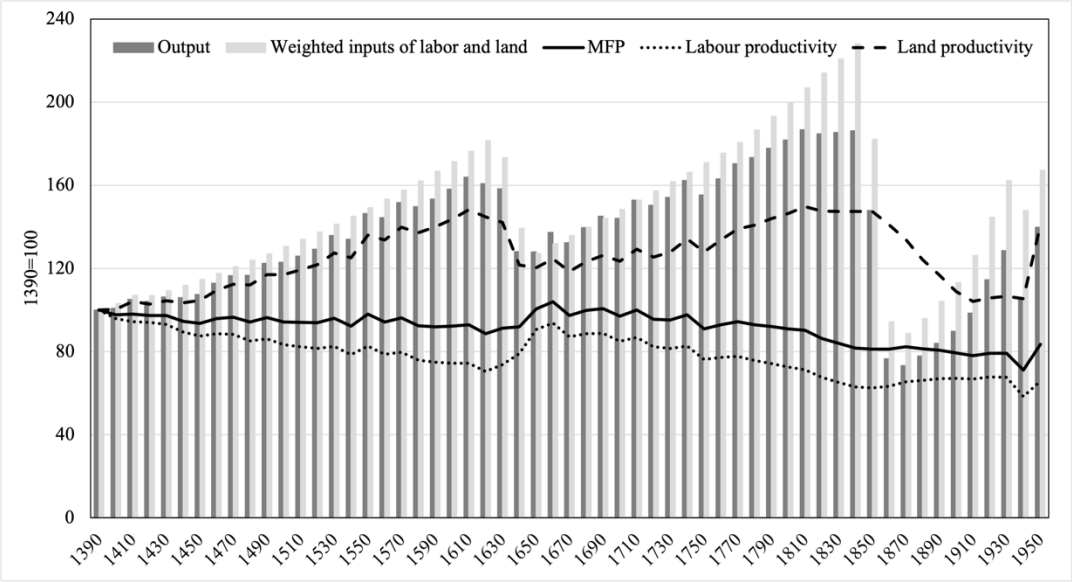

Figure 5.5 GDP, input, multifactor productivity, labour productivity and land productivity, 1390-1950 (averages per decade, 1390=100)

Sources and notes: GDP data, see Appendix E. Inputs data are from labour (population) and cultivated land. The shares of labour and land were set to 0.6 and 0.4. Inputs data come from Chapter Two. MFP refers to multifactor productivity, that is, output divided by weighted inputs. All variables are set to 100 in 1390.

Next, I use the same method as in the previous section to estimate multifactor productivity for the Yangzi Delta economy. The only difference between this calculation and the agricultural calculation is that the output is changed from agricultural output to GDP and the labour force is changed from workdays to population. Labour and land factor shares remain 0.6 and 0.4, respectively. The extreme cases of assuming a 0 share for labour and a 0 share for land are also shown, i.e. land productivity and labour productivity, as in the previous section. Figure 5.5 depicts the results, which show that MFP fell virtually over several centuries. Of course, if land were the only input factor, MFP would have increased. Even if this were true, land productivity increased little during the Qing Dynasty. Still, it is unrealistic to think land was the only input. Labour was always more important than land. If all input factors were assumed to be labour, MFP would have declined more rapidly. For the most part, population and land accounted for all economic growth. Thus, there is no evidence of improved input-output efficiency. This means that, while Smithian growth features might exist, evidence of their

enhancement of input-output efficiency has not been discovered. In other words, consistent with the earlier discussion of the Yangzi region's limited productivity gains in the Boserupian model, even if there are examples of Smithian growth in the Yangzi Delta, relying on this pattern of growth is likely to make it difficult for the region to transition to modern economic growth. As a result, we must proceed with caution when assessing the presence of Smithian development features in the Yangzi Delta's economic growth process.

5.3.4 Summary

To summarise, it appears that no single label-based model can adequately capture the Yangzi Delta's economic growth process. (1) While the Malthusian model adequately depicts the long-term link between population and per capita GDP in the Yangzi Delta, it fails to capture the region's continuous innovation and consistently high per capita GDP levels. (2) To some extent, the potential drop in per capita GDP caused by population growth is mitigated by the labuor-intensive innovations driven by population growth in the Yangzi Delta, which are explicable by the Boserupian and Smithian models. However, the Yangzi Delta's "new things" did not improve Total Factor Productivity (TFP) or long-term labour productivity. This implies that these innovations did not "revolutionarily" transform the economy. Given that technological progress, which promotes economic growth, usually entails large productivity gains, these "new things" in the Yangzi Delta did not appear to have fully contributed to persistent positive trends in per capita GDP. As a result, it cannot be classified as strictly Boserupian or Smithian growth.

The exploration of the three primary growth models highlights the complexities of the Yangzi Delta's story, which may be insufficiently expressed using label-based language. Clearly, the Yangzi economic growth is more optimistic than the Malthusian model predicts, but it does not entirely line with either the Boserupian or Smithian growth models because continuous per capita output growth was not witnessed. In other

words, while these "new things" had the potential to contribute to per capita GDP growth, continual population growth offset this by keeping per capita GDP decreasing. The interaction of these competing factors produced long-term stagnation or even a fall in per capita GDP. As a result, the positive driving force of these "new things" should not be overstated.

In this context, I prefer the phrase "high-level equilibrium trap", as given by Mark Elvin when summarising pre-modern Chinese economic growth process. The "high-level equilibrium trap" describes a scenario in which population growth increases the overall size of the economy, which is accompanied by labour-intensive innovations that offset the negative effects of population growth on per capita output, allowing a high level of per capita income to be maintained. As a result, the economy is not stagnant. However, this paradigm may not contribute to structurally improving labour productivity in the same manner as capital-intensive technologies do, resulting in no long-run trend growth in labour productivity. Without external forces, the economy may remain at a high level within pre-modern resource constraints and technological levels, but it may not move into a growth model dominated by capital-intensive technologies, as witnessed in Western Europe. The term "high-level equilibrium trap" would be a good way to describe the Yangzi economic growth process. Nonetheless, the preceding discussion emphasises the complexity of China's or the Yangzi Delta's economic growth process, cautioning against oversimplifications with label-based growth models present in the literature.

5.4 Conclusion

This chapter uses GDP data to analyse the Yangzi Delta's economic growth over several centuries. (1) There is no doubt that the Yangzi Delta is one of China's most developed regions and thus can represent China in international comparisons, i.e., the topic of the Great Divergence. (2) Using any single label such as Malthusian,

Boserupian, or Smithian to describe the economic growth process of the Yangzi Delta may not be appropriate. Overall, the economic growth of the Yangzi Delta before the 1870s is better summarised by the concept of a "high-level equilibrium trap". Specifically, it aligns with the predictions of the Malthusian model in terms of long-term per capita GDP growth trends. However, the economy was not entirely characterised by Malthusian-style long-term stagnation, as continuous innovation had consistently countered the downward trend in per capita GDP caused by population growth. This could be seen as a reconciliation point between the Involution School and the California School. (3) After 1870s, the Yangzi economy experienced a new pattern of growth in which population and GDP per capita increased concurrently for the first time. The introduction of Western technology, a significant change in economic structure, and a weakening of the Malthusian effect all contributed to a significant reduction in economic shrinkage during this period. It is possible that institutional change was the driving force behind this. However, this period cannot be considered a period of modern economic growth. Traditional input factors such as labour, land, and capital remained the primary drivers of economic growth. Gains in the so-called "economic efficiency" (TFP) were virtually nonexistent. This means that the growth style was still very much pre-modern. Indeed, while the Yangzi economy might still be stuck in a "high-level equilibrium trap", the situation was steadily changing in comparison to prior centuries. This could be viewed as the first step in the Yangzi Delta's transition to a path of modern economic growth, or as a formal escape from the centuries-long "high-level equilibrium trap".

CHAPTER SIX: INTERNATIONAL COMPARISONS: THE YANGZI DELTA IN THE GREAT DIVERGENCE

6.1 Introduction: returning to the California School issue

In this chapter, I will examine the Great Divergence by placing Yangzi Delta's economic growth in an international context. As I mentioned in Chapter One, East-West comparisons have persisted for centuries. Due to the lack of a standard methodology and knowledge of historical economic development, many of these comparisons are subjective and vague. For a long time, therefore, the East's backwardness was treated as an unavoidable default. Explaining why the East failed and the West succeeded became one of the most popular topics, with many schools of thought focusing on technology, institutions, geography, culture, and so on. Only in the last two decades has a body of evidence-based quantitative work, such as global historical economic growth accounting along the traditional research framework of Colin Clark, Simon Kuznets, Paul Bairoch, and others, initiated by Angus Maddison, gone some way toward answering this long-standing question.

The California School approach East-West comparisons in a more direct manner than Maddison and others who focus on cross-national database construction. At about the same time as Maddison, the California School made its most notable contribution to answering the more fundamental question of when Eastern economies lagged behind Western ones. This School—represented by Pomeranz—published studies that challenge conventional wisdom. They were trying to draw attention to the East economy and were making assumption that the economic divergence between the East and West did not occur until much later. Although these assumptions were challenged in the following two decades, the California School raised the question of how to make international comparisons.

(1) the Maddison Project's historical economic growth data was based on contemporary national boundaries. However, comparing large economies like China and India to Britain or France can be problematic. Pomeranz claims that the Yangzi Delta, one of China's most developed economies, was comparable to Britain in the 18th and 19th centuries. Such comparisons between the most developed economies of the East and West can help to provide a more accurate picture of the long-term development of the global economy. His new comparison object later became a consensus.

(2) The California School's emphasis on quantitative evidence for international comparative issues is another important contribution. Pomeranz and LI Bozhong's work strongly reflects this style. They put in a lot of work to estimate output and consumption per person, and this has been maintained in many follow-up studies. Although this line of thought may appear less novel now, it was certainly forward-thinking more than two decades ago, when international comparison studies were based on much qualitative evidence, particularly in the literature of Asian economic history.

The California School thus advanced the study of international comparisons and the history of global economic growth to a new level. The first wave of academic reaction came in 2002, when historians such as Philip Huang, Brenner, and Isett published one of the first debates with the California School in the *Journal of Asian Studies*. As a result, economic historians from Europe and Asia have joined the discussion and have produced a number of international comparative studies, including Broadberry and Gupta's analysis of wages in the East and West (Broadberry and Gupta, 2005), Allen et al.'s research on wages and agricultural productivity (Allen, 2009b; Allen et al., 2011), the Broadberry team's analysis of millennial GDP (BGL, 2018, 2021), and Li and van Zanden's (2012) exploration of regional GDP and so on. Although these studies are still largely based on traditional productivity or living standards methods, with the inclusion of both European and Asian scholars in an international comparative framework, such research is extremely straightforward and critical to answering the Great Divergence questions. Since then, comprehensive historical databases have been

created, including the GPIH project (Global Price and Income History Group)[41], the Maddison Project[42], which continues to be maintained after Professor Maddison's passing, and the ambitious Clio Infra database[43], etc.

There is no doubt that the California School raises important questions and has significantly contributed to the creation of historical databases, particularly for regions outside of Europe. However, the growing number of scholars who have joined the discussion also find that the California School's comparative picture, which relies on a few scattered fragments of evidence, may have been wrong too. The timing of the Great Divergence has now been shifted from the nineteenth century to earlier. The recent studies even suggest that the Great Divergence might have occurred earlier than the 18th century, although direct evidence is lacking. Pomeranz has since admitted that his initial conclusions may have been too optimistic (Pomeranz, 2011, 2017).

This chapter uses annual frequency GDP data for the Yangzi Delta to answer the Great Divergence debate. Before I begin, I will briefly describe the comparator. Table 6.1 shows the populations of some Chinese and European economies. In comparison to China, European countries appear to be too small. Most of the time, China appeared to have a larger population than the entire continent of Europe. When China average GDP per capita is compared to that of European countries, it is clear that China might have lagged behind Europe prior to the 14th century (BGL, 2018, 2021). The findings here appear to be consistent with the so-called Eurocentrism. However, the discussion in the previous chapter made us aware that the GDP per capita in China's most developed regions was probably 1.6-1.8 times the China average, implying that as the California School argues, comparing China as a whole to a specific European economy is potentially unfair.

[41] http://gpih.ucdavis.edu/

[42] https://www.rug.nl/ggdc/historicaldevelopment/maddison/releases/maddison-project-database-2020?lang=en

[43] https://clio-infra.eu/#

Table 6.1 Population of some economies in China and Europe

	Yangzi	China	Britain	France	Italy	Netherlands	Spain	Europe
				Population (million)				
1400	11.52	71.80	2.49	12.00	8.00	0.60	4.50	67.85
1500	16.33	117.00	2.63	15.00	9.00	0.95	5.00	84.85
1600	23.53	160.00	4.92	18.50	13.30	1.50	6.80	107.05
1700	18.79	138.00	6.21	21.50	13.50	1.95	7.40	114.85
1800	27.64	341.60	10.63	29.00	18.10	2.10	10.50	188.63
1870	12.31	358.00	25.87	38.00	28.00	3.65	16.20	310.32
				Size (thousand km²)				
	51	9600	314	544	301	33	505	10383

Sources and notes: population data, for Yangzi Delta, see Chapter Two; China between 1400-1800 is derived from Broadberry, Guan and Li (2018); China in 1870, see Maddison Project 2020; the British data is from Broadberry et al. (2015: 227-244); for France, Germany, Italy, Netherlands, Spain and Europe, see Malanima (2009: 9). Territory size data, for Yangzi Delta, see Cao (2001: 708-709); for China, since China's territory is constantly changing, I only give the contemporary territory as a reference, the size of which stands between the Ming and Qing dynasties; the European data is taken from Malanima (2009: 16).

But is smaller really better? It is not true that a poor pre-modern empire did not have highly developed regions. It is easy to create artificial prosperity by exploiting and controlling other empire regions. At the extreme, we could compare the royal palaces of pre-modern economies or the Prime Minister office's average income. Are such results indicative of human civilisation development? Certainly not. Unfortunately, finding the best unit of comparison is often impossible. In international comparisons, it is difficult to ignore the specific contexts that national and cultural borders bring to the fore. Arbitrarily dividing a country's economy can be even more perplexing. A fair and rational international comparison is not usually achieved by randomly selecting a five square kilometre area of central England or China's eastern coastline. In this study, I stick to the previous method of comparison: in Europe, each country is used as the unit of comparison; in China, the Yangzi Delta is chosen as the area that can be compared with its European counterpart. Is the Yangzi Delta China's best representative? There is no perfect answer. Perhaps Beijing, China's capital, could also be compared to the European economies as a developed region of China. However, returning to our study, the least I can say is that, as much of the literature shows, the Yangzi Delta may not be the best

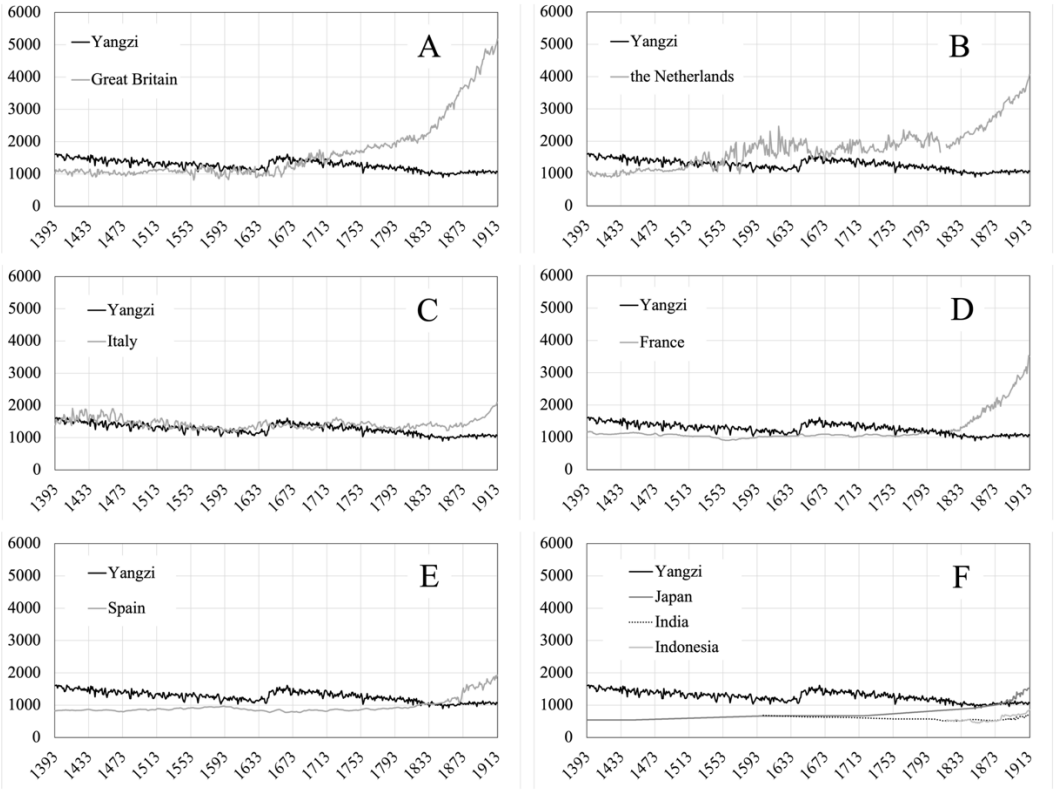

Figure 6.1 GDP per capita comparison of European and Asian economies, 1393-1913 (in 1990 international dollars)

Sources and notes: For the Yangzi Delta, see this study; Great Britain before 1870, see Broadberrry et al. (2015); Great Britain after 1870, see Maddison Project 2020; for the Netherlands, Holland before 1808, see van Zanden and van Leeuwen (2012); the Netherlands after 1807, see Smits, Horlings and van Zanden (2000); to link Holland series to the Netherlands, I use Smits, Horlings and van Zanden (2000: 259)'s 1808 the Netherlands benchmark; Italy, see Malanima (2010); Spain before 1850, see Álvarez-Nogal and Prados de la Escosura (2013); Spain after 1850, see Prados de la Escosura (2017); France before 1800, see Ridolfi (2017); France after 1800, see Maddison Project (2020); Japan, see Bassino et al. (2019); India, see Broadberry, Custodis and Gupta (2015); Indonesia, see van Zanden (2012).

unit of comparison, but it is certainly fairer than comparing China to a single European country.

The rest of this chapter is much easier to understand than the history of the Great Divergence. I begin by displaying the direct results of the Great Divergence. I then go over some counterfactuals to double-check the dates of the divergence I have identified as the robustness checks. Finally, I move on from the Great Divergence period to the

so-called Post Divergence period, where I discuss the Yangzi Delta's struggle to transition into a modern economic growth path in the context of international comparison.

6.2 Dating the Great Divergence

6.2.1 Sub-country comparison

The Great Divergence is discussed by Pomeranz in the 18th and 19th centuries, but what was the Yangzi Delta and European economies' trajectory before that? Was the Great Divergence's turning point as late as the California School claims? Or was it much earlier? Was there more than one divergence over centuries of growth? GDP per capita in nine economies, including the Yangzi Delta, is depicted in Figure 6.1. Britain, the Netherlands, and Italy, the three most developed economies in pre-modern Europe, are depicted in subgraphs A, B, and C, respectively. The two representative continental European economies, France and Spain, are shown in the subgraphs D and E, respectively. Figure F examines the economic performance of several Asian countries.

A. Great Britain

Despite being the birthplace of the Industrial Revolution, Great Britain was not wealthy for a long time (Broadberry et al., 2015). Before the 18th century, Great Britain had a lower per capita income than the Yangzi Delta. The region had 0.03 percent annual economic growth for over 200 years before the 1650s (Crafts and Mills, 2017). However, since GDP per capita in the Yangzi Delta had been declining during the Ming Dynasty, Britain's per capita income was very close to that of the Delta by the early 17th century. The Yangzi Delta's sudden rise in per capita income during the Ming-Qing Transition prevented Britain from overtaking it soon. It is interesting to note that Britain also lost population in the mid-17th century, allowing her GDP per capita to rise, as the Yangzi Delta did. As a result, the two economies continued to grow in lockstep. "The 17th century General Crisis" may have a complicated cause. Conflicts in Asia and Europe escalated, and population declines were accompanied by Malthusian-

like income increases. If Malthusian theory was still valid, British incomes would soon return to "normal" like the Yangzi Delta. However, from the end of the 17th century, the British economy avoided the Malthusian trap by growing population and per capita income at the same time. This caused the British economy to start ahead of the Yangzi Delta and keep widening the gap until the 20th century. By the time the Imperial Chinese Army lost its first battle to the British Navy in the First Opium War (1840-1842), the per capita income gap between the two sides was nearly double. When the China average was considered, the gap was about five times. While the outcome of the war was determined by a variety of factors, a five-fold increase in per capita income was a surprisingly large disparity in pre-modern times.

B. the Netherlands

Let us now turn our attention to the Netherlands. The Dutch story may be more complicated. During the Ming Dynasty, the Netherlands' economy was thriving while the Yangzi Delta's was declining. At the start of the 15th century, the Yangzi Delta had almost 1.6 times the per capita income of the Netherlands, but different growth patterns on the two sides of the continent—one negative and one positive—allowed the Netherlands to catch up in the first half of the 16th century. The Netherlands overtook the Yangzi Delta for the first time in the second half of the 16th century and maintained this advantage for nearly a century until Yangzi's per capita income increased in the 1640s. In contrast to the 19th-century Opium Wars, which are often considered the first war between the Chinese Empire and the West, the Ming navy fought and mostly won an unimpressive naval battle against the Vereenigde Oostindische Compagnie (VOC) in 1633[44]. This battle was not as devastating for the Ming Empire as the Qing Empire's

[44] The Dutch began looking for trading opportunities along China's Fujian coast in the early 17th century. However, due to the Chinese government's trade ban, the free trade that the Dutch hoped for almost never happened. As a result, the Dutch experimented with various strategies, including aiding the Ming government in its fight against piracy and attempting to integrate local pirates. However, the results were unsatisfactory. Finally, in autumn 1633, Dutch warships fought the Chinese navy. The two sides assembled over a hundred ships, and the Ming navy eventually defeated the Dutch warships. However, the Ming naval victory in October that year was preceded by the loss of a number of ships to Dutch raids in June. Thus, this year's wars resulted in mutual victory and defeat. But considering that the Dutch did not achieve what they had hoped to achieve 200 years later, as the British did, and eventually made reparations for the war effort, the Dutch did not achieve a meaningful result overall (Huang, 2016; Xu, 2003).

defeat in 1840, so it is rarely mentioned in Chinese history. We cannot say that the outcome of the war was entirely determined by the economy, but given the different outcomes of the two naval battles with the West in the late Ming and late Qing Dynasties, the gap between China and the West at the end of the Ming would not have been as large as it was at the end of the Qing. In the 1640s, the Yangzi Delta's per capita income rose, ending a century-long economic divergence with the Netherlands. After returning to the same starting line, this race for neck-and-neck growth lasted less than 50 years. The Netherlands took the lead for the second time around the end of the 17th century. After the jump from the 1640s to the 1690s, the Yangzi Delta did not experience sustained growth. At the same time, the Netherlands also appeared to have entered a period of stagnant growth. The "peace dividend" with Spain reduced military and public spending, which might have contributed. Another possibility seems to be partially associated with the instability of international services (van Zanden and van Leeuwen, 2012). In any case, in the last decades of the 17th century, the Netherlands overtook the Yangzi Delta and, like Britain, expanded its dominance over the centuries.

But it is important to consider whether the Netherlands' economy is comparable to that of the Yangzi Delta. It is mostly because the Dutch economy was so tiny in comparison to others in Europe. Its population was roughly one-tenth that of the Yangzi Delta. A more serious issue is that the GDP data for the Netherlands are largely based on the estimates of one of the provinces, Holland. Given that Holland had a population of around 300,000 people, it is also questionable to what extent its GDP figures can be used for international comparisons. This issue will be addressed later. But, in any case, the final economic divergence between the Yangzi Delta and the Netherlands should occur at the end of the 17th century.

C. Italy, France and Spain

Italy, France, and Spain are discussed together. A major reason is that until the 19th century, none of the three economies showed the same level of sustainable growth as Britain and the Netherlands. Italy was the centre of European civilization and the most

developed economy until almost the 16th century, but its GDP per capita did not grow until the mid-19th century. Per capita income in the region was declining two centuries after the Black Death. In fact, in terms of growth trajectory, Italy appears to have been more like the Yangzi Delta than Britain. The competition for growth between Italy and the Yangzi Delta can be said to have lasted from the end of the 14th century to the beginning of the 19th century. When the Yangzi Delta fell into the negative growth trap during the Qing Dynasty, Italy finally won with a somewhat shaky performance in which there was no growth and no decline in the 1800s. This victory was not early, and the California school's claim would have been correct if the Great Divergence had only occurred in Italy and the Yangzi Delta. Unfortunately, Italy was not had the most developed economy in Europe since the 15th century, which suggests that the Great Divergence might not have occurred as late as the California School claims.

In light of the Italian example, it is clear that Europe was not a homogeneous whole and that different parts of the continent experienced very different historical trajectories of growth. Neither Eurocentrists nor revisionists should draw conclusions from a single image of Europe or China. This also implies that when making international comparisons, great care should be taken in selecting which countries to compare. Only economies with similar status, like the Yangzi Delta and Britain/the Netherlands in Northwest Europe after the 16th century or Italy before the 16th century, are comparable. Comparing a developed economy to an underdeveloped one can yield disturbingly unrealistic results.

France and Spain resemble a poorer version of Italy. Similar to Italy, economic stagnation occurred over centuries, but per capita income was lower. Therefore, the GDP per capita of these two countries did not surpass that of the Yangzi Delta until the nineteenth century.

The description of the five European economies suggests that the Yangzi Delta was more advanced than most of the European economies before the mid-16th century.

Following European Little Divergence in the 17th century, the Yangzi Delta lagged behind Britain and the Netherlands, becoming more akin to a middle-class European economy. Over the century from the European Little Divergence to the mid-19th century, Yangzi Delta's economic performance was inferior to Britain and the Netherlands, similar to Italy, and superior to France and Spain. This is not a terribly gloomy result. In comparison to Italy, France, Spain, and Eastern Europe (Broadberry, 2021), the Low Countries and Britain appeared to be the outliers. Like other continental European economies, the Yangzi Delta had no miracle of self-sustaining growth beyond pre-modern economies, but it was not underdeveloped. While this is fine for the Yangzi Delta and still proves that it was not as poor as imagined, given the international comparisons between China and Europe, the gradual fall of the Yangzi Delta toward being an average or even poor European country strongly suggests that the rest of China could only get poorer. As BGL (2018, 2021) shows, China's economic performance as a whole was gradually distancing itself from Europe as the Yangzi Delta was losing its comparable status with the European most developed economies.

D. Little Divergence in Asia

The comparison with Japan, India, and Indonesia supports the idea that eastern part of Asia should have performed much worse than Europe in the 18th and 19th centuries. Before the 1870s, the economy of the Yangzi Delta was the most prosperous in Asia, surpassing that of both Japan (which experienced modern economic growth first in Asia) and India (which had the largest economy in South Asia). Of course, due to India's vast territory and population, future studies should focus on a smaller region. Given that India was poorer than China on average (BGL, 2018, 2021), the Yangzi Delta, as one of China's most developed regions, could also be considered one of Asia's most developed economies.

Other Asian economies differed from the Yangzi Delta in GDP per capita levels, but they all had a similar growth pattern, which was consistent with long-run stagnation in regions other than Britain and the Low Countries. But Japan was an outlier. The Toku-

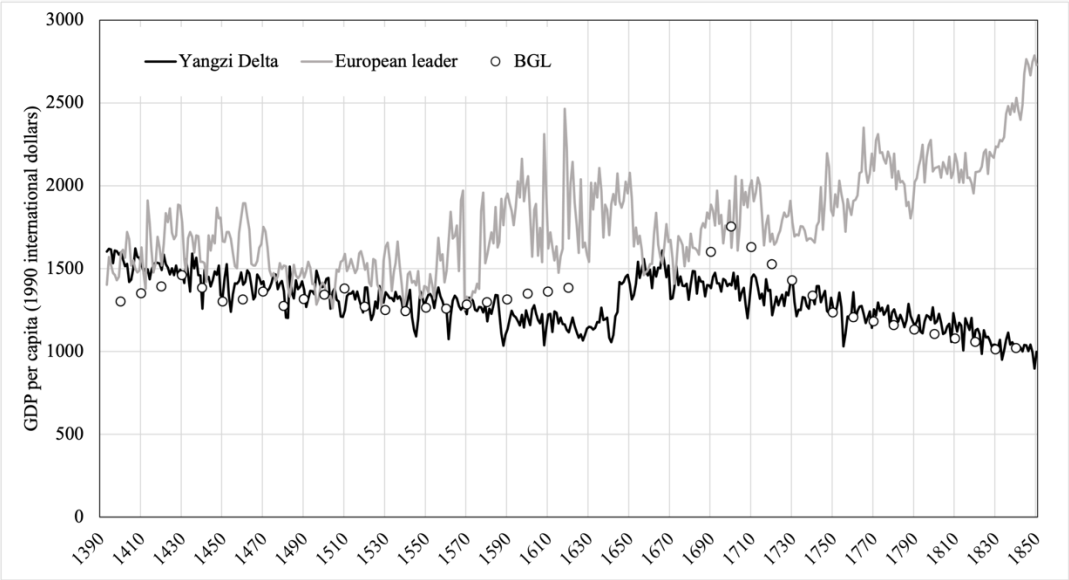

Figure 6.2 GDP per capita in China and Europe's most developed regions, 1393-1850 (in 1990 international dollars)

Sources and notes: The Yangzi Delta data, see the study. The European leader is a mixed series including three most developed economies in chronological order, Italy, the Netherlands and Great Britain. Data are taken from Figure 6.1. The BGL series is calculated by multiplying China average per capita GDP by 1.7, which is the per capita income of China's most developed economy as defined by Broadberry, Guan and Li (2018, 2021).

gawa period saw some weak growth, but it is the growth miracle of the 1860s onwards that brought Japan into the developed world. Japan was unique in that the Japanese economic growth rate in the late nineteenth century far outpaced that of other Asian peers. Let us imagine a late 19th-century Japan without high growth. In this scenario, the relative positions of these Asian economies would remain largely unchanged. Therefore, If we exclude Japan, Asian economies before the 20th century were mediocre and lifeless, with a very old-fashioned growth model.

Before the mid-19th century, Asian economic growth including Japan did not appear to be comparable to European growth. More importantly, although there is little data before the 19th century, given the Yangzi Delta's per capita income compared to other Asian economies, these Asian economies were far from developed. Since the Yangzi Delta had gradually become an average or poor European economy from the 18th century onward, these Asian economies, which were far less developed, only had worse

economic status in international comparisons. This implies that, at least until Japan's rapid growth in the mid-nineteenth century, no Asian economy should have a per capita income higher than that of Europe's most advanced economies.

6.2.2 European leader comparison

What is the "Great Divergence" between the Yangzi Delta and Europe's most developed economies? Figure 6.2 compares the Yangzi GDP per capita to Europe's most developed regions. The leading European economies changed over time. I follow BGL (2018, 2021) in choosing Britain, the Netherlands, and Italy, which had the highest per capita incomes at different times, as European leading economies. Europe's most developed region was Italy until the 16th century, then the Netherlands until the 19th century. Great Britain was the wealthiest after c. 1800. To test BGL's (2018, 2021) hypothesis that China's most developed regions should be 1.7 times the China average, I multiply their GDP per capita estimate by 1.7 to get the BGL series. This series is actually the main evidence for their discussion of the Great Divergence debate, with the BGL series matching well with my Yangzi GDP per capita. This is not surprising, as previously discussed: the Yangzi Delta's per capita income had long been 1.6-1.7 times China's. The main difference is that in the early 18th century, the Yangzi GDP per capita was slightly less than 1.7 times that of the national average. This nuance suggests that 1.7 times China average GDP per capita may place the Great Divergence at c. 1700. According to data in this study, the Great Divergence occurred around the 1670s. Given external factors like calculation errors, two or three decades delay would not be harmful. In any case, we can conclude that the so-called Great Divergence occurred in the late 17th century based on these two types of data. This conclusion is consistent with BGL's (2018, 2021) conclusion that the Great Divergence happened later than the Eurocentric view and earlier than the California School.

But another question may arise: were there two Great Divergences? The question arises from the period from the 1550s to the 1650s, when Europe's leading country, the

Netherlands, surpassed the Yangzi Delta in terms of per capita income for more than a century. If this overtaking is an earlier Divergence, then the 1550s were the turning point. However, this brief overtaking may not be a Divergence like the late 17th century. If the negative growth of the Yangzi Delta and the positive growth of the Netherlands in the 16th century could continue, it would be a Great Divergence. However, during the Ming-Qing Transition in the 1640s, the Yangzi Delta stopped declining and per capita income increased, postponing the likely long-overdue Great Divergence until the end of the 17th century. If the Netherlands had maintained its century-long growth rate, the Yangzi Delta's per capita income increase would not have equalised the two economies. But the Dutch economy also declined. The Dutch economy decline and the Yangzi Delta growth brought both sides' per capita incomes back to the same level after 100 years since 1550s. From the 1550s to the 1650s, Dutch per capita income was significantly higher than Yangzi Delta's, but it is unclear if this was permanent. The seemingly good economic growth was also different from modern economic growth like 18th-century Britain. After 1665, the population of Holland, the centre of the Netherlands, began to decline (van Zanden and van Leeuwen, 2012), implying that the economic growth that followed was likely to differ from the concurrent growth in population and per capita income in Britain.

Another issue has been mentioned earlier. The Netherlands is actually quite small in Europe. Table 6.1 shows that the Netherlands had a long-term population of less than one million until the 16th century and only two to three million even in the 19th century. Being so small, the Netherlands might not represent the whole Europe. The current GDP data in the Netherlands are established by assuming Holland's GDP per capita growth was in line with the Netherlands'. This means that in the end, we are only using the economic situation of Holland with a few hundred thousand people to represent the economic performance of Europe for nearly three centuries, which is also questionable in practice. In fact, when Holland's economy appeared to be growing quickly before the 16th century, the rest of Europe's economies did not exhibit the same growth pattern. Although Britain's modern economic growth after the 17th century was also unique in

Europe, Britain's growth was permanent. Holland's growth, on the other hand, stalled quickly. All of this suggests that the Netherlands may not be a good comparator in the international comparisons.

I do not deny that the Netherlands diverged from the Yangzi Delta in the mid-16th century, but any previous divergence may have been insignificant compared to the most important turning point at the end of the 17th century. It is worth noting, however, that while the undeniable turning point occurred at the end of the 17th century, the Yangzi Delta also experienced a very negative pattern of growth until the 1640s. If not for the 1640s growth spurt, Italy and Britain may have surpassed the Yangzi Delta's per capita income by the 16th or 17th century. Even if only the late 17th century counts as a truly Great Divergence, the way for the Yangzi Delta to be overtaken may have been paved a century earlier. Sustainable economic growth in the Low Countries and Britain began gradually in the 17th century, though the ultimate modern economic growth occurred in Britain at the end of the 17th century. With the Little Divergence occurring in Europe, the 1640s leap was more like a last chance for the Yangzi Delta to catch up before the final divergence appeared. In any case, the seventeenth century was crucial for both Europe and China. The roots of the Great Divergence may have been hidden to some extent during these magical 100 years. In other words, the Great Divergence could have been a gradual process rather than an instantaneous event. Romantically speaking, the process could have continued in a struggle throughout the 17th century. Much like the countless advances and retreats of a football match in midfield, after ninety minutes of intense attacking and defending, the striker eventually broke free of the defenders, burst into the box with a beautiful dummy, and kicked the ball into the goal. The final goal in the 90th minute signalled the end of the game, as well as the growth race between East and West at the end of the 17th century.

6.3 Double-check on the Great Divergence: A counterfactual analysis

Assessing the reliability of conclusions drawn from historical estimation research is crucial, especially when dealing with contentious topics such as the Great Divergence. In Chapter One, I have already discussed the reliability and sensitivity analysis of the various data and sub-series estimated in this study, demonstrating that my data are generally reliable. In order to strengthen the reliability of the conclusions drawn about the timing of the Great Divergence from my data, I conduct a robustness analysis from a new perspective in this section. In the context of the Great Divergence debate, the viewpoints of the California School and the Eurocentric School appear to differ from my findings regarding the timing of the Great Divergence. Hence, in this part, I employ a counterfactual analysis to explore the implications if the judgement of the California School or the Eurocentric School were correct. My analysis suggests that accepting either of these viewpoints may result in situations that deviate from historical facts. Conversely, accepting the conclusions of this study regarding the timing of the Great Divergence may align more closely with historical facts.

Economic performance and living standards in China after the 19th century are now widely accepted. Both China's overall GDP per capita growth and sectoral output growth trends (e.g., BGL, 2018, 2021; Ma and de Jong, 2019; Xu et al., 2017) and wage studies (Allen et al., 2011; Peng, 2013; Yan, 2008) indicate that China's per capita income trend changed little, almost in a straight line, from 1800 to 1936. Similar regional studies also show that income per capita and living standards in the Yangzi Delta and the Jiangsu and Zhejiang regions where the Delta is located did not change much in the century from 1800s (e.g., Allen et al., 2011; Chang, 1933; Garuana-Galizia and Ma, 2016; Li, 2010b; Li and van Zanden, 2012; Jiang and Wang, 2020; Ma, 2008; Yan, 2008). In the early 20th century, the Yangzi Delta might see a slight rise in income per capita, but it was not very significant. In other words, over the century following the 19th century, the per capita income of the Yangzi Delta and the Jiangsu and Zhejiang

regions changed quite slowly relative to the China average. This is consistent with the historical fact that during the traditional period in China, growth trends across different regions were remarkably similar (Broadberry and Guan, 2022).

Thanks to a wealth of macro- and micro-statistical evidence, we can roughly determine that China's per capita income in the early decades of the twentieth century was around 550-600 in 1990 international dollars (e.g., Liu and Yeh, 1965; Ma and de Jong, 2019; Xu et al., 2017). Yangzi had higher per capita income than China, probably around 1,000 in 1990 international dollars (Ma, 2008). Given the little variation in per capita income trends over time, the early 19th century per capita income levels in the Yangzi Delta can be largely confirmed. Li (2010b) and Li and van Zanden (2012) provide estimates of GDP per capita in the Yangzi Delta in the early 19th century, which translate to around 1074 in 1990 international dollars in 1823-1829 (Smits, Horlings and van Zanden, 2000; BGL, 2018). These findings are very consistent with my data. It implies that the Yangzi Delta's per capita GDP in the 1820s was probably around 1,000 in 1990 international dollars. So, how far back in time can this data be extrapolated? According to recent research on daily and annual wages in China between 1795 and 1820, there should not have been a trend in living standards during this time period (Sun and Li, 2020). This also matches my data. Outside of my research, there is little quantitative evidence for earlier periods. The majority of the evidence available at the time on the economic situation in the Yangzi Delta is included in my study. Although there are some wage studies (Allen et al., 2011; Liu, 2022), I am cautious not to use this evidence to speculate on earlier scenarios because current wage studies are controversial and many are on daily rather than annual wages. In general, per capita income in the Yangzi Delta after 1800 should be fine.

Thus, my next counterfactual analysis will begin in 1800. I assume we know nothing about the Yangzi Delta's per capita income before 1800. I have taken three different scenarios—two California School views and one Eurocentric view—as true. In the fo-

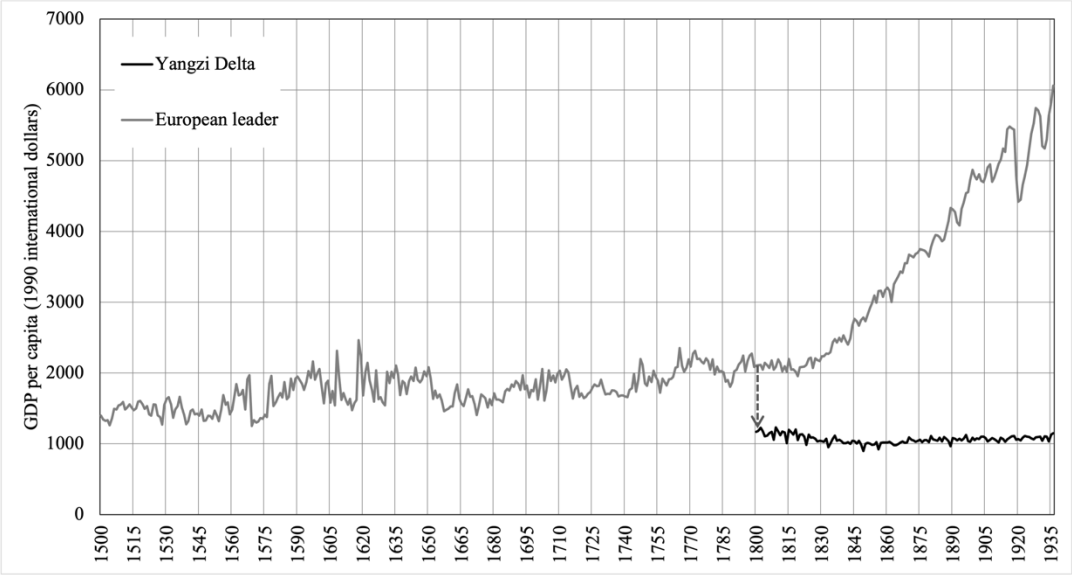

Figure 6.3 The Great Divergence in a counterfactual framework: 1800

Sources and notes: For Yangzi Delta, see this study; European leading economy is derived from figure 6.2. The arrow shows counterfactual economic growth.

llowing section, I will discuss how unrealistic the results would have been if they were correct.

6.3.1 The counterfactual analysis: California School

First, Let us consider the California School's assertions. What if these revisionists were right in their early claims that China and the most developed European economic regions were similar until the 19th century? Figure 6.3 shows this situation. In 1800, the Yangzi Delta experienced a precipitous decline in GDP per capita, almost vertically to the ground. This kind of decline is almost unheard of in history. It is difficult to find such a horrific fall in GDP per capita in historical narratives. Clearly, this is not consistent with historical facts. The California School has largely abandoned this original version of the Great Divergence conclusion as being too contrary to common sense. Instead, the most recent version of the turning point is thought to be around the 1750s (Pomeranz, 2011, 2017).

Was 1750, then, the correct year? Let us simplify the GDP per capita formula as follows:

$$
\begin{aligned}
&GDPpc = GDP / Population \\
&= (Ag + NonAg) / Population \\
&= (Ag + Ag \times structure) / Population \\
&= Ag / Population \times (1 + structure) \\
&= (Yield \times Land) / Population \times (1 + structure) \\
&= Landpc \times Yield \times (1 + structure)
\end{aligned}
\tag{6.1}
$$

where *Ag* refers to agricultural output and *NonAg* refers to non-agricultural output. *structure* refers to the structure of the economy, i.e. non-agricultural output as a proportion of agriculture. *Land* refers to cultivated land. *Yield* represents land productivity, i.e. agricultural output divided by cultivated land. *Landpc* is cultivated land per capita.

Figure 6.4 shows that GDP per capita would have to fall by half, or 40-50 percent, in the 50 years from 1750 to 1800 if the California School's later updated view that 1750 was the turning point is correct. This figure is also very gruesome, but it is less intuitive than a horrific scenario such as a 50 percent drop in one year. Is such a drop in 50 years possible? In the final form of equation (6.1), if the left-hand side falls by 50 percent, the right-hand side must also fall by 50 percent. According to the data in Chapter Two, per capita cultivated land fell by approximately 17 percent during this period. Long-term per capita land decline in the Yangzi Delta is almost universally acknowledged. Different scholars' population and land data are derived from nearly identical sources. Their estimates may vary, but there are no major differences. This 17 percent drop is thus largely unproblematic.

In terms of land productivity, there is little evidence of significant change over a 50-year period. When it comes to crop yields, the timing of the decline in productivity of individual plots of land may be debatable, but most scholars agree that there was little evidence of much of a decline in crop yields between 1750 and 1800. Even with double cropping and cash crop proliferation, land productivity should have increased faster than crop yields during this period. However, the land productivity calculations in Cha-

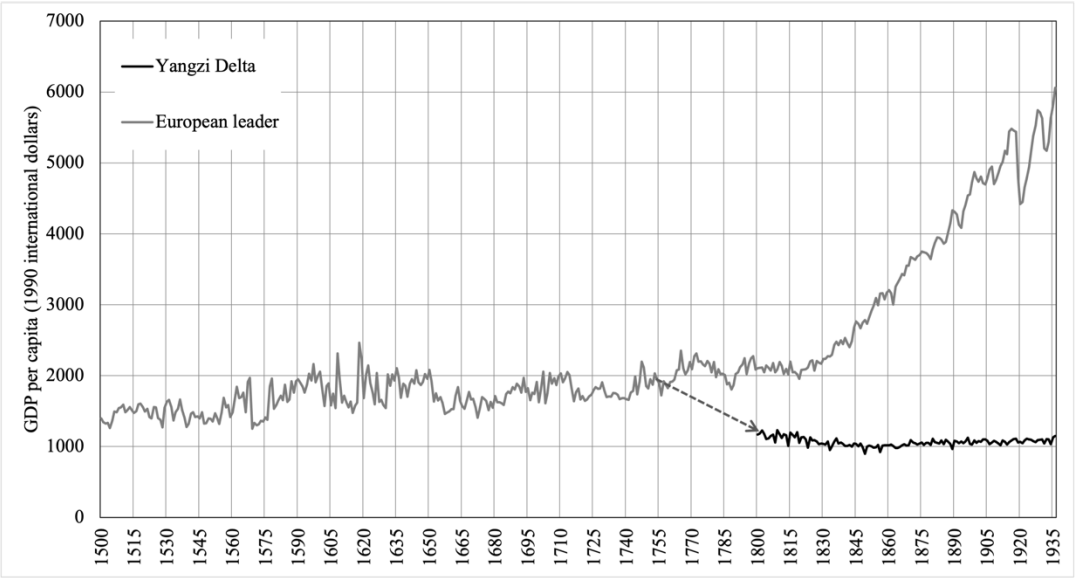

Figure 6.4 The Great Divergence in a counterfactual framework: 1750

Sources and notes: For Yangzi Delta, see this study; European leading economy is derived from figure 6.2. The arrow shows counterfactual economic growth.

pter Five show that, even when these factors are considered, land productivity did not change significantly faster than crop yields during this period. Overall, this period saw no significant changes in land productivity.

Thus, the updated California School time point can only be achieved if the economy structure declines by 33 percent. This, however, is not possible. The decline in economic structure refers to the decline in non-agricultural output to agricultural output. This is puzzling. Even the California School thinks the non-agricultural share should have risen. Data on urbanisation rates show no significant changes during this time period. Of course, urbanisation rates may not reflect proto-industrialisation. But if urbanisation rates did not change and we expect the non-agricultural shares to fall, reverse proto-industrialisation is the only option. According to YANG Cheng (2022), Yangzi Delta's male labour force always made up about 55 percent of employment during this period. As a result, the wives in the rural family should begin to give up their jobs in the cotton textile industry. In some ways, this is a ridiculous conclusion. Almost no narrative evidence mentions this.

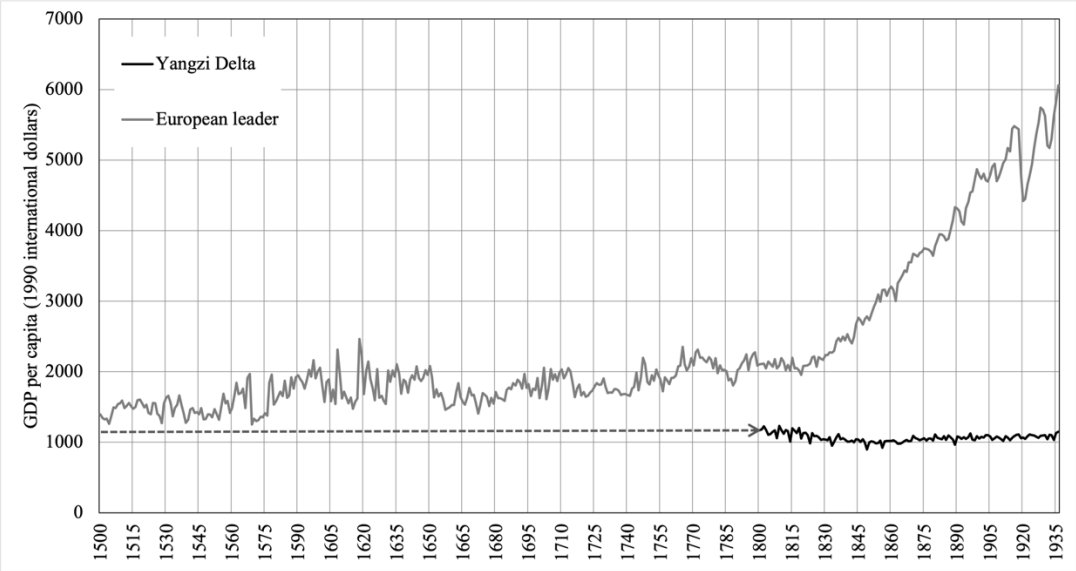

Figure 6.5 The Great Divergence in a counterfactual framework: Eurocentrism

Sources and notes: For Yangzi Delta, see this study; European leading economy is derived from figure 6.2. The arrow shows counterfactual economic growth.

Basically, we find it hard to believe that 1750 is credible as the turning point of the Great Divergence.

6.3.2 The counterfactual analysis: Eurocentrism

However, the following question may be less obvious. The greatest challenge to the timing of the Great Divergence is Eurocentrism (e.g., Weber, 1930; Landes, 1969; North and Thomas, 1973). In other words, they hold that the Yangzi Delta was poor and never ahead of Europe. Figure 6.5 depicts a flat GDP per capita curve beginning in 1800 and moving backwards to demonstrate this. Indeed, some Chinese scholars' understanding of the Qing Dynasty economy responds eerily to Eurocentric conclusions. There is a well-known debate in Chinese history about whether or not the so-called "High Qing (1681-1796)" (康乾盛世) was a prosperous time for the Qing Dynasty. Intuitively, this period meets the ancient Chinese political criteria of absence of war, population growth, and territory expansion. Even in terms of economy size, there is no doubt that total GDP grew steadily. But per capita income growth is disputed. Recent studies of GDP, wages, and urbanisation rates appear to agree that per capita welfare should have declined during this period. However, there is still a body of scholarship

that disputes the claim that China's per capita income declined during this period (e.g., Chen and Peng, 2022; Peng, 2020). These studies agree that Qing China's per capita welfare did not decline. This literature seems to give a very positive and upbeat assessment of the Qing economy, but failing to acknowledge a decline in per capita income in Qing China would imply that its view of the Great Divergence should be Eurocentric. Is it possible that the economic trajectory prior to 1800 was a straight line? We can discuss it using the equation (6.1).

The Yangzi Delta's land per capita was 1.7 Mu in 1800 and 2.4 Mu in 1700, a 30 percent decrease. Land productivity fell by less than 4 percent during this period, remaining nearly unchanged. So, maintaining no change in GDP per capita from 1700 to 1800 would imply a 34 percent improvement in the (1+economic structure) part. Chapter Four confirms that 18th-century local non-agricultural shares increased. According to Chapter Four, agriculture had a 40 percent share in 1800, so if the economic structure part had improved by 34 percent, agriculture would have had a 54 percent share in 1700. This is practically impossible to achieve. Both Yang's (2022) study of the Yangzi Delta's occupational structure and the local urbanisation rate make it difficult to understand such a large change in the economic structure in a century. According to Yang's data (2022), male agricultural labourers permanently accounted for approximately 55 percent of male employment during the 18th century. Assume that this was also the overall occupational structure in the early 18th century. If their wives had gone from not working in textiles to working exclusively in textiles from the early 18th century to the early 19th century (which is impossible since many women were already working in textiles), the whole economy's agricultural labour force would have reached 35 percent in 1800. However, according to Li (2010b), the per capita income of rural textile workers was roughly one-third that of agricultural wage earners. This implies that the decline in agricultural value-added shares could not have been so significant. Improving the economic structure over time is a difficult task. The early twentieth century saw the Yangzi Delta's fastest industrialisation, which did little more than reduce agriculture share from 35 percent to around 30 percent. Per capita cultivated land and land

productivity are well-documented, making revisions difficult. This means that maintaining a constant per capita income in the Yangzi Delta during the Qing Dynasty would have been practically impossible. Extending the period to the Ming Dynasty yields similar results. As a result, Eurocentrism was also difficult to satisfy.

Thus, multiple counterfactual hypotheses do not match reality. The Great Divergence occurring before Eurocentrism and after the California School should not be a problem.

6.4 The Final Issue: the Yangzi Delta's struggle towards modern economic growth in an international comparison perspective

In this section, I briefly discuss the Yangzi Delta's first tortuous path to modern economic growth in the late 19th century in the context of international comparisons. The Great Divergence is a very important issue. Another fascinating period is the centuries after the Great Divergence. In some ways, the precocious maturation of the Low Countries and Britain appeared to be an anomaly. Indeed, Italy, France, Spain, Eastern Europe, and Asia dominated pre-modern growth patterns. Despite the fact that the European Little Divergence occurred, the economic centre shifted to the north-west, and Britain experienced the Industrial Revolution, the rest of Europe should not despair.

After the mid-19th century, economies that had missed the Little Divergence caught up with European leaders. If someone observed the economies of the time at the end of the 19th century, it would seem that for most of the once underdeveloped countries, not having experienced the benefits of the Little Divergence, not having experienced the Industrial Revolution, but to some extent was not a problem either. In the 19th century, the technological revolution spread from Britain to the rest of Europe. Germany began to rise. The US had quickly caught up with British per capita income. Even Japan, a traditionally agricultural economy, experienced unprecedented growth. So much so that

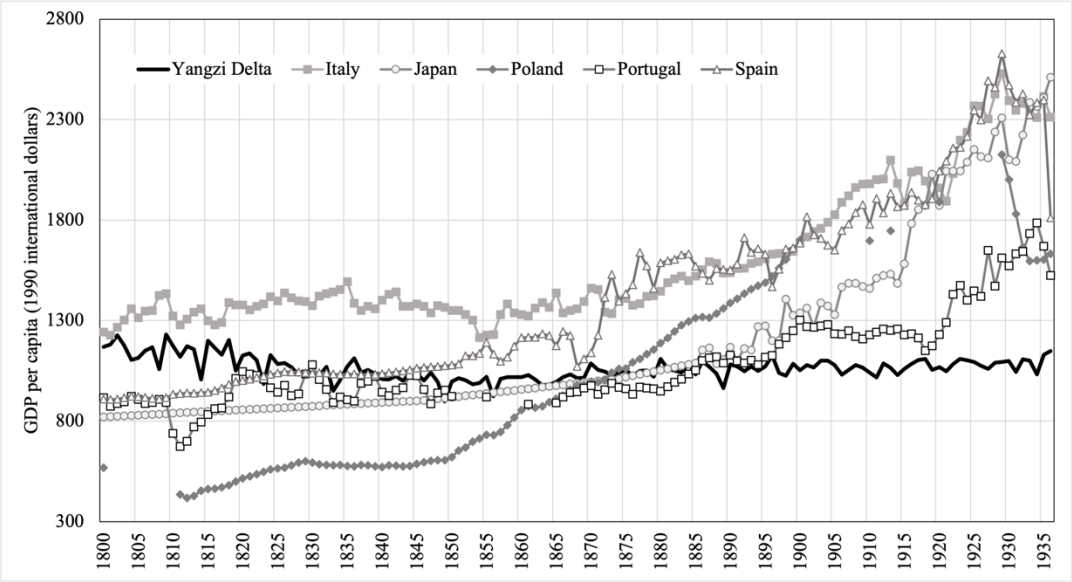

Figure 6.6 The Post-Divergence: GDP per capita of some European and Asian economies, 1800-1936 (in 1990 international dollars)

Sources and notes: The Yangzi Delta, see this text; data for Italy, Japan, Poland, Portugal and Spain are taken from Maddison Project (2020).

in less than a century, Japan fought a world war against major industrial powers like the US and Britain.

In other words, the Great Divergence does not appear to be the final turning point in the fortunes of all economies, particularly the Yangzi Delta. The Great Divergence reduced the Yangzi Delta from the equivalent of a developed European economy to a medium or poor country in 19th century Europe. But the Yangzi Delta still had a chance since these underdeveloped European economies eventually industrialised in the 19th century. As I discussed in the previous chapter, the Yangzi Delta experienced the first attempt to modern economic growth in the late nineteenth century, albeit imperfectly and with little or no TFP improvement. But there is no doubt that the local economy was entering a new age. However, when the Yangzi Delta's first foray into modern economic growth is compared to Europe's underdeveloped economies, it pales in comparison.

Figure 6.6 depicts the economic performance of the six economies that became less developed following the Great Divergence from 1800 to 1936. In contrast to Northwest Europe's leaders, the five regions outside the Yangzi Delta were not developed until the 19th century. Surprisingly, all of these less developed regions gradually achieved rapid growth during the nineteenth century. The Yangzi Delta was almost the second-richest of the six economies in 1800. By 1936, the Yangzi Delta had the lowest per capita income, half that of Japan. All economies experienced sustained growth after the mid-19th century. The Yangzi Delta also achieved self-sustaining non-negative growth for the first time since the 15th century, but its growth rate lagged far behind the other five regions. Even during the First World War, when it was seen as a good opportunity for the Chinese economy, the Yangzi Delta growth was not impressive (Liu, 2020). Japan's rapid growth after the Meiji Restoration in the late 19th century is noteworthy. It likely surpassed the Yangzi Delta after the 1870s and reached per capita incomes comparable to Italy and Spain between the 1910s and 1930s. The economic centre of Asia, which might have been China for millennia, shifted to Japan in less than 50 years.

Indeed, the real tragedy of the Yangzi Delta was the competitive failure in the 19th century. A century of technological explosion did not appear to have been absorbed by China or the Yangzi Delta. In the mid-19th century, the East's great civilization collapsed, becoming one of the world's poorest. Failure in the Great Divergence of the 17th century was not fatal for the Yangzi Delta; failure in the widespread growth of the 19th century was. The apparent rapid growth of the Chinese economy was delayed until the 1980s, when Europe and Japan had been growing rapidly for nearly a century.

Why did China and the Yangzi Delta miss the late 19th-century global growth train? Why was China, which had opened up for decades, less effective at absorbing Western knowledge than Japan, which had only opened for a few years? Much of the literature attempts to analyse the possible reasons in terms of institutions or state capabilities, such as Ma (2004, 2005). In any case, in the future, it may be possible to value both the stories of the underdeveloped economies that failed after the Great Divergence and the

explanations for the Great Divergence equally. I will not examine every cause, but it is clear that most successful economies' frequency and change rate of economic shrinking years decreased significantly after 1850 (Broadberry and Wallis, 2017). With high frequencies and rates, economic shrinking changes in the Yangzi Delta appeared to be less favourable.

Table 6.2 compares the years of increasing and decreasing GDP per capita in the Yangzi Delta, Britain, Italy, and Japan from 1800 to 1936. (1) First, of these four economies, the Yangzi Delta shrank the most frequently, even during the period 1900-1936, when Europe was hit by the First World War and the Great Depression. (2) When compared to Britain, the Yangzi Delta's rate of change was higher in both growing and shrinking years before 1900. The picture becomes clear in the growth decomposition: despite the higher contribution in the growing years, the shrinking was much more severe than in Britain, causing the Yangzi Delta to lag behind in economic growth during the same period. However, after 1900, the shrinking control of the Yangzi Delta outperformed Britain. Even when shrinking was more frequent, shrinking years contribution performed better than Britain. The Yangzi Delta's overall rate of change lagged behind Britain because the frequency of shrinking was too high. The growth contribution lagged behind Britain even though the growth years had similar rates of change. (3) Although the rate of change in the Yangzi Delta was higher in both years of growth and decline, for the majority of the time, the difference was comparable to that of Italy. The Yangzi Delta's high shrinking frequency was the main reason it did not outpace Italy. (4) When compared to Japan, the Yangzi Delta's rate of change was better in the shrinking years before 1900, while the rate of change in the growing years was also slightly lower. The main reason for the overall rate of change lag was improved control of shrinking frequency in Japan. The Yangzi Delta lagged behind Japan in every way after 1900. Japan clearly outperformed in terms of both the frequency of shrinking and the rate of change in growing and shrinking years.

Overall, the Yangzi Delta lagged behind the overall rate of change of different countries in different eras for various reasons. But the high frequency of shrinking was a common denominator. The Yangzi Delta, in particular, performed significantly better in controlling the rate of change in shrinking years than Japan did in the early years of the Meiji Restoration. However, the frequency of shrinking years was the main reason Japan overtook the Yangzi Delta. The same is true for the comparison with Italy. This suggests that the Yangzi Delta's biggest issue at the start of growth was its inability to reduce economic shrinkage. Any positive growth was quickly snuffed out by economic shrinkage. On the other hand, it can be seen that the Meiji Restoration was a success in that it effectively controlled economic shrinkage.

What factors contribute to the weakening of the shrinkage or "negative fluctuations" in the Yangzi economy? In the previous chapter, I examined several common factors that can cause shrinkage and found that technological and institutional factors are likely more important in reducing economic volatility in the Yangzi Delta since the mid-19th century compared to other factors. Among these factors, institutions are likely to be a decisive determinant (at least relatively so compared to other factors, although firm conclusions still depend on further empirical evidence). According to growth accounting calculations, capital growth during this period was crucial for the Yangzi region to overcome long-term economic decline. This partly confirms the role of institutions, since "good institutions" are often necessary conditions for capital growth. However, when conducting international comparisons, we still find that the Yangzi economy, despite performing better than its previous situation in weakening the "negative fluctuations" before the mid-19th century, still performed worse than several other economies discussed earlier. One inference could be that the contribution of technological progress was limited, considering that my previous calculations did not show positive growth in Total Factor Productivity (TFP) during this period. But the question that follows is whether this is due to a lack of technological input. Before the 1950s, there is insufficient evidence to suggest that the Yangzi Delta faced greater barriers in terms of know-

Table 6.2 Growing and Shrinking of GDP per capita in the Yangzi Delta, Britain, Italy and Japan, 1800-1936

		Yangzi Delta			Britain			Italy			Japan	
		1800-1849	1850-1899	1900-1936	1800-1849	1850-1899	1900-1936	1800-1849	1850-1899	1900-1936	1885-1899	1900-1936
Frequency	Growing	0.44	0.52	0.51	0.58	0.60	0.62	0.54	0.64	0.68	0.67	0.59
	Shrinking	0.56	0.48	0.49	0.42	0.40	0.38	0.46	0.36	0.32	0.33	0.41
Change rate	All years	-0.69	0.38	0.14	0.64	1.12	0.58	0.09	0.37	0.94	1.38	1.69
	Growing	4.89	3.45	2.72	3.12	2.77	3.00	2.22	1.89	2.90	4.54	4.58
	Shrinking	-5.07	-2.94	-2.55	-2.78	-1.36	-3.36	-2.41	-2.34	-3.21	-5.02	-2.46
Contribution	All years	-0.69	0.38	0.14	0.64	1.12	0.58	0.09	0.37	0.94	1.38	1.69
	Growing	2.15	1.79	1.39	1.81	1.66	1.86	1.20	1.21	1.97	3.04	2.70
	Shrinking	-2.84	-1.41	-1.25	-1.17	-0.54	-1.28	-1.11	-0.84	-1.03	-1.66	-1.01

Sources and Notes: The Yangzi Delta data, see the text. Data for Britain, Italy and Japan, see Figure 6.1. Frequency refers to the proportion of growing and shrinking years in GDP per head over a fixed period. The Change rate refers to the average change of GDP per capitta over a fixed period for all years, the growing years and the shrinking years, respectively. The definition of contribution comes from Broadberry and Wallis (2017): frequency of growing years times the rate of change plus frequency of shrinking years times the rate of change.

ledge diffusion compared to today. New ideas were constantly introduced to China through the Treaty Ports, concessions, and the influx of Westerners. Many international students obtained degrees from universities in North America, Europe, and Japan. Foreign direct investment, trade, and foreign-owned factories also grew rapidly. In other words, the quantity of technological inputs or stock might not have been lacking. The essence of the problem lies in why the introduction of these technologies did not contribute to TFP growth in the same way as in the West.

So, what ate the technology contribution that was supposed to fuel TFP growth? This issue may be complicated and require further study. However, something behind technology may be important. One possible explanation is the unstable political environment. Institutional and legal reforms only occurred near Western settlements in the Treaty Port system. Domestic governance was notorious for political and legal stability (Long, Ding and Ma, 2021; Ma, 2019). Failure to apply technology was the direct cause of local growth's lack of TFP gains, but the unstable political environment might have been a deeper factor. Thus, institutions still cannot be completely ruled out. Outside of Treat Ports, the institutional environment might be completely different. In other words, institutions were crucial to the Yangzi Delta's progress during this period. However, the spread of the new institutions was not uniform, which could be one of the reasons why the Yangzi Delta lagged behind other economies. Of course, worker production culture might also have played a role. Cultural differences may affect productivity (Clark, 1987). Overall, these factors were more likely to be intertwined and influence each other. Unfortunately, these discussions may be beyond the scope of this study. This part of my discussion is more of a question than an answer. However, there is no doubt that the Yangzi Delta's inability to control economic shrinkage was a major reason for its failure to modernise. International comparisons indicate that the initial phase of modernisation may be characterised by a reduction in the frequency of economic shrinkage.

6.5 Conclusion

The Great Divergence is a topic full of beauty and fascination. In this chapter, I use the Yangzi GDP per capita data to provide a straightforward answer for the first time in the literature. My findings differ from both the Eurocentrism and the California School. The timing of the Great Divergence, which I believe occurred essentially at the end of the 17th century, is consistent with the "third way" that the BGL once took. I have tried to double-check my conclusions from a counterfactual framework to support this seemingly unpopular new conclusion. An eclectic conclusion implies that the Industrial Revolution, which in classic literature seems to have been a turning point for human civilisation, may have been a consequence rather than a cause. East and West economic development might have diverged a century before the Industrial Revolution. On the other hand, although Europe seemed to have been distinct in the past, early scholars' more pessimistic perception of Asia may also have been exaggerated. The clarity of the timing of the Great Divergence indicates that more explanatory frameworks based on better historical facts can be proposed as a next step. Why did the Great Divergence occur? Why did once-glorious China fall behind the West? More convincing explanatory models for such questions may thus emerge. This, however, does not necessarily mean that dating the Great Divergence is over. Sub-regions of China and other parts of Asia, such as Beijing and Mumbai, are also worth exploring. Also, there could be other interesting things besides productivity (e.g., van Zanden et al., 2014, 2021). Indicators closely related to human well-being, such as health, longevity, and nutrition, must be pushed back further the 19th century in future research. Clearly, debate over the various perspectives on the Great Divergence is just getting started.

Finally, I shift my gaze to the two centuries following the Great Divergence. Along the lines of the previous chapter, I revisit the Yangzi Delta's tortuous experiences and struggles on the road to modern economic growth by incorporating an international comparative context. Although the Yangzi Delta's economic growth during this period

appeared relatively favourable on its own, international comparisons show that it was still not very impressive, especially when compared to the rapid economic growth of various countries that were once considered poor in the late 19th century. What caused this? It is far beyond the scope of this chapter. Although I have attempted to analyse the issue in terms of economic shrinkage, my discussion is more like asking the question than giving a final answer. The discussion of the economic shrinkage perspective is more like a beginning, where I try to pinpoint specific causes to technology, political circumstances, and even culture. However, each of these factors is far beyond the scope of this study, and it is well worth investigating further in future research. Identifying these issues through international comparisons helps explain China's economic growth history. If the Yangzi Delta, China's most developed economy, had remained weak in the first half of the twentieth century, China's truly modern economic growth would have occurred much later. Was it the new Communist-led China that began in 1949, or the market-oriented reforms that began in 1978? These topics deserve further discussion.

CHAPTER SEVEN: CONCLUSIONS

7.1 Methodology: rethinking Historical National Income Accounting in the Yangzi Delta case

My tens of thousands of words of research come to an end here. Many topics have been covered in the first six chapters. However, "arithmetic" is really the only concept that underpins them all. In essence, my research has been focused on one thing: counting or arithmetic. All of my chapters serve as an introduction to and extension of my arithmetic steps. It is also the essential paradigm for historical national income accounting. One of the most significant enlightenments brought about by the development of the Great Divergence study over the last 20 years may be the recognition of the importance of simple arithmetic in economic history. This contrasts with the rise of Cliometrics in the second half of the twentieth century, which emphasised the application of economic models and methods to the study of economic history. In some ways, the arithmetic I would like to talk about is neither a new research method nor a new field of study. Even whether the so-called "arithmetic" is relevant to economics is unimportant. Despite the fact that big names like Colin Clark, Simon Kuznets, Paul Bairoch, and Angus Maddison have made the field extremely academic and specialised, it is essentially nothing more than a simple form of addition and subtraction. The easiest way to describe economic growth is always to calculate an economy's output using simple math.

In economic history, descriptive research with "arithmetic" at its core has a long tradition. In the past two decades, comparative studies of economic growth and living standards from a global perspective have grown, requiring more rigorous arithmetic and data measurement. As a result, descriptive research with "arithmetic" at its core has advanced significantly more since the Great Divergence Debate than it had in the previous century of academic history. Many rigorous descriptive methods, not only for historical

national income accounting but also for wages, consumption, calorie intake, height, life expectancy, mortality, health conditions, inequality, security, social systems, and so on, have been developed (van Zanden et al., 2014, 2021).

These methods are not particularly novel and are drawn primarily from existing social science toolkits. However, since the Great Divergence, not only have these methods advanced in their application to more or earlier economies, but scholars have begun to seriously debate the benefits and drawbacks of applying them to history versus their simpler application in the past. Which outcomes from these tools should be viewed with caution in our understanding of economic development throughout history? Under what circumstances do the methods we employ fail to assess the issues we are concerned about? These could be among the most significant gains made in the last two decades.

Almost every time an indicator or method has been used, it has been met with a challenge and a response. As an illustration, the debates between Allen and Humphries et al. on the British wage study (e.g., Allen, 2015; 2020; Humphries, 2013a, 2013b; Humphries and Schneider, 2019; Humphries and Weisdorf, 2019) and the debates between Allen et al. and Deng and O'Brien on Chinese wages (Allen et al., 2011; Broadberry and Gupta, 2006; Deng and O'Brien, 2016, 2018) push our understanding of East-West wages to a deeper stage.

The debate over historical GDP studies has also lasted a long time. For instance, Deng and O'Brien (2017), Ma and van Zanden (2017), Broadberry, Guan and Li (2018, 2021), Broadberry (2021), Deng and O'Brien (2021), Goldstone (2021), Solar (2021a, 2021b), and van Zanden and Bolt (2021) are just a few of the authors who have addressed the issue.

Agriculture debates are common in both Eastern and Western contexts, as a field that almost always comes first in economic history; for example, in Broadberry et al. (2018) and Clark (2018) on English agriculture, in Chen and Peng's (2022) retrospective

review of Chinese agricultural history, and earlier in Huang (1990) and Li (1998) on the Yangzi Delta agriculture. In fact, both mainstream and non-mainstream discussions have contributed to our understanding of how to analyse and evaluate historical economic development.

Wages, for example, which I discuss in Chapter One, as well as labour productivity, GDP, consumption, height, and other commonly used indicators in the literature, are all imperfect but useful indicators. This is why methods like historical national income accounting and others exist: with a diverse toolkit, we can always choose the right screwdriver to twist the corresponding screw. So, when studying or judging the economic development of the past, it is important to ask what questions are important instead of getting caught up in the details of how an indicator is calculated. Let us return to the historical national income accounting framework that was used in this research. What things should we keep in mind when using this method, especially in the Yangzi Delta? In fact, I have mentioned it in the specific calculations in the various sections of this study.

(1) The first lesson is that, based on what we know about the past, historical national income accounting methods may be a better way to measure how China's economy has changed in the past than other methods. This knowledge is not always a theorem. We will abandon this lesson if new materials or archives containing a large amount of evidence, such as wages that were scarce in the past, become available. In most cases, though, it is probably more efficient to perform calculations using an output-based methodology, keeping in mind the fact that Chinese materials lack sufficient micro-evidence. Although the raw data cannot always be used directly, agricultural macro-data in China is of high quality, as I have stated numerous times. This is due to the Chinese fiscal system's unique interest in such information.

(2) The second lesson is that, in the absence of sufficient data, not all sectors of the economy should be given equal weight. Agriculture was the most important sector for

the majority of the time. This is partly because agriculture had the highest share of GDP in the pre-modern period; for example, the Yangzi Delta, China's region with the most modern economic structure, had an agricultural share of more than 50 percent in the long run. Agriculture's final products, on the other hand, were frequently intermediate inputs for the non-agricultural sector, such as rice milling, textiles, oil pressing, and so on. Furthermore, due to the special design of the fiscal system, there was often very good data available for calculating agricultural output, such as cultivated land, population, and grain yields, which basically ensured a palpable agricultural output.

There is often no good data available for sectors other than agriculture. However, many sub-sectors, such as construction, are highly correlated with population size, implying that output per capita has remained roughly constant. In other words, in the case of the Yangzi Delta and even China, population, cultivated land, and output per acre are the most important indicators. Sometimes studies may inevitably get bogged down in excessive attention to details, as in the specific case of stamp production or the Chinese brush industry in the Yangzi Delta. However, in reality, these industries contributed very little to the economy. Giving them a fixed proportional share based on reasonable evidence has little impact on the final GDP outcome.

(3) The third lesson serves as a counterpoint caution to the second, namely that while historical GDP calculations may never be perfect, researchers must be aware of the potential impact of calculation errors on the issues they are trying to answer. In my opinion, historical GDP can be useful in answering some questions, but it might not be useful in all cases, as in the case of the previously mentioned extremely small sectors in the Yangzi Delta.

The Yangzi Delta's agricultural output is probably not too contentious overall. The two main factors, essentially cultivated land and grain yields, do not vary significantly in the literature; as a result, the agricultural output obtained is typically subject to relatively small errors. The non-agricultural sector is where the issues could originate. I'm

also aware of this problem in Chapter Four's calculations. Whatever angle is used to examine the non-agricultural sector in the Yangzi Delta, there doesn't seem to be enough data to tell the entire story. Therefore, rather than relying solely on the outcomes of any one approach, my response is to employ several approaches and check them against one another. Fortunately, there is little variation in the outcomes of my various methods. Instead of calculating specific non-agricultural output, I could have tried to make a more cautious basic trend determination, such as what was the per capita growth of non-agricultural output in the Yangzi Delta. Understanding the long-term trends in output or income per capita for the region as a whole—one of my main concerns—would be made possible with the help of an answer to this question. After loosening the assumptions, such an exploration would still suggest that the Yangzi Delta's most optimistic scenario for non-agricultural output would be constant output per capita. Given that agricultural output per person decreased over time, the Yangzi Delta's long-term trend of declining income per capita is generally acceptable.

Lessons two and three are, in fact, two sides of the same coin. The former necessitates a problem-solving approach that captures the most important information or a significant portion of GDP rather than focusing on an endless stream of minute details. The latter warns us to be aware of how research errors may affect how we respond to the ultimate question. Both lessons address the same topic: what the research questions are.

The choice of the most appropriate methods and assumptions for the question at hand is nearly the most important aspect of historical national income accounting. This is why I have spent nearly half or more of this chapter introducing the development of historical economic growth or living standards measures. There is no perfect criterion for assessing historical economic development. In many cases, a unique design is required to avoid elements that are nearly impossible to achieve and are unimportant for answering the questions we are interested in.

Even if the final attempt to calculate GDP is incorrect, presenting the evidence and the calculation process is a contribution to future researchers: at the very least, we know why the existing methods fail. Let me return to the analogy of sailing on the sea that I used in Chapter One. The possibility of taking the wrong course is something that all captains worry about or consider with caution, but we can only get close to the end by taking the first step. Even if the course was completely incorrect, it would be noted on the navigational charts for future reference as "This is not the way to go." Historical national income accounting and other attempts to investigate historical economic development must be pursued in this regard. This is not just a task for economists; in fact, all researchers can benefit from this very simple, discipline-independent arithmetic work.

7.2 Key findings: the Yangzi Delta in China and the Yangzi Delta in the World

The study's findings are as brief and straightforward as the methodology. As the region that has received almost the most attention in Chinese economic history, there are quite divergent views on what the Yangzi Delta's historical development looked like. The two sharply opposing sides can be roughly divided into two camps: pessimistic and optimistic. While the Yangzi Delta is one of China's most developed economies, the former do not see a development pattern that goes beyond that of pre-modern economies, i.e. a picture of long-term stagnation. The latter, represented by the California School, believes that the Yangzi Delta's economic development occurred in a very modern manner. New technologies, ideas, and methods were constantly emerging. In agriculture, the former sees local agriculture as being in an Involutionary pattern of growth in aggregate but stagnation in per capita terms. The latter believes that, while population pressure did exist, the emergence of new business practises and other new things largely contributed to a revolution in the so-called Boserupian style of rural economy. In the economy as a whole, the former remained as pessimistic as agriculture,

while the latter began to promote the idea that population growth led to the development of markets and so-called Smithian economic growth.

However, many of these arguments are based on incomplete information. Based on the evidence cited by each of these scholars, it appears that none of them is incorrect. But in reality, there is only one truth. My "arithmetic" exploration of the Yangzi Delta has helped to reconcile these two opposing viewpoints. Based on my calculations, it appears that my results likely to support the Involution School regarding the trajectory of per capita GDP growth, or the so-called "high-level equilibrium trap" that predicts divergent growth patterns for per capita and total output. There is no doubt that economic aggregates increased, both in agriculture and in the overall economy, as population increased in most cases. Nevertheless, from a per capita standpoint, there was almost no local economic progress or even a steady decline. That is also what Mark Elvin (1973: Chapter 17) referred to as "quantitative growth, qualitative standstill".

Of course, I am not dismissing the California School argument entirely. In fact, the "new things or changes" they advocate were all present, such as double cropping, an increase in cash crops, and so on, brought about by agricultural intensification, a decline in agricultural share, and continuous improvement in the economic structure. Their presence did, in fact, boost per capita output or, to put it another way, postpone the falling trend in per capita output. However, these changes, which resembled struggles or resistance, did not affect the overall pattern of economic growth in terms of per capita output. For the Yangzi Delta, population pressure had always been the most challenging problem. These new changes could simply be a passive reaction to population pressure. They did, in fact, lessen the projected fall in per capita output, but not sufficiently to completely reverse the situation.

Why did the Malthusian mechanism of "death to the poor, birth to the rich" fail in the Yangzi Delta is also an intriguing question. The long-term decline in GDP per capita suggests that the Malthusian mechanism of preventive check was not very effective in

the local context: even as per capita income fell, people continued to have children without concern, eventually leading to increased population pressure. If the literature's estimates of China's overall GDP are correct, China as a whole is, for the most part, in the same situation as the Yangzi Delta.

The Great Divergence debate, to which I have been referring, can be resolved by examining the Yangzi Delta's economic growth within the historical context of global economic growth. The Yangzi Delta, as one of China's most developed economies, grew at a similar rate to the leading European economies until the 18th century. When compared to continental economies such as France, Eastern Europe, and Southern Europe prior to the 18th century, the Yangzi Delta performed significantly better. However, after the 18th century, the Yangzi Delta's continued decline in per capita income versus the continued rise of European leaders resulted in permanent backwardness. In other words, it can be said that the Great Divergence happened in the final decades of the 17th century. This finding represents the so-called "Third Way", which lies midway between the revisionists and their opponents.

7.3 What can we expect in the future?

Instead of ending the conversation about the Great Divergence, I would prefer to think that my research is a new beginning. There are still many unexplored areas in the Chinese and Asian regional economies. Beijing, China's capital, and Guangzhou, the almost largest trading port in South China, are two other economies worth investigating. Also, the story of sub-regions within India as a giant territorial economy could be a new breaking point for the Great Divergence topic. Most of Asian history is still up for debate, and many countries' GDP does not go back to the 18th century.

Furthermore, GDP is not the entire story of human civilisation (e.g., Costanza et al., 2009; Fleurbaey, 2009; Jones and Klenow, 2016), but rather a more understandable and

intuitive measurement (Leunig, 2011). One expectation for the future is to delve deeper into other aspects of the story in the long-term comparison of East and West. This could be more difficult for China or the Yangzi Delta. A significant limitation is the lack of data. It may be difficult to draw new conclusions from existing data using traditional input-side measures such as wages and productivity. However, the output-side, such as human welfare or health, which may be our ultimate goal, merits further investigation. Archaeological evidence is likely to yield new materials that are well worth the wait. The ongoing Global History of Health Project in Asia, which is said to contain tens of thousands of samples, could yield some new health history findings (Wang and Zhang, 2020).

Following the descriptive study, we would like to return to the classic East-West comparison question of why, at least in modern times, Eastern civilisation lagged significantly behind the West, or why the Industrial Revolution occurred in the West. An earlier date for the Great Divergence would force us to think much further back in time. What caused the apparent divergence of Eastern and Western societies prior to the Glorious Revolution or Industrial Revolution? And what prompted these changes? Perhaps this is a never-ending story. It will, however, be an exciting question for economists, historians, and economic historians alike

Appendices

Appendix A: Sources for grain yields

272 pieces come from land transaction contracts in Huizhou Prefecture, Anhui Province. The contracts are from the first and second series of "*Mingqing huizhou jingji ziliao congbian*" *(Huizhou Socio-economic Data Series in Ming and Qing*, 明清徽州经济资料从编) (1988, 1990), and "*Zhongguo lidai qiyue cuibian*" (*Compilation of Chinese Contracts in Past Dynasties, 3 volumes in total*, 中国历代契约粹编) (2014).

178 pieces come from three ledgers in "*Huizhou qiannian qiyue wenshu: song-yuan-ming bian, di wu juan*" (*Huizhou Millennium Contract Documents: Song Yuanming Compiled, Volume 5*, 徽州千年契约文书: 宋元明编, 第五卷) (1993). No. 100000-100097; No.300001-300040; No. 400001-400028.

1349 pieces come from Chao Kang et al.'s (1995) appendix in page 99-123. The authors compiled 61 consecutive rent collection records from accounting books.

52 pieces come from "*Dou shan gongjia yi*" (*Regulations and Law of Cheng Family*, 窦山公家议), which is the management regulations of a Huizhou family in the Ming Dynasty.

882 pieces come from Zhang Youyi (1984, 1988). In Zhang's two books, he studied in detail dozens of complete manor ledgers.

434 pieces are from Shi Zhihong (2017)'s Appendix 3. Shi collected more than 3000 records of grain yields across the country by consulting thousands of local gazetteers and publications of the Qing Dynasty, of which 434 were in the Yangzi Delta.

31 pieces are from Guo Songyi (2010) and Liang Zhuying (2006). These figures were respectively collected from the local gazetteers of the Yangzi Delta in the Ming Dynasty, similar to Shi's method in the Qing period.

6 pieces come from surveys in the Republic of China and the 1950s. The data for the Republic of China comes from the aggregation of Chang C. C.'s county-level survey (1929). The data in the 1950s comes from "*Jiangsu Agricultural Statistics*, 江苏省农业统计资料" (1976) and "*Shanghai General Gazetteer (Volume 1)*, 上海通志第一卷" (2005).

Appendix B: Semantic and lexical classification criteria for describing the degree of agricultural harvest

Levels of yearly harvests	1 Very poor	2 Poor	3 Slightly poor	4 Average	5 Near bumper	6 Bumper
Harvest rating in percentage	<40 percent	40-50 percent	50-60 percent	60-70 percent	70-80 percent	>80 percent
Direct wording on assessment of crop yield	Very poor harvest; Very bad year; Nothing was reaped; No harvest in vast areas	Poor harvest; Poor grain harvest; Bad year; No prospect for harvest; No any bumper crops	Slightly poor harvest; No enough crop yield; No good harvest/year	Normal harvest; Unusual year; Not bad year; Common year	Bumper harvest; Good harvest; Bumper year; Favorable year	Large bumper harvest; Large harvest; A golden year; Bumper harvest of all "five" crops
Impact wording on assessment of food security related to crop harvest directly	People became cannibal; Large famine and no food; Deadly famine year and beggars were everywhere, many people died of hunger	People were starving; No enough food for people; People had pale and anemic complexions; Production on alcohol and related drink were prohibited			Surplus grain stored in the fields; Foods and clothes more than enough	

Related features, e.g., tax remission, people's livelihoods, grain prices and grain storage status	All taxes were remitted; People fled everywhere; Pirates and beggars were rampant; Food storage was exhausted	Taxes were partly remitted; People were not engaged in agriculture; People lived in poverty; People could not support themselves; Most of the people were poor; People were impoverished and had many complaints; The granaries were nearly empty; The whole country was poor and weak; The grain price was five or ten thousand Qian per Dan; The grain price was soaring; Grain became more and more expensive	Farms were laid waste; People had no surplus food storage		People lived a prosperous and contented life; There was enough grain for store	Every family had adequate supplies of food and clothes; People were well-off; The whole country was in safety and good order; The granaries were all full; The grain price was so low that peasants could not earn enough money

Sources and notes: the table is directly derived from Hao et al. (2020)

Appendix C: data for Cotton price expressed in rice

Year	Cotton price in rice (Ming/Qing shi per hundred Jin)	Year	Cotton price in rice (Ming/Qing shi per hundred Jin)	Year	Cotton price in rice (Ming/Qing shi per hundred Jin)
1368	5.36	1483	4.78	1662	1.47
1368	7.14	1484	4.68	1662	1.38
1376	3.98	1487	5.13	1663	2.61
1383	3.36	1487	3.67	1664	2.47
1385	9.09	1500	5.71	1665	2.35
1397	12.20	1501	5.71	1666	3.36
1397	12.20	1503	10.48	1667	2.67
1407	11.36	1506	4.76	1667	3.92
1407	9.47	1620	2.68	1668	4.27
1421	4.50	1624	2.02	1669	2.20
1422	5.63	1631	4.76	1669	4.70
1422	6.68	1644	0.22	1670	3.50
1426	2.50	1644	0.94	1670	2.35
1426	1.88	1645	0.94	1671	3.08
1428	6.25	1646	0.78	1671	1.81
1428	7.50	1647	0.59	1672	2.55
1429	12.50	1648	0.76	1672	2.14
1429	6.25	1649	1.57	1673	1.25
1429	12.50	1649	1.07	1673	3.92
1429	6.25	1650	2.78	1674	3.17
1432	3.33	1650	1.31	1674	3.92
1433	9.17	1651	0.60	1675	3.36
1436	6.67	1652	0.71	1676	2.50
1440	10.00	1653	0.87	1676	2.94
1441	8.05	1654	0.94	1677	2.50
1442	6.66	1655	0.94	1677	2.94
1464	6.66	1656	1.47	1678	1.67
1471	7.01	1657	3.57	1678	2.61
1476	2.67	1657	3.36	1679	0.86
1478	5.37	1658	1.74	1679	1.31
1479	5.24	1659	2.25	1680	1.30
1480	5.97	1659	1.18	1680	1.02
1480	5.12	1660	1.27	1681	2.37
1481	5.00	1661	1.18	1681	1.57
1482	4.89	1661	1.38	1682	5.86

Year	Cotton price in rice (Ming/Qing shi per hundred Jin)	Year	Cotton price in rice (Ming/Qing shi per hundred Jin)	Year	Cotton price in rice (Ming/Qing shi per hundred Jin)
1682	3.36	1711	2.94	1750	2.04
1683	2.61	1712	3.36	1751	1.74
1684	1.50	1713	2.61	1752	1.45
1684	2.61	1714	2.61	1753	1.94
1685	2.61	1715	1.96	1754	2.04
1686	2.35	1716	2.35	1755	1.77
1687	2.27	1717	2.35	1756	1.23
1687	2.14	1718	2.94	1757	1.97
1688	3.00	1719	3.36	1758	1.91
1688	3.92	1720	2.94	1759	1.72
1689	2.43	1721	2.61	1760	1.54
1689	2.14	1722	2.35	1761	1.84
1690	1.70	1723	2.35	1762	1.75
1690	2.35	1724	1.96	1763	1.84
1691	2.35	1725	1.96	1764	1.93
1692	1.71	1726	2.61	1765	1.74
1692	3.36	1727	1.81	1766	1.74
1693	1.60	1728	1.96	1767	2.01
1693	2.35	1729	1.96	1768	1.94
1694	1.18	1730	1.96	1769	1.70
1694	2.14	1731	1.96	1770	1.68
1695	5.00	1732	1.81	1771	2.07
1695	3.36	1733	1.68	1772	2.16
1696	4.71	1734	1.96	1773	2.46
1696	3.36	1735	2.35	1774	2.06
1697	2.94	1736	3.35	1775	1.63
1698	2.61	1737	3.05	1776	1.60
1699	2.73	1738	2.58	1777	1.79
1700	2.83	1739	2.39	1778	1.91
1701	2.94	1740	2.79	1779	1.44
1702	2.55	1741	2.50	1780	1.79
1703	2.26	1742	2.19	1781	1.54
1704	2.03	1743	2.09	1782	3.22
1705	1.84	1744	2.16	1783	1.95
1706	1.68	1745	2.36	1784	2.26
1707	1.81	1746	2.45	1785	1.91
1708	1.47	1747	2.08	1786	1.52
1709	1.96	1748	1.64	1787	1.83
1710	2.61	1749	1.98	1788	2.47

Year	Cotton price in rice (Ming/Qing shi per hundred Jin)	Year	Cotton price in rice (Ming/Qing shi per hundred Jin)	Year	Cotton price in rice (Ming/Qing shi per hundred Jin)
1789	2.68	1846	1.50	1882	2.82
1790	2.82	1847	1.28	1883	2.61
1791	2.74	1847	1.89	1884	2.87
1792	2.92	1848	1.26	1885	3.09
1793	2.94	1848	1.35	1886	2.35
1794	6.65	1849	2.23	1887	2.18
1805	3.32	1849	1.45	1888	2.72
1806	1.37	1850	1.80	1889	2.29
1807	1.70	1851	1.60	1890	2.00
1808	1.34	1852	2.64	1891	2.45
1809	1.36	1853	2.51	1892	2.13
1810	1.52	1854	2.16	1893	2.24
1811	1.66	1855	2.25	1894	2.08
1812	1.52	1856	2.63	1910	1.27
1813	1.53	1857	1.70	1911	0.95
1814	1.38	1858	1.62	1912	0.90
1815	1.76	1859	1.73	1913	0.93
1817	3.04	1860	2.44	1914	1.22
1821	1.04	1861	1.75	1915	0.87
1824	3.47	1862	1.21	1916	0.90
1825	1.33	1863	2.24	1917	1.06
1826	1.46	1864	2.11	1918	1.12
1827	1.53	1865	2.11	1919	0.79
1828	1.53	1866	2.42	1919	0.97
1829	1.50	1867	2.86	1920	0.79
1830	1.46	1868	3.78	1920	0.68
1831	1.33	1869	3.27	1921	0.82
1832	1.28	1870	3.08	1921	0.74
1833	2.65	1871	2.70	1922	0.78
1835	2.50	1872	2.57	1922	0.65
1836	1.48	1873	2.01	1923	0.74
1837	1.53	1874	2.01	1923	0.71
1838	1.60	1875	2.85	1924	0.78
1841	1.50	1876	2.52	1924	0.93
1842	1.51	1877	2.13	1925	0.79
1843	1.42	1878	1.90	1925	0.77
1844	1.05	1879	2.35	1925	1.27
1845	1.12	1880	2.83	1926	0.78
1846	1.31	1881	3.20	1926	0.60

Year	Cotton price in rice (Ming/Qing shi per hundred Jin)	Year	Cotton price in rice (Ming/Qing shi per hundred Jin)	Year	Cotton price in rice (Ming/Qing shi per hundred Jin)
1926	0.72	1930	0.71	1933	0.99
1927	0.74	1930	0.70	1933	1.31
1927	0.93	1930	0.79	1933	1.41
1927	0.81	1931	0.86	1933	1.46
1928	0.84	1931	1.01	1934	0.89
1928	1.25	1931	1.05	1934	1.01
1928	1.15	1931	0.88	1934	1.10
1929	0.85	1932	0.85	1934	1.13
1929	0.89	1932	1.04	1935	0.82
1929	0.90	1932	0.98	1935	0.85
1930	0.72	1932	0.91	1935	0.93
1930	0.68	1932	0.80	1935	0.99

Appendix D: data for unhusked rice yield per Mu

Year	Unhusked rice (Jin/Mu)	Year	Unhusked rice (Jin/Mu)	Year	Unhusked rice (Jin/Mu)
1393	410	1429	412	1465	375
1394	419	1430	404	1466	385
1395	420	1431	379	1467	453
1396	388	1432	444	1468	445
1397	421	1433	406	1469	427
1398	422	1434	359	1470	437
1399	415	1435	463	1471	401
1400	424	1436	425	1472	411
1401	408	1437	456	1473	420
1402	393	1438	409	1474	439
1403	402	1439	410	1475	467
1404	357	1440	319	1476	468
1405	366	1441	428	1477	423
1406	396	1442	403	1478	442
1407	450	1443	412	1479	452
1408	430	1444	386	1480	420
1409	431	1445	404	1481	337
1410	415	1446	431	1482	338
1411	399	1447	423	1483	505
1412	408	1448	450	1484	422
1413	409	1449	367	1485	404
1414	385	1450	363	1486	465
1415	411	1451	421	1487	438
1416	428	1452	462	1488	448
1417	437	1453	374	1489	467
1418	438	1454	325	1490	440
1419	439	1455	379	1491	384
1420	423	1456	411	1492	413
1421	441	1457	411	1493	441
1422	416	1458	421	1494	442
1423	408	1459	448	1495	433
1424	392	1460	413	1496	514
1425	410	1461	422	1497	491
1426	393	1462	459	1498	463
1427	419	1463	451	1499	464
1428	394	1464	415	1500	474

Year	Unhusked rice (Jin/Mu)	Year	Unhusked rice (Jin/Mu)	Year	Unhusked rice (Jin/Mu)
1501	494	1541	485	1581	518
1502	499	1542	526	1582	497
1503	395	1543	421	1583	540
1504	453	1544	371	1584	587
1505	468	1545	346	1585	588
1506	430	1546	417	1586	509
1507	426	1547	530	1587	413
1508	374	1548	510	1588	360
1509	374	1549	470	1589	413
1510	399	1550	502	1590	439
1511	452	1551	523	1591	487
1512	462	1552	529	1592	529
1513	463	1553	515	1593	508
1514	473	1554	474	1594	503
1515	445	1555	527	1595	487
1516	475	1556	564	1596	466
1517	447	1557	528	1597	519
1518	428	1558	509	1598	461
1519	404	1559	478	1599	546
1520	498	1560	474	1600	509
1521	499	1561	354	1601	477
1522	431	1562	454	1602	557
1523	383	1563	522	1603	578
1524	403	1564	544	1604	541
1525	453	1565	535	1605	510
1526	429	1566	504	1606	494
1527	513	1567	489	1607	542
1528	455	1568	505	1608	388
1529	456	1569	496	1609	478
1530	496	1570	475	1610	547
1531	487	1571	549	1611	552
1532	478	1572	549	1612	462
1533	479	1573	538	1613	569
1534	470	1574	502	1614	564
1535	505	1575	497	1615	511
1536	481	1576	518	1616	543
1537	492	1577	518	1617	511
1538	473	1578	497	1618	511
1539	423	1579	534	1619	485
1540	449	1580	460	1620	474

Year	Unhusked rice (Jin/Mu)	Year	Unhusked rice (Jin/Mu)	Year	Unhusked rice (Jin/Mu)
1621	511	1661	463	1701	587
1622	554	1662	537	1702	529
1623	511	1663	505	1703	578
1624	480	1664	537	1704	487
1625	453	1665	537	1705	520
1626	473	1666	600	1706	536
1627	441	1667	558	1707	477
1628	473	1668	516	1708	423
1629	509	1669	558	1709	499
1630	520	1670	442	1710	581
1631	509	1671	447	1711	593
1632	487	1672	484	1712	583
1633	487	1673	563	1713	545
1634	508	1674	495	1714	502
1635	497	1675	526	1715	524
1636	560	1676	494	1716	487
1637	491	1677	494	1717	588
1638	485	1678	505	1718	544
1639	485	1679	447	1719	550
1640	385	1680	505	1720	452
1641	358	1681	552	1721	491
1642	383	1682	552	1722	523
1643	456	1683	474	1723	491
1644	466	1684	542	1724	513
1645	513	1685	527	1725	535
1646	502	1686	527	1726	492
1647	507	1687	475	1727	546
1648	523	1688	518	1728	536
1649	528	1689	518	1729	586
1650	491	1690	508	1730	608
1651	436	1691	552	1731	515
1652	448	1692	568	1732	465
1653	485	1693	533	1733	492
1654	558	1694	534	1734	492
1655	500	1695	503	1735	546
1656	527	1696	552	1736	545
1657	558	1697	547	1737	513
1658	516	1698	527	1738	502
1659	506	1699	538	1739	568
1660	527	1700	538	1740	547

Year	Unhusked rice (Jin/Mu)	Year	Unhusked rice (Jin/Mu)	Year	Unhusked rice (Jin/Mu)
1741	525	1781	558	1821	596
1742	602	1782	537	1822	567
1743	603	1783	571	1823	462
1744	538	1784	550	1824	596
1745	566	1785	517	1825	558
1746	588	1786	552	1826	564
1747	506	1787	632	1827	548
1748	506	1788	577	1828	514
1749	573	1789	555	1829	526
1750	529	1790	532	1830	526
1751	507	1791	555	1831	515
1752	546	1792	589	1832	560
1753	602	1793	510	1833	448
1754	542	1794	504	1834	502
1755	376	1795	565	1835	568
1756	430	1796	605	1836	611
1757	506	1797	602	1837	544
1758	506	1798	587	1838	560
1759	516	1799	652	1839	543
1760	615	1800	574	1840	519
1761	494	1801	587	1841	518
1762	537	1802	626	1842	539
1763	559	1803	585	1843	516
1764	570	1804	527	1844	559
1765	537	1805	537	1845	558
1766	498	1806	570	1846	525
1767	524	1807	585	1847	567
1768	552	1808	493	1848	523
1769	482	1809	645	1849	424
1770	565	1810	599	1850	530
1771	538	1811	553	1851	550
1772	599	1812	609	1852	539
1773	562	1813	597	1853	516
1774	579	1814	467	1854	515
1775	547	1815	639	1855	546
1776	565	1816	611	1856	444
1777	593	1817	582	1857	533
1778	500	1818	648	1858	533
1779	567	1819	514	1859	532
1780	590	1820	585	1860	531

Year	Unhusked rice (Jin/Mu)	Year	Unhusked rice (Jin/Mu)	Year	Unhusked rice (Jin/Mu)
1861	541	1892	469	1923	445
1862	509	1893	487	1924	435
1863	482	1894	465	1925	426
1864	481	1895	482	1926	407
1865	495	1896	525	1927	392
1866	516	1897	450	1928	412
1867	525	1898	438	1929	411
1868	504	1899	484	1930	410
1869	503	1900	455	1931	361
1870	570	1901	473	1932	406
1871	533	1902	462	1933	396
1872	522	1903	489	1934	335
1873	501	1904	487	1935	407
1874	510	1905	467	1936	415
1875	520	1906	427	1937	423
1876	488	1907	444	1938	398
1877	508	1908	461	1939	414
1878	507	1909	449	1940	397
1879	476	1910	428	1941	404
1880	552	1911	407	1942	404
1881	506	1912	459	1943	420
1882	495	1913	439	1944	405
1883	483	1914	408	1945	405
1884	522	1915	430	1946	388
1885	471	1916	446	1947	395
1886	526	1917	459	1948	394
1887	499	1918	460	1949	376
1888	467	1919	415	1950	404
1889	404	1920	422	1951	399
1890	502	1921	403	1952	394
1891	491	1922	428	1953	389

Appendix E: Sectoral real output, real GDP, population and real GDP per capita in the Yangzi Delta

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1393	208	79	111	398	11,065	36.0
1394	213	80	112	405	11,129	36.4
1395	213	80	113	406	11,194	36.3
1396	197	80	110	387	11,259	34.4
1397	214	81	114	409	11,325	36.1
1398	214	82	114	410	11,391	36.0
1399	211	82	114	407	11,457	35.5
1400	216	82	116	414	11,524	35.9
1401	208	83	115	406	11,591	34.9
1402	200	83	113	396	11,658	34.0
1403	205	83	115	403	11,726	34.3
1404	182	83	111	376	11,794	31.8
1405	186	83	112	381	11,863	32.2
1406	201	84	116	401	11,932	33.6
1407	229	86	121	436	12,002	36.4
1408	219	86	120	425	12,071	35.2
1409	220	87	120	427	12,142	35.1
1410	212	87	119	418	12,212	34.2
1411	204	87	118	409	12,283	33.3
1412	209	88	120	417	12,355	33.7
1413	209	88	120	417	12,427	33.6
1414	197	88	118	403	12,499	32.2
1415	210	89	121	420	12,572	33.4
1416	219	90	124	433	12,645	34.2
1417	223	91	125	439	12,719	34.5
1418	224	91	126	441	12,793	34.4
1419	224	92	126	442	12,867	34.4
1420	217	92	125	434	12,942	33.5
1421	226	87	122	435	12,242	35.6
1422	214	87	120	421	12,287	34.3
1423	210	87	120	417	12,332	33.8
1424	201	87	118	406	12,377	32.9

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1425	210	88	120	418	12,422	33.7
1426	202	88	119	409	12,467	32.8
1427	215	89	122	426	12,513	34.1
1428	203	88	120	411	12,559	32.7
1429	212	89	122	423	12,605	33.5
1430	208	89	121	418	12,651	33.1
1431	195	89	119	403	12,697	31.7
1432	228	91	126	445	12,743	34.9
1433	209	90	123	422	12,790	33.0
1434	185	89	118	392	12,837	30.6
1435	239	92	129	460	12,884	35.7
1436	219	92	125	436	12,931	33.7
1437	235	93	129	457	12,978	35.2
1438	211	92	124	427	13,026	32.8
1439	211	92	125	428	13,073	32.7
1440	164	90	116	370	13,121	28.2
1441	221	93	127	441	13,169	33.5
1442	207	93	125	425	13,217	32.2
1443	212	93	126	431	13,265	32.6
1444	199	93	124	416	13,314	31.2
1445	209	94	126	429	13,363	32.1
1446	223	95	129	447	13,412	33.3
1447	218	95	129	442	13,461	32.8
1448	233	96	132	461	13,510	34.1
1449	189	94	124	407	13,559	30.1
1450	187	94	124	405	13,609	29.8
1451	217	96	130	443	13,659	32.5
1452	238	97	134	469	13,708	34.3
1453	193	96	126	415	13,759	30.1
1454	168	95	121	384	13,809	27.8
1455	196	96	127	419	13,859	30.2
1456	212	97	130	439	13,910	31.7
1457	213	98	131	442	13,961	31.6
1458	218	98	132	448	14,012	32.0
1459	232	99	135	466	14,063	33.2
1460	214	99	132	445	14,115	31.5
1461	219	99	133	451	14,166	31.9
1462	238	101	137	476	14,218	33.4
1463	233	101	137	471	14,270	33.0

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1464	215	100	134	449	14,322	31.3
1465	194	100	130	424	14,375	29.5
1466	199	100	131	430	14,427	29.8
1467	235	102	139	476	14,480	32.9
1468	231	102	138	471	14,533	32.4
1469	222	102	137	461	14,586	31.6
1470	227	103	138	468	14,639	31.9
1471	208	102	135	445	14,693	30.3
1472	213	103	136	452	14,747	30.6
1473	218	103	137	458	14,801	31.0
1474	228	104	140	472	14,855	31.8
1475	243	105	143	491	14,909	32.9
1476	243	106	143	492	14,963	32.9
1477	220	105	139	464	15,018	30.9
1478	229	106	141	476	15,073	31.6
1479	235	106	143	484	15,128	32.0
1480	219	106	140	465	15,184	30.6
1481	176	104	132	412	15,239	27.0
1482	176	105	133	414	15,295	27.0
1483	263	109	150	522	15,351	34.0
1484	220	107	142	469	15,407	30.4
1485	210	107	140	457	15,463	29.6
1486	242	109	147	498	15,520	32.1
1487	228	109	144	481	15,576	30.9
1488	233	109	146	488	15,633	31.2
1489	243	110	148	501	15,691	31.9
1490	229	110	146	485	15,748	30.8
1491	200	109	141	450	15,806	28.5
1492	215	110	144	469	15,863	29.6
1493	230	111	147	488	15,921	30.7
1494	230	112	147	489	15,980	30.6
1495	226	112	147	485	16,038	30.2
1496	268	114	155	537	16,097	33.4
1497	256	114	154	524	16,156	32.4
1498	241	114	151	506	16,215	31.2
1499	242	114	152	508	16,274	31.2
1500	247	115	153	515	16,333	31.5
1501	258	116	155	529	16,393	32.3
1502	261	116	156	533	16,453	32.4

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1503	206	114	146	466	16,513	28.3
1504	237	116	153	506	16,574	30.5
1505	244	116	154	514	16,634	31.0
1506	225	116	151	492	16,695	29.4
1507	222	116	151	489	16,756	29.2
1508	195	115	146	456	16,817	27.1
1509	195	116	147	458	16,879	27.1
1510	208	117	149	474	16,941	28.0
1511	236	118	155	509	17,003	30.0
1512	241	119	157	517	17,065	30.3
1513	242	119	157	518	17,127	30.3
1514	247	120	159	526	17,190	30.6
1515	233	120	156	509	17,253	29.5
1516	248	121	160	529	17,316	30.6
1517	234	121	157	512	17,379	29.4
1518	224	121	156	501	17,443	28.7
1519	211	120	154	485	17,506	27.7
1520	260	123	164	547	17,570	31.1
1521	261	124	164	549	17,635	31.1
1522	225	122	158	505	17,699	28.6
1523	200	122	153	475	17,764	26.7
1524	211	122	156	489	17,829	27.4
1525	237	124	161	522	17,894	29.2
1526	225	124	159	508	17,959	28.3
1527	269	127	168	564	18,025	31.3
1528	238	125	163	526	18,091	29.1
1529	239	126	163	528	18,157	29.1
1530	260	127	168	555	18,223	30.5
1531	255	128	167	550	18,290	30.1
1532	250	128	167	545	18,357	29.7
1533	251	128	167	546	18,424	29.7
1534	246	128	167	541	18,491	29.3
1535	265	130	171	566	18,559	30.5
1536	253	130	169	552	18,627	29.6
1537	258	130	171	559	18,695	29.9
1538	248	130	169	547	18,763	29.2
1539	222	129	165	516	18,832	27.4
1540	236	131	168	535	18,901	28.2
1541	255	132	172	559	18,970	29.4

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1542	276	133	176	585	19,039	30.8
1543	221	131	166	518	19,109	27.1
1544	195	130	161	486	19,179	25.4
1545	181	130	159	470	19,249	24.5
1546	219	132	167	518	19,319	26.8
1547	279	136	179	594	19,390	30.6
1548	268	136	178	582	19,461	29.9
1549	247	135	174	556	19,532	28.5
1550	264	136	178	578	19,604	29.5
1551	275	137	180	592	19,675	30.1
1552	278	138	181	597	19,747	30.2
1553	270	138	180	588	19,819	29.7
1554	249	138	177	564	19,892	28.3
1555	277	139	182	598	19,965	30.0
1556	296	141	187	624	20,038	31.1
1557	277	140	184	601	20,111	29.9
1558	268	140	182	590	20,184	29.2
1559	252	140	180	572	20,258	28.2
1560	249	140	180	569	20,332	28.0
1561	186	138	168	492	20,407	24.1
1562	239	141	178	558	20,481	27.2
1563	275	143	186	604	20,556	29.4
1564	286	144	189	619	20,631	30.0
1565	281	144	188	613	20,707	29.6
1566	265	144	186	595	20,782	28.6
1567	257	144	184	585	20,858	28.1
1568	266	145	187	598	20,935	28.5
1569	261	145	186	592	21,011	28.2
1570	250	145	185	580	21,088	27.5
1571	289	148	193	630	21,165	29.7
1572	289	148	193	630	21,243	29.7
1573	283	148	193	624	21,320	29.3
1574	264	148	189	601	21,398	28.1
1575	261	148	189	598	21,476	27.9
1576	272	149	192	613	21,555	28.5
1577	272	150	193	615	21,634	28.4
1578	261	150	191	602	21,713	27.7
1579	281	151	195	627	21,792	28.8
1580	242	150	188	580	21,872	26.5

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1581	273	152	195	620	21,952	28.2
1582	262	152	193	607	22,032	27.6
1583	284	153	198	635	22,113	28.8
1584	310	155	203	668	22,194	30.1
1585	310	156	204	670	22,275	30.0
1586	268	154	196	618	22,356	27.7
1587	218	152	187	557	22,438	24.8
1588	190	151	182	523	22,520	23.2
1589	217	153	188	558	22,602	24.7
1590	231	154	191	576	22,685	25.4
1591	256	156	197	609	22,768	26.8
1592	279	158	202	639	22,851	28.0
1593	268	158	200	626	22,935	27.3
1594	265	158	200	623	23,019	27.1
1595	257	158	199	614	23,103	26.6
1596	246	158	198	602	23,187	25.9
1597	273	160	203	636	23,272	27.4
1598	243	159	198	600	23,357	25.7
1599	287	162	207	656	23,443	28.0
1600	268	162	204	634	23,528	26.9
1601	251	161	201	613	23,614	26.0
1602	293	164	210	667	23,701	28.1
1603	305	165	213	683	23,787	28.7
1604	285	165	210	660	23,874	27.6
1605	269	165	207	641	23,962	26.7
1606	260	165	206	631	24,049	26.2
1607	285	166	211	662	24,137	27.5
1608	204	163	196	563	24,225	23.3
1609	252	166	206	624	24,314	25.6
1610	288	168	214	670	24,403	27.4
1611	291	169	215	675	24,492	27.5
1612	243	167	206	616	24,582	25.1
1613	299	171	218	688	24,672	27.9
1614	296	171	218	685	24,762	27.7
1615	269	170	213	652	24,852	26.3
1616	286	172	217	675	24,943	27.0
1617	269	171	214	654	25,034	26.2
1618	269	172	215	656	25,126	26.1
1619	255	172	213	640	25,218	25.4

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1620	249	172	212	633	25,310	25.0
1621	269	174	217	660	25,403	26.0
1622	292	176	222	690	25,496	27.0
1623	269	175	218	662	25,589	25.9
1624	253	175	215	643	25,682	25.0
1625	238	175	213	626	25,776	24.3
1626	249	176	216	641	25,871	24.8
1627	233	176	213	622	25,965	23.9
1628	249	177	217	643	26,060	24.7
1629	268	179	221	668	26,155	25.6
1630	274	179	223	676	26,251	25.8
1631	268	176	219	663	25,769	25.7
1632	257	173	214	644	25,296	25.4
1633	256	170	210	636	24,831	25.6
1634	267	167	210	644	24,375	26.4
1635	261	164	206	631	23,927	26.4
1636	294	163	209	666	23,488	28.4
1637	258	158	199	615	23,057	26.7
1638	255	156	196	607	22,633	26.8
1639	255	153	193	601	22,218	27.0
1640	202	148	180	530	21,810	24.3
1641	188	144	175	507	21,409	23.7
1642	201	143	175	519	21,016	24.7
1643	239	142	180	561	20,630	27.2
1644	244	140	178	562	20,251	27.8
1645	235	109	145	489	15,355	31.9
1646	232	109	145	486	15,412	31.6
1647	237	110	146	493	15,468	31.9
1648	246	111	148	505	15,525	32.5
1649	251	111	150	512	15,582	32.8
1650	235	111	147	493	15,639	31.5
1651	211	110	143	464	15,697	29.5
1652	219	111	145	475	15,755	30.1
1653	239	112	149	500	15,812	31.6
1654	278	114	157	549	15,870	34.6
1655	251	113	152	516	15,929	32.4
1656	267	115	155	537	15,987	33.6
1657	285	116	159	560	16,046	34.9
1658	264	115	156	535	16,105	33.2

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1659	259	115	155	529	16,164	32.8
1660	270	116	158	544	16,224	33.5
1661	238	115	152	505	16,283	31.0
1662	276	117	160	553	16,343	33.8
1663	261	117	157	535	16,403	32.6
1664	277	118	161	556	16,463	33.8
1665	278	119	161	558	16,524	33.7
1666	310	121	168	599	16,584	36.1
1667	289	120	164	573	16,645	34.4
1668	264	119	160	543	16,706	32.5
1669	286	121	164	571	16,768	34.1
1670	226	118	153	497	16,829	29.5
1671	229	118	154	501	16,891	29.7
1672	248	120	158	526	16,953	31.1
1673	290	122	167	579	17,016	34.0
1674	255	121	160	536	17,078	31.4
1675	272	122	164	558	17,141	32.6
1676	256	122	161	539	17,204	31.3
1677	256	122	162	540	17,267	31.3
1678	262	123	163	548	17,330	31.6
1679	232	122	158	512	17,394	29.4
1680	263	124	164	551	17,458	31.6
1681	288	126	170	584	17,522	33.3
1682	289	126	170	585	17,587	33.3
1683	247	124	163	534	17,651	30.3
1684	281	127	170	578	17,716	32.5
1685	273	127	168	568	17,781	31.9
1686	273	127	169	569	17,846	31.9
1687	246	126	164	536	17,912	29.9
1688	269	128	169	566	17,978	31.4
1689	269	128	169	566	18,044	31.4
1690	264	128	169	561	18,110	31.0
1691	287	130	174	591	18,177	32.5
1692	297	131	176	604	18,243	33.1
1693	277	130	173	580	18,310	31.7
1694	278	131	173	582	18,378	31.7
1695	262	130	171	563	18,445	30.5
1696	289	132	176	597	18,513	32.3
1697	287	132	177	596	18,581	32.1

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1698	276	132	175	583	18,649	31.3
1699	283	133	177	593	18,718	31.6
1700	280	133	176	589	18,786	31.4
1701	307	135	182	624	18,855	33.1
1702	275	134	176	585	18,925	30.9
1703	302	136	182	620	18,994	32.7
1704	253	134	173	560	19,064	29.3
1705	270	135	177	582	19,134	30.4
1706	281	136	179	596	19,204	31.0
1707	249	135	174	558	19,275	28.9
1708	219	134	168	521	19,346	26.9
1709	261	136	177	574	19,417	29.6
1710	307	139	186	632	19,488	32.5
1711	315	140	188	643	19,560	32.9
1712	309	140	188	637	19,632	32.5
1713	289	140	184	613	19,704	31.1
1714	265	139	180	584	19,776	29.6
1715	278	140	183	601	19,849	30.3
1716	254	139	179	572	19,922	28.7
1717	311	143	191	645	19,995	32.2
1718	286	142	186	614	20,068	30.6
1719	290	143	187	620	20,142	30.8
1720	236	140	177	553	20,216	27.4
1721	257	142	182	581	20,290	28.7
1722	278	143	187	608	20,365	29.9
1723	260	143	183	586	20,440	28.7
1724	273	144	187	604	20,515	29.4
1725	286	145	190	621	20,590	30.1
1726	261	144	185	590	20,666	28.6
1727	293	147	192	632	20,742	30.5
1728	288	147	191	626	20,818	30.1
1729	316	149	197	662	20,894	31.7
1730	329	150	201	680	20,971	32.4
1731	276	148	191	615	21,048	29.2
1732	244	147	185	576	21,125	27.2
1733	259	148	188	595	21,203	28.1
1734	259	148	189	596	21,281	28.0
1735	290	151	195	636	21,359	29.8
1736	290	151	196	637	21,437	29.7

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1737	272	151	193	616	21,516	28.6
1738	267	151	192	610	21,595	28.2
1739	305	153	200	658	21,675	30.4
1740	292	153	198	643	21,754	29.6
1741	280	153	197	630	21,834	28.8
1742	324	156	206	686	21,914	31.3
1743	325	157	207	689	21,995	31.3
1744	288	155	200	643	22,076	29.1
1745	304	156	203	663	22,157	29.9
1746	317	158	206	681	22,238	30.6
1747	270	156	198	624	22,320	27.9
1748	266	156	197	619	22,402	27.6
1749	304	159	206	669	22,484	29.7
1750	279	158	201	638	22,567	28.3
1751	267	158	199	624	22,650	27.5
1752	289	159	204	652	22,733	28.7
1753	321	162	211	694	22,816	30.4
1754	287	160	205	652	22,900	28.5
1755	190	155	186	531	22,984	23.2
1756	222	158	193	573	23,069	24.8
1757	266	161	202	629	23,153	27.2
1758	266	161	203	630	23,238	27.1
1759	273	162	205	640	23,324	27.4
1760	330	166	217	713	23,409	30.4
1761	260	163	203	626	23,495	26.6
1762	285	164	209	658	23,582	27.9
1763	297	166	212	675	23,668	28.5
1764	300	166	213	679	23,755	28.6
1765	280	166	210	656	23,843	27.5
1766	258	165	206	629	23,930	26.3
1767	273	167	209	649	24,018	27.0
1768	290	168	213	671	24,106	27.9
1769	249	166	206	621	24,195	25.7
1770	298	170	216	684	24,284	28.1
1771	282	169	214	665	24,373	27.3
1772	318	172	221	711	24,463	29.1
1773	296	171	218	685	24,552	27.9
1774	306	173	220	699	24,643	28.4
1775	288	172	217	677	24,733	27.4

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1776	299	173	220	692	24,824	27.9
1777	315	175	224	714	24,935	28.6
1778	260	173	214	647	25,047	25.8
1779	300	175	222	697	25,159	27.7
1780	310	177	225	712	25,272	28.2
1781	291	176	222	689	25,386	27.2
1782	278	176	220	674	25,499	26.5
1783	298	178	225	701	25,614	27.4
1784	286	178	223	687	25,729	26.7
1785	266	178	220	664	25,844	25.7
1786	287	180	225	692	25,960	26.7
1787	335	183	235	753	26,076	28.9
1788	302	182	230	714	26,193	27.3
1789	289	182	228	699	26,311	26.6
1790	276	182	226	684	26,429	25.9
1791	290	184	229	703	26,547	26.5
1792	310	186	234	730	26,666	27.4
1793	263	184	226	673	26,786	25.1
1794	260	184	226	670	26,906	24.9
1795	295	187	234	716	27,026	26.5
1796	315	189	238	742	27,148	27.3
1797	313	190	239	742	27,269	27.2
1798	304	190	238	732	27,392	26.7
1799	342	193	246	781	27,515	28.4
1800	296	191	238	725	27,638	26.3
1801	304	193	240	737	27,762	26.5
1802	328	195	246	769	27,886	27.6
1803	304	194	242	740	28,011	26.4
1804	269	193	236	698	28,137	24.8
1805	275	194	238	707	28,263	25.0
1806	294	196	242	732	28,390	25.8
1807	304	197	245	746	28,517	26.2
1808	250	195	235	680	28,645	23.7
1809	340	201	254	795	28,773	27.6
1810	312	200	249	761	28,903	26.4
1811	285	200	245	730	29,032	25.1
1812	314	202	251	767	29,162	26.3
1813	307	203	251	761	29,293	26.0
1814	230	199	236	665	29,424	22.6

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1815	332	206	258	796	29,556	26.9
1816	315	206	255	776	29,689	26.1
1817	298	205	253	756	29,822	25.4
1818	339	209	262	810	29,956	27.0
1819	258	205	246	709	30,090	23.6
1820	301	208	256	765	30,225	25.3
1821	307	209	258	774	30,345	25.5
1822	289	209	255	753	30,466	24.7
1823	227	206	243	676	30,587	22.1
1824	306	212	260	778	30,708	25.3
1825	283	211	256	750	30,830	24.3
1826	286	212	258	756	30,953	24.4
1827	277	212	257	746	31,076	24.0
1828	257	212	253	722	31,199	23.1
1829	263	213	255	731	31,323	23.4
1830	263	214	256	733	31,447	23.3
1831	256	214	256	726	31,572	23.0
1832	283	217	262	762	31,698	24.0
1833	216	214	249	679	31,824	21.3
1834	248	216	257	721	31,950	22.6
1835	286	219	265	770	32,077	24.0
1836	312	222	271	805	32,205	25.0
1837	272	220	264	756	32,332	23.4
1838	281	221	267	769	32,461	23.7
1839	270	222	265	757	32,590	23.2
1840	256	222	263	741	32,719	22.7
1841	255	222	264	741	32,849	22.6
1842	267	224	267	758	32,980	23.0
1843	254	224	265	743	33,111	22.4
1844	278	226	271	775	33,242	23.3
1845	277	227	272	776	33,375	23.3
1846	258	227	269	754	33,507	22.5
1847	282	229	275	786	33,640	23.4
1848	256	228	270	754	33,774	22.3
1849	197	226	259	682	33,908	20.1
1850	259	230	273	762	34,043	22.4
1851	271	232	276	779	34,178	22.8
1852	245	215	255	715	31,720	22.5
1853	217	199	234	650	29,439	22.1

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1854	205	185	218	608	27,322	22.2
1855	204	172	205	581	25,357	22.9
1856	148	157	182	487	23,533	20.7
1857	172	148	176	496	21,841	22.7
1858	162	137	164	463	20,270	22.9
1859	150	128	152	430	18,813	22.9
1860	140	118	141	399	17,460	22.9
1861	133	110	132	375	16,204	23.1
1862	117	102	121	340	15,039	22.6
1863	102	94	111	307	13,957	22.0
1864	95	87	103	285	12,954	22.0
1865	91	81	96	268	12,022	22.3
1866	97	82	98	277	12,079	22.9
1867	100	82	99	281	12,136	23.2
1868	97	83	98	278	12,193	22.7
1869	98	83	99	280	12,251	22.8
1870	114	84	102	300	12,309	24.4
1871	107	84	101	292	12,367	23.7
1872	106	85	102	293	12,425	23.5
1873	102	85	101	288	12,484	23.1
1874	105	85	102	292	12,543	23.4
1875	109	86	103	298	12,602	23.7
1876	103	86	103	292	12,662	23.0
1877	109	87	104	300	12,722	23.6
1878	110	87	105	302	12,782	23.6
1879	103	87	104	294	12,842	22.9
1880	124	89	108	321	12,903	24.9
1881	113	89	107	309	12,985	23.8
1882	112	89	107	308	13,067	23.6
1883	110	90	107	307	13,150	23.4
1884	122	91	110	323	13,234	24.4
1885	110	91	108	309	13,318	23.2
1886	126	92	112	330	13,402	24.6
1887	120	92	111	323	13,487	24.0
1888	112	92	111	315	13,573	23.2
1889	96	92	108	296	13,659	21.7
1890	125	94	114	333	13,745	24.3
1891	123	95	114	332	13,833	24.0
1892	119	95	114	328	13,920	23.5

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1893	125	96	116	337	14,009	24.1
1894	120	96	116	332	14,098	23.5
1895	127	97	117	341	14,187	24.1
1896	141	99	121	361	14,277	25.3
1897	120	98	117	335	14,368	23.3
1898	117	98	117	332	14,459	23.0
1899	133	100	121	354	14,551	24.4
1900	126	100	120	346	14,643	23.6
1901	133	101	122	356	14,736	24.2
1902	131	102	123	356	14,829	23.9
1903	141	103	125	369	14,923	24.7
1904	142	104	126	372	15,018	24.7
1905	136	104	126	366	15,113	24.2
1906	124	104	124	352	15,209	23.1
1907	132	105	126	363	15,306	23.7
1908	139	106	128	373	15,403	24.2
1909	137	106	128	371	15,501	23.9
1910	130	107	128	365	15,599	23.4
1911	124	108	128	360	15,813	22.8
1912	145	112	135	392	16,030	24.4
1913	139	114	136	389	16,250	23.9
1914	129	116	136	381	16,473	23.1
1915	139	119	140	398	16,699	23.8
1916	147	122	144	413	16,928	24.3
1917	153	125	147	425	17,160	24.8
1918	155	127	150	432	17,396	24.9
1919	139	129	149	417	17,634	23.7
1920	144	132	153	429	17,876	24.0
1921	137	135	154	426	18,121	23.5
1922	149	138	159	446	18,370	24.3
1923	158	142	164	464	18,622	24.9
1924	155	145	166	466	18,877	24.7
1925	153	148	169	470	19,136	24.6
1926	147	151	171	469	19,399	24.1
1927	141	154	173	468	19,665	23.8
1928	151	159	178	488	19,935	24.5
1929	152	162	181	495	20,208	24.5
1930	154	166	185	505	20,486	24.7
1931	133	169	184	486	20,767	23.4

year	Agriculture (m. 1820 taels)	Industry (m. 1820 taels)	Services (m. 1820 taels)	GDP (m. 1820 taels)	Population (k.)	GDP per capita (1820 taels)
1932	156	174	193	523	21,052	24.8
1933	154	178	196	528	21,340	24.7
1934	126	181	194	501	21,633	23.2
1935	163	188	205	556	21,930	25.4
1936	170	193	211	574	22,231	25.8
1937	169	160	184	513	21,856	23.5
1938	152	130	158	440	21,487	20.5
1939	155	196	209	560	21,125	26.5
1940	143	199	209	551	20,769	26.5
1941	142	149	170	461	20,419	22.6
1942	138	88	121	347	20,075	17.3
1943	140	92	124	356	19,736	18.1
1944	130	69	104	303	19,403	15.6
1945	126	54	91	271	19,076	14.2
1946	122	123	145	390	19,754	19.7
1947	126	193	201	520	20,455	25.5
1948	125	197	206	528	21,182	24.9
1949	117	192	201	510	21,934	23.3
1950	127	200	211	538	22,713	23.7
1951	127	209	219	555	23,520	23.6
1952	128	217	227	572	24,355	23.5
1953	129	226	235	590	25,220	23.4

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