The Biological Standard of Living in Mexico: c.1850-1992

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Abstract

In the present study I analyse the long-run dynamics of adult average height in Mexico and the influence of the country's environmental/socioeconomic context on this average height. Three main questions guide the course of this study: How did inequality evolve during the second half of twentieth century in Mexico? Did the processes of industrialisation and urbanisation affect the evolution of average height in Mexico? If so, can it be asserted that for such period in Mexico physical stature is determined more by environmental factors rather than biological ones?

Results from the empirical analysis show that: (1) for the period 1951-1992, Mexico showed a positive but moderate trend; (2) for the period 1953-1982, once current and original individual and local characteristics were controlled for, the results suggest that urbanisation/overcrowding had a positive effect on heights, but that there were also costs related to urbanisation that reduced this net positive effect; (3) for Mexicans born during 1962-1986, three main findings were obtained: (a) wealthier parents produced taller children; (b) while height increases could be observed across the socioeconomic ladder, the differences between socioeconomic groups persisted; and (c) tallness increased the probability of reaching relative upper class positions, and reduced the probability of descending to the lower ones.

These results contribute to the present literature on anthropometric history for the Mexican case. Firstly, present findings contribute to extend height series for Mexico until the end of twentieth century. Secondly, both the urbanisation penalty and the gender comparison findings are new for the post 1950s Mexican historical period. And thirdly, anthropometric analysis from the mirror of economic history permits to evaluate economic results of Mexico from a perspective that captures several effects that are closed related to poverty and inequality. In particular, results for the second half of twentieth century show that positive and constant economic growth during such period was not reflected in the same proportion on the biological standard of living for all Mexicans. In particular, the implemented model of development, in which a significant effort was allocated around Mexico City, was not enough to reduce inequality. To sum up, these results show that inequality and not only economic growth matters.

1. Introduction

The analysis of living standards with regard to physical height belongs to the literature on anthropometric history. In particular, the study of the biological standard of living, which Timothy Cuff highlights to be the objective of the main international journal on the topic, *Economics and Human Biology*, is 'devoted to the exploration of the effect of socio-economic processes on human beings as biological organisms'.[1] In economic history research, height is widely accepted as a measure of the biological standard of living. Depauw and Oxley ask: "what does mature stature capture?".[2] Besides genetics, the quality of diet alongside factors such as work effort and disease environment during early childhood and adolescence are proximate determinants of adult height, *i.e.*, physical stature reflects the history of childhood and adolescent welfare.[3] Steckel points out that adult physical stature does not reflect adults' health status but, rather, their childhood and adolescence history of 'net' nutrition.[4] As Fogel contends, adult height is a net measure of nutrition that 'reflects the past nutritional experience of individuals throughout their growing years, including the fetal period'.[5]

The original objective of the present dissertation was to fill the gap in the anthropometric history literature on the Mexican case. While previous analyses have covered the

[1] T. Cuff, "Historical Anthropometrics" (no page number in the accessed electronic format). The first issue of *Economics & Human Biology* was published in 2003 (http://www.journals.elsevier.com/economics-and-human-biology/).
[2] Depauw, E. and Oxley, D., 'Toddlers, Teenagers and Terminal Heights', p. 926.
[3] For a discussion of the main determinants of heights and the importance of anthropometric history research, see Komlos and Baten, 'Looking Backward and Looking Forward'; Steckel, 'Stature and the Standard of Living'; Steckel, 'Strategic Ideas in the Rise of a New Anthropometric History'.
[4] Steckel, 'Stature and the Standard of Living'.
[5] Fogel, 'Economic Growth, Population Theory, and Physiology', p. 374.

eighteenth, nineteenth and first half of the twentieth centuries, little research exists to date on Mexico's biological standard of living in its post-revolutionary period.[6] Post 1950s Mexico arguably presents an interesting case study for several reasons. Firstly, even though Mexico exhibited its longest period of uninterrupted economic growth during c.1930-1980, inequality remained high. Secondly, the country's process of industrialisation took place after the 1930s, meaning that Mexico experienced a late industrialisation. Finally, in terms of the human biology approach, it may be seen as interesting to analyse a period just after the epidemiological transition took place.

Anthropometric studies conducted by economic historians are based on different kinds of data sources. As mentioned by Salvatore, Coatsworth and Challú, the most commonly used sources in the analyses that have been undertaken since the 18th century are army and jail records, passports and other identification papers.[7] For earlier periods of study, Richard H. Steckel, for example, has based such analyses on human skeletons, which are commonly used in physical anthropology.[8] For more contemporary studies, the evolution of the generation of statistical information, including anthropometric measuring, have allowed experts to conduct analyses based on data obtained from nationally representative

[6] López-Alonso and Porras Condey, 'The Ups and Downs of Mexican Economic Growth: The Biological Standard of Living and Inequality, 1870-1950'; López-Alonso, 'Growth with Inequality: Living Standards in Mexico, 1850-1950'; Challú, 'Agricultural Crisis and Biological Well-Being in Mexico, 1730-1835'; Grajales-Porras and Moramay López-Alonso, 'Physical Stature of Men in Eighteenth Century Mexico: Evidence from Puebla'; López-Alonso, *Measuring up: A History of Living Standards in Mexico, 1850-1950*.
[7] Salvatore, Coatsworth and Challú, *Living Standards in Latin American History: Height, Welfare and Development, 1750-2000*.
[8] Steckel developed a methodology employing skeletal measures in order to analyse social performance. For details, see Steckel, 'What Can Be Learned from Skeletons That Might Interest Economists, Historians, and Other Social Scientists?'.

surveys. The National Health and Nutrition Examination Survey (NHANES) carried out in the US, for example, can be seen as an international reference on this matter.[9]

In the economic history literature on Mexico, studies have analysed height data based on army archives and passport records. For the present dissertation, I used several data sources for the analysis, including both historical records and nationally representative surveys. This involved conducting archival research in order to obtain height data from criminal records from Mexico City's jail in the 1970s, as well as the examination of cross-section, panel data and matched surveys to analyse height dynamics at national level. In particular, nationally representative surveys present an advantage over sources such as the most commonly used in historical analysis: there is no a potential bias problem due to predetermined height requirements or sample selection.[10]

Three main results were obtained from the empirical analysis:

1. Over 1951-1992 Mexico showed a positive increase in average height. However, such an increase has not been big enough to converge with the average height of other similar economies or to close the gap with more developed countries. Such backwardness can be explained by the effect of inequality.

[9] The NHANES has been conducted since the early 1960s. Today, it is a nationally representative survey, conducted each year and including 5000 individuals. For more details on this US programme, see: https://www.cdc.gov/nchs/nhanes/about_nhanes.htm (Accessed 05/06/2019).
[10] Badenhorn, Guinnane and Mroz argue that most of the used historical sources for heights "are not random draws from the population in question.", 'Problems of Sample-selection Bias', p. 4.

2. For the period 1953-1982, I tested the hypothesis of a height penalty due to the hardships of overcrowding during Mexico's process of urbanisation. For males and females, once their current and original individual and local characteristics were controlled for, the results suggest that urbanisation/overcrowding had a positive effect on heights, but that there were also costs related to urbanisation that reduced this net positive effect.
3. For both female and male Mexicans born during 1962-1986, three main findings were obtained following an intergenerational social mobility analysis: (a) on average, wealthier parents produced taller children; (b) while height increases could be observed across the socioeconomic ladder, the differences between socioeconomic groups persisted; and (c) once potential endogeneity was controlled for, tallness increased the probability of reaching relative upper positions, and reduced the probability of descending to the lower ones.

These results contribute to the present literature on anthropometric history for the Mexican case. Firstly, present findings contribute to extend height series for Mexico until the end of twentieth century. Secondly, both the urbanisation penalty and the gender comparison findings are new for the post 1950s Mexican historical period. And thirdly, anthropometric analysis from the mirror of economic history permits to evaluate economic results of Mexico from a perspective that captures several effects that are closed related to poverty and inequality. Results show that positive and constant economic growth during the period of study was not reflected in the same proportion on the biological standard of living for all Mexicans. In particular, the implemented model of development, in which a significant effort was allocated around Mexico City, was not enough to reduce inequality. To sum up, these results show that inequality and not only economic growth matters.

For the international literature the present work also makes some contribution. Firstly, the fact of filling the gap for more recent Mexican height series allows us to make comparisons of height patterns with some other Latin American countries, as well with different international experiences such as the ones of more developed regions. A second contribution of the present work for the international literature is the adopted approach for the analysis on both the urban penalty and the social mobility analyses. For the first case, it confirms the existence of an urban penalty in a context of a country that experienced its industrialisation process during and just after the worldwide epidemiological transition of the 1940s. And for the second case, it introduces for the first time the approach of social mobility into the discussion of biological living standards in the context of a country with a very high level of social stratification. In this particular case, the findings show that high stratification reinforces the influence of origin and therefore limits the biological standard of living accomplishment options for individuals.

The remainder of this thesis is organized as follows. In chapter 2, I discuss the meanings and determinants of height, and explain the main puzzle in the literature on anthropometric history. Chapter 3 explains the main methodological steps used to check the data quality of the database I built when undertaking archival research on Mexico City's jail records from the 1970s. This chapter also presents the surveys that were used for the remaining analyses of the dissertation. The subsequent chapters include the main analyses of this study, organised by period and aim, as follows. Chapter 4 presents the analysis of the dynamics of average male height in Mexico for 1850-1992. For the sub-period 1951-1992, both males and females are included. Chapter 5 analyses the effect of urbanisation on both male and female average height for the period 1953-1982. Chapter 6 employs an intergenerational social mobility approach to analyse both male and female height dynamics for Mexican adults born during 1962-1986.

2. Height and Standard of Living: Meanings, Determinants and Puzzles

Crafts contends that height has been mostly used in two key ways – as an 'index of welfare per se', or as a 'good diagnostic in a particular historical situation that real income/wages are failing to measure changes in welfare very well'.[11] Komlos and Baten argue that anthropometric measures are well accepted among historians because they show some advantages over conventional living standard measures. Firstly, unlike anthropometric measures, conventional measures do not capture the impact of factors such as environmental externalities, intra-household distribution of resources, and inequalities at the society level. Secondly, at the instrumental level, it is difficult to find representative and disaggregated historical data on, for example, income and wages.[12] For historical analysis, data availability is crucial. In that sense, there exist substantial historical data sources from which to obtain anthropometric information. Moreover, due to both the nature of the measure and the non-variability of individuals' final height during most of their adult life, it is possible to undertake longitudinal analyses with single cross-sectional databases by simply re-arranging individuals by birth cohort.

Increasing family incomes, higher levels of education and improvements in the public health system are all factors with potential positive effects on the future heights of children. In addition to the potential increases in food intake, higher incomes allow parents to send their offspring to school and reduce child labour, which implies physical work

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[11] Crafts, 'Some Dimensions of the "Quality of Life"' pp. 618-19.
[12] Komlos and Baten, 'Looking Backward and Looking Forward'.

effort.[13] Moreover, education provides the knowledge to facilitate the improved diet and healthcare of future generations. In terms of public health, the implementation of new medical technologies improves the epidemiological environment and reduces the necessity of using physical growth energy to combat diseases.

2.1.Disentangling the Effects of Height Determinants

As Steckel argues, social scientists are interested in the influence of socioeconomic factors on height differences. Identifying these factors and measuring their impact facilitates the understanding of such differences.[14] On this matter, common wisdom states that there should be a positive correlation between economic growth and height. However, historical evidence shows that such a relationship is not invariably a direct one. Two historical periods of economic expansion show a reduction in physical stature: during the early Industrial Revolution (c. 1760-1800) in Europe and during the so-called antebellum puzzle in the United States (1830-60).[15] Furthermore, in the case of England during the former period, Komlos finds that boys from the city of London were shorter than those from rural areas of the country.[16]

[13] Basu and Hoang Van argue that even though parents care about their children's wellbeing, stark poverty may force them to send their offspring 'to work for reasons of survival'. See Basu and Hoang Van, 'The Economics of Child Labor', pp.412-3. At the empirical level, evidence for the United States in 1920 suggests that parents did not reduce their labour market participation as a result of increases in child labour participation. See Marco Manacorda, 'Child Labor and the Labor Supply'.
[14] Steckel, 'Height and Per Capita Income', Steckel, 'Stature and the Living Standard'.
[15] Margo and Steckel, 'Heights of Native-Born Whites'; Komlos, 'The Height and Weight of West Point Cadets'; Komlos, 'The Secular Trend in the Biological Standard of Living'.
[16] Komlos, 'The Secular Trend in the Biological Standard of Living', pp. 130-139.

There are two main approaches to explaining these puzzles. On one hand, Haines, Craig and Weiss contend that height decreases during periods of economic growth are the result of an increasing disease environment.[17] On the other hand, Komlos argues that this phenomenon is mainly explained by the endogenous factors of an economic process, such as increases in income inequality, urbanisation, and industrialisation.[18] Komlos agrees with the fact that there are exogenous factors such as the weather or the epidemiological environment that can affect height. However, in the case of the latter, he contends that the transmission of diseases would be more common with increasing population density. In such a case, disease would spread in a more universal way and its negative effects would be reflected in heights across all social strata. However, he also points out that several studies of both the early period of the industrial revolution and the antebellum puzzles do not show such a pattern.[19] Conversely, Voth and Leunig find that smallpox reduced height (by 1 inch) in London in 1770-1873. Based on their results, they adopt an intermediate position, whereby: 'height acts as an aggregate measure, capturing not only the effect of real wages via changes in nutritional intake, but also that of disease'.[20] Finally, it should be noted that in contemporary societies in which universal vaccination has been established, instead of the types of diseases common in the 19th century, pollution and its influence on cardiovascular function have, today, became a potential source of negative effect on height.[21]

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[17] Haines, Craig and Weiss, 'The Short and the Dead'.

[18] As part of these endogenous factors, Komlos also includes the increase in relative food prices and the variability of income. *Op cit*, p. 782.

[19] Komlos, 'Shrinking in a Growing Economy?'

[20] Voth and Leunig, 'Did Smallpox Reduce Height?', p. 558.

[21] See Gauderman, Avol, Gilliland, Vora, Thomas, Berhane, McConnell, Kuenzli, Lurmann, Rappaport, Margolis, Bates and Peters, 'The Effect of Air Pollution'; and Rojas-Martinez, Perez-Padilla, Olaiz-Fernandez, Mendoza-Alvarado, Moreno-Macias, Fortoul, McDonnell, Loomis and Romieu, 'Lung Function Growth'.

There is a third and more recent approach that basically put in doubt the existence of the puzzle due to sample selection bias in the data sources. On this matter, Badenhorn, Guinnane and Mroz conclude that: "industrialization is no puzzle once one appreciates the consequences of the endogenous selection process underlying many height sources."[22] The main argument behind their claim is that observed changes in average height "may be driven…by changes in the probability that individuals of different heights were selected into the sample."[23] In response to such critique, Komlos and A'Hearn offer evidence to discard such hypothesis for the period of the antebellum puzzle.[24] Firstly, they show that total compensation (bounty + wages) in the Army increased from the early to the late war period. As a result, they state that such compensation became more attractive than both urban and rural civilian earnings. They conclude that "this is exactly the opposite of what would be required to generate a spurious downward trend in heights".[25] Secondly, they argue that if there is any self-selection by age, it is the opposite of what the critique implies. In particular, by comparing military/civilian wealth by age, older soldiers were relatively less wealthy. Due to the opportunity cost argument of the critique, negative selection should be more intense among older soldiers. For Komlos and A'Hearn such result implies for the puzzle that, "[i]f anything, we are more likely to be underestimating the fall in heights."[26]

22 Badenhorn, Guinnane and Mroz, 'Sample-selection Biases and The "Industrialization Puzzle"', p. 35.
23 Badenhorn, Guinnane and Mroz, 'Sample-selection Bias in The Historical Heights Literature"', p. 5.
24 Komlos and A'Hearn, 'Clarifications of a Puzzle'.
25 Ibid., p. 1146.
26 Ibid., p. 1149.

In relation to the endogenous factors proposed by Komlos, Steckel contends that population average height increases are negatively related with income inequality.[27] He argues that, as height shows decreasing marginal returns to income,[28] it follows that if income inequality rises, *ceteris paribus*, average height can be negatively affected.[29] For example, in a study on height in the US during the twentieth century, Komlos and Baur suggest that Americans ceased growing taller, in spite of higher income per capita, owing to greater inequality, inefficiencies in their health system, and lack of social safety nets.[30]

Urbanisation and industrialisation, two of the other explanatory factors of the height puzzle proposed by Komlos, can be accompanied by improvements in income, education, healthcare and sanitation. Those benefits are positively reflected in the net nutritional status of the population through average height increases. However, there exist other economic disaggregate effects of such processes that have a potential negative impact on physical stature. Firstly, while unemployment and underemployment in industrialised areas are not necessarily permanent, during early childhood temporary periods of food shortages have permanent effects on future height.[31] Secondly, a generalised food shortage in cities can occur when agriculture productivity is not capable of growing at the same

[27] Assuming that there exists a society where the wealthiest group of people has already reached its potential in terms of human growth, if the benefits of economic growth are only captured by this group, then average height will remain constant even if income per capita increases.
[28] Steckel, 'Height and Per Capita Income'.
[29] Theoretically speaking, increases in inequality can also be accompanied by average income increases. In this case, it is necessary to analyse if households from the low side of the income distribution are still far from obtaining sufficient resources to reach their potential physical stature.
[30] Komlos and Baur, 'From the Tallest to (one of) the Fattest'.
[31] Migration to urban areas is not always the best option for families. Following the Harris-Todaro model, migration rates are growing higher as urban-rural expected income differentials are also increasing. From this perspective, however, the scenario is also possible where increasing differences in urban-rural wages promote higher rural-to-urban migration rates even when urban unemployment and underemployment are high, or even increasing. Harris and Todaro, 'Migration, Unemployment and Development'.

rate as urban food demand, and no other alternatives (such as food imports) are available. Thirdly, even when market integration and new technologies such as refrigeration systems could increase the variety and quality of food products, given that a greater variety of goods is offered, food substitution is more likely to occur.[32]

Fourthly, as Komlos correctly explains, changes in relative prices caused by economic development could negatively affect height.[33] For example, assuming that both household income and food prices increase, on one hand there will be an increase in the demand for food due to the income effect. On the other hand, however, a decrease in food demand would take place due to the substitution effect. If the latter effect is greater than the former, households will consume less or lower quality food, thus negatively affecting children's future height. Moreover, assuming that an income increase allows a family to reach a higher utility level, it could be said that the family would be better-off; instead, physical stature shows a decrease. As a result, it has to be noted that height is also subject to critiques as a measure of living standards.

Finally, the importance of family structure has to be emphasized. On this matter, Hatton argues "there is a trade-off between the quality (as measured by health) and the quantity of children".[34] As a result, he points to decreased family size as a potential driver of height increases (reducing the problem of 'resource dilution' suffered in large families). In a

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[32] If household income and food prices (relative to non-food items) are increasing, on one hand the income effect will have a positive impact on household food consumption; on the other, relative price changes will induce the substitution of food by other non-food items. If this substitution effect overcomes the income effect, households will reduce their food consumption and the adult height of children will be negatively affected, even if income is increasing. Komlos, 'Shrinking in a Growing Economy?', p. 782, pp.785-7.
[33] Ibid.
[34] Hatton, T. J., 'How Have Europeans Grown so Tall?', p. 355.

study for the British population, Hatton estimates that the experienced decrease in family size for the whole century since the 1870s accounts for one eighth (1.25 centimetres) of the total height increase (10 centimetres). In another case study for the Netherlands on conscripts born in 1944-1947, Stradford, van Poppel and Lumey finds, once it is controlled for birth order and some other available factors in the database, that recruits from smaller families are, on average, 2 centimetres taller than those from larger families.[35] For a cross-country study for 15 European countries, Hatton finds that a decline of one child per married woman of childbearing age increases average height by 0.5-0.6 centimetres. Such an effect is significant but modest in comparison to others such as increases in GDP per capita (1-6-1.8 centimetres) and decreases in the infant mortality rate (4.4-4.8 centimetres).[36] Finally, in a multiple regression analysis for a cross-country study that includes 119 countries, Grasgruber and Hrazdíra find that total fertility rate is the best predictor of male height just after nutrition.[37]

The Height-Income Relationship

Baten contends that it is difficult to estimate individual or household income data for periods prior to the mid-nineteenth century.[38] Moreover, for developing countries there is reliable income data only for the second half of the twentieth century onwards (in some cases after the '70s or '80s). When these data have been available, height has been used as a proxy for income. The question remains as to the validity of such a strategy.

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[35] Stradford, L., van Poppel, F. and Lumey, L. H., 'Can Resource Dilution Explain Differences in Height'.
[36] Ibid. This result is also reported in Hatton, T. J., 'Stature and Sibship: Historical Evidence'.
[37] Grasgruber, P. and Hrazdíra, E., 'Nutrtional and Socio-economic Predictors'.
[38] Baten, 'Economic Development and the Distribution'.

Contemporary evidence shows that income and height are positively correlated (see Table 2.1). There are exceptions, such as the aforementioned historical periods of the Industrial Revolution and the Antebellum Puzzle. As mentioned in the previous section, in the 20th century Americans ceased growing taller, in spite of higher income per capita. In two of the first specific case studies on the relationship between height and income, Steckel and Floud found a positive correlation between them.[39] Steckel estimated a cross-country model, with adult height data for the 1950s, 1960s and 1970s, by using the logarithm of per capita income as the main determinant of height. Once other non-income variables were controlled for, the results showed that income had a positive and significant impact on average height. His results also showed a negative and significant impact of income inequality.[40]

Table 2-1. Correlation between Heights and the Log of Income per Capita

	Correlation	Number of countries
Adult males	0.84	16
Adult females	0.90	17

Source: Steckel, Richard H. 'Height and Per capita Income', p. 4. The national data includes information from the 1950s, 1960s and 1970s.

[39] Steckel. 'Height and Per Capita Income'; Floud, 'The Heights of Europeans since 1750: A New Source for European Economic History'.
[40] Steckel contends that average height (not individual) increases are negatively related with income inequality. An extreme case is that in which economic growth benefits are captured only by the richest group, where average population height will remain constant even if income per capita increases. For studies on height that measure inequality, see Quiroga and Coll, 'Income Distribution in the Mirror of Height'.

The econometric model contained some flaws. For example, for the variable of place of residence – rural-urban – not only one dummy variable was defined, but two. As a result, the regression yielded coefficients for both rural and urban areas, and not only for one with respect to the other (the omitted/reference one). The analysis also had another potential limitation: current but not original income was used as the explanatory variable, given the fact that final height was mostly determined during early childhood and adolescence. This drawback is not a problem if income and inequality composition levels do not change from childhood to adulthood, but this assumption is a strong one.

In a different set of studies, height has been defined as a function of several variables throughout all the years of human physical growth (by using the so called YASSIS curve, i.e., annual physical stature increases).[41] In the study by Brinkman et al., income per capita is included as the sole height determinant, and a linear relationship between height and income is assumed. Conversely, in the study by Coll, some other variables such as food and non-food prices are also included, and a Cobb-Douglas type function is estimated. In both cases, as other variables that endogenously affect height are not included, the results are not conclusive.

Allen suggests that real wages could be a better predictor of height than GDP.[42] It can be argued that wages, as a measure of income, are more sensitive to the socioeconomic distribution and, therefore, to the dynamics of average height. In contrast, Floud contends

[41] Brinkman, Drukker, and Slot, 'Height and Income: A New Method for the Estimation of Historical National Income Series'; Coll, 'The Relationship between Human Physical Stature and GDP (Some Experiments with European Time Series)'.
[42] Allen, 'The Great Divergence'.

that '[a]t the least, measures of real wages need to be qualified by knowledge of changes in work intensity, of the impact of urban living and factory working and, perhaps most important, of the effect of all these changes on health and mortality'.[43] Two other potential problems arise with wages. Firstly, they do not capture at least two strata of the population: owners and unemployed individuals (and women working at home). Secondly, wages do not directly show the distribution patterns within households. Moreover, as Crafts argues with regard to his work on quality of life during the Industrial Revolution, real wages are not 'comprehensive measures of economic welfare'.[44] On the contrary, even though final adult height is determined by households' purchasing power, it also captures the effects of public goods such as public health, as well as the distribution patterns of commodities and work roles in the family.

In general, Steckel concludes that height should not be used as a proxy for income.[45] This argument applies even in the case when height data are available but income data are not, and vice versa. The existing correlation between height and income results in a strong temptation to use them as proxies for each other. However, the evidence also shows that the relationship between height and income is not a direct one. Both height and income reflect certain results, but their nature and composition are not the same. With respect to wages, if the interest lies in analysing, in detail, the distribution of the benefits (or costs) of economic development among the whole population, wages are not good enough predictors of height. Moreover, wages do not capture the effects of non-income factors

[43] Floud. 'The Heights of Europeans', p. 2.
[44] Crafts, 'Some Dimensions of the "Quality of Life" During the British Industrial Revolution', p. 618.
[45] Steckel, 'Height and Per Capita Income', p. 4.

that also affect height, such as public health and intra-household distribution. Overall, as Crafts contends, height captures components of living standards that real wages do not.[46]

2.2.Genetics as a Determinant of Height: Do they Matter?

A controversial issue among researchers is the role of genetics as a determinant of height. The question, essentially, is whether physical stature is more determined by environmental than genetic factors. If the latter is not the case, in spite of environmental differences adult heights should not be significantly different within a specific ethnic group; or, the other way around, physical stature disparities should stay similar after the reduction of environmental differences among ethnic groups.

Habicht et al. compare the heights and weights of groups of children (aged 0-7 years) from different ethnic groups, socioeconomic levels and world regions. They find two interesting results. Firstly, as they call them, the 'well-to-do' children from different ethnic groups (in most cases, ethnicity is defined in geographical terms), show only an average height variation of around 3%. Secondly, children from different socioeconomic levels but with a similar ethnicity show different patterns in height growth. The study measures suggest that individuals from the 'non-poor' group are not too different in terms of height from those of a developed country. However, this is not the case for the 'poor' group. As a

[46] Crafts, 'Some Dimensions of the "Quality of Life" During the British Industrial Revolution'.

conclusion, the authors suggest that environmental factors are more important determinants than genetic ones of physical growth patterns.[47]

Following Habicht et al., Amigo et al. compare children's (aged 6-9 years) and parents' heights across three different socioeconomic levels and two different ethnic groups in the city of Santiago and the south-central region of Chile. This exercise is more accurate than the one by Habicht et al. in the sense that it controls for ethnicity within the population group. The sample includes both indigenous (of Mapuche origin) and non-indigenous children (of Spanish origin) from schools in different communities. Five different socioeconomic levels (quintiles) are defined, from 'very high vulnerability' to 'very low vulnerability'. For the analysis of height, only three quintiles are included: the first, third and fifth ones. Three exercises were conducted: 1) children-parents comparison using a size/age index, 2) indigenous-non-indigenous comparison within socioeconomic groups (children as well as parents), and 3) parent comparison across the socioeconomic groups. The results show an increase in the average height of indigenous children that is positively correlated to the quintiles. This pattern is not clear in the case of non-indigenous children. In addition, there is no evidence of significant height differences between indigenous and non-indigenous children within the quintiles. In this case, such a difference only emerged as significant for girls in the most vulnerable group, where the non-indigenous children were found to be taller. Among parents, there was a positive relationship between height and quintiles for indigenous and non-indigenous individuals. Moreover, non-indigenous parents were found to be taller than indigenous ones in all three quintiles. Finally, children

[47] The environment includes socioeconomic factors alongside others such as nutrition and disease, weather, altitude, social codes, etc. Habicht et al., 'Height and Weight Standards', pp. 612-614.

in all quintiles were taller than their parents in terms of the size/age index, but more so in the case of the indigenous population. The authors note that despite the differences in height between non-indigenous and indigenous parents, indigenous children were not found to be shorter than non-indigenous ones within the quintiles. As such, they conclude that environmental factors rather than ethnicity are more important determinants of height differences.[48]

In another study, Martorell and Habicht analyse the role of genetics in body size. They take two different socioeconomic groups of children (aged 0-7 years) from eight developing countries (Brazil, Costa Rica, Guatemala, Haiti, Jamaica, Nigeria, India and Hong Kong), and compare each single mean height with the one in the NCHS growth charts (National Center for Health Statistics of the United States). The results show that the upper socioeconomic groups are located around the 50th American percentile, i.e., that differences by ethnic origin do not make a difference in terms of height. On the other hand, all of the lower socioeconomic groups were found to be below the 25th US percentile, implying that socioeconomic disparities explain mean height more than genetics.[49]

All aforementioned studies focus on children no older than nine years old. In terms of human growth, however, adolescence also plays an important role. As mentioned by Depauw and Oxley, it is not clear if "early stunting persists into adulthood".[50] In their study on Flanders (1800-1876), they find that food prices and crude death rates during

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[48] Amigo et al., 'Estatura de padres e hijos chilenos', pp. 505-508.
[49] Martorell and Habicht, 'Growth in Early Childhood', p. 244.
[50] Depauw, E. and Oxley, D., 'Toddlers, Teenagers and Terminal Heights', p. 926.

adolescence (11-18 years old) explains 75% of adult heights.[51] Evidence also shows that for historical periods individuals continued to grow even after their twenties. Beekink and Kok, for example, finds that 19 years old males from nineteenth century Woerden in The Netherlands kept growing until they were 25 years old (5 centimetres on average). Moreover, the original gap among socioeconomic classes was reduced as well.[52]

A different way of analysing the role of genetics as a determinant of the mean height of population groups is by comparing migrant and non-migrant groups of children. In one such study, two groups similar in terms of ethnicity were exposed to different environmental contexts. Smith et al. undertook this comparison between two groups of Maya children (aged 6-12 years). One group was living in Guatemala and the other in the US.[53] The authors argue that there is no 'selective migration for taller parents'. The results show that for all ages, the group of migrants emerged around 10 cm taller. Moreover, the migrants' group was found to be around 5cm shorter than US natives.[54] These results suggest that environmental differences, rather than the genetics, had an important impact on the mean height of Maya children.

With respect to the height difference between Maya migrants and the median American, the analysis does not offer evidence to conclude that they are similar in socioeconomic terms. To tackle this problem, a strategy such as the one adopted by Amigo et al. can be

[51] Ibid.
[52] Beekink, E. and Kok, J., 'Temporary and Lasting Effects'.
[53] For the Guatemalan group, the authors used a database from 1998. For the US group, they had two samples, one for 1992 and the other for 2000. Only the Guatemalan and the US-2000 groups are included in the current explanation. Smith et al., 'Economic and anthropological assessments of the health', p. 148.
[54] The National Health and Nutrition Examination Survey reference standards for US children.

followed: to identify different ethnic groups with a similar socioeconomic status living in a similar environment. Another alternative is to study groups of children of a similar socioeconomic origin who were adopted by families from a different ethnic group living in a different environment, e.g., in middle class US suburbs. Proos, for example, reviews a set of studies on children from developing countries who were adopted in the US and North-western Europe. In the particular case of Korean children in the US, those adopted at a later age show lower increases in height. On this matter, Pross concludes that the evidence suggests that optimal intrauterine, infant and childhood growth are the main determinants of physical growth options during adolescence.[55]

More recent studies are changing the conventional wisdom on the relationship between height and genetics. Grasgruber and co-authors have analysed the association of socioeconomic factors, nutrition and genetics with average stature. Grasgruber et al. do a cross-country analysis for contemporary European countries.[56] One characteristic among them is that, once it is controlled for factors such as GDP per capita, health expenditure or children's mortality rate, a height advantage for eastern European countries is observed. Besides their results show that nutrition is the most important factor associated with average height, they also find that the genetic factors, such as lactose intolerance, matter for explaining the afore mentioned eastern-western difference. A'Hearn also finds that among European countries the southern ones behave as outliers for the correlation between late twentieth century GDP per capita and male average height.[57] In particular,

55 Proos, 'Anthropometry in Adolescence', pp. 18-24.
56 Grasgruber, P., Cacek, J., Kalina, T. and Sebera, M., 'The Role of Nutrition and Genetics'.
57 A'Hearn, B., 'The Anthropometric History of the Mediterranean World'.

he finds that Italy, Portugal, Turkey, and Spain in a lesser extent, show heights below the expected ones given their level of economic prosperity (he also finds that Serbian average height is quite above the expected one). He concludes that given the fact that contemporary average heights are not fully explained by factors such as income, diet and public health, from now and on genetic differences become one possible explanation.

In a more recent study, Grasgruber and Hrazdíra extend the cross-country analysis to almost the whole world, including American countries.[58] Their study confirms the main importance of nutrition, especially inadequate protein. They find economic wealth 'only a mediocre correlate of physical growth' because it poorly captures nutritional quality and wealth distribution.[59] For American countries they find a positive correlation of height with both European and African ancestry. They conclude that more analysis is needed, but that perhaps genetic factors are involved.

Population average height controls for natural variance, therefore, allows to isolate the effect of socioeconomic processes.[60] The evidence shows that environmental factors make a difference in terms of attained height. However, more recent analyses also point out that genetic factors play a main role for explaining height differences. As Grasgruber et al., conclude, their findings "suggests that with the gradual increase of living standards, genetic factors will increasingly be getting to the foreground."[61]

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[58] Grasgruber, P. and Hrazdíra, E., 'Nutrtional and Socio-economic Predictors'.
[59] Ibid., p. 1
[60] One of the practical implications of quantitative analysis when working with variables such as height, where most of the variation is natural (genetic) and unexplained, the explanatory power of econometric models (R^2s of regressions) is low.Komlos and Lauderdale, 'Spatial Correlates of US Heights', p. 63.
[61] *Op Cit.*, p. 99

3. What and How to Analyse: Anthropometric Data

This chapter presents the conventional way in which a height database is analysed in the field of anthropometric history. The main objective here is to establish the common base from which the different types of data sources used in the present dissertation are analysed. To achieve this, the chapter offers a review of the relevant literature, followed by an analysis of an unprecedented and particular Mexican data source.

The adult height data were obtained from the fingerprints and anthropometric records of Mexico City's jail. The analysis used a sample of 907 males aged 18-49 who were born between 1922-1958. By following the conventional way of analysing data quality in anthropometric studies, several results emerged that merit attention. Firstly, and based on the visual inspection of the height distribution, no shortfalls were observed. Secondly, there was a rounding problem with the reported heights, as over 32 per cent of them ended in zero or five (155, 160, 165, 170, 175 centimetres, and so on). Among those, a high concentration was observed at 165 and 170 centimetres, representing 10 and 8 per cent of the sample, respectively. However, there was no evidence to suggest that such rounding occurred more frequently among a specific birth cohort or occupation group. As a result, no correction for bias should be required. Thirdly, a specific problem with the sample was the high concentration of birth years in a short period of time, given the fact that only reports from 1970 and 1976 were recorded during the archival research. Therefore, in order to increase the size of elderly groups, only three birth cohorts were defined for the whole group: 1922-1933, 1934-1945 and 1946-1958. One important implication of the latter is that the height estimations showed lower precision for elder groups. Finally, and in addition to age groups, the database enabled height comparisons for two further types of characteristics: place of origin and current occupation (previous to being imprisoned). Once this was done, the quality analysis was once again conducted by assuming, from the start, that several limitations would arise due to the size of the resulting sub-samples.

The descriptive statistics suggest that even when controlling by birth cohort, those who were born in the more northern states were, on average, taller, followed by those from Distrito Federal (Mexico City). In this case, and contrary to the results presented in the following chapters, among the lower tail of the distribution those who were born in the central region were found to be shorter than those born in the south-southeast. In the case of occupational status, the results were consistent with what could be expected: on average, those in professional managerial activities were the tallest, and those in manual occupations the shortest. Once a multivariate analysis was followed by an OLS regression model, the previous results were confirmed. It should here be noted that the explanatory power of the regression model was lower than that commonly observed of this type in the literature. This limitation can mainly be explained by the size and composition of the sample, but also by the sample's representativeness, insofar as lower-class population are generally overrepresented in prison samples.

The remainder of this chapter is organised as follows. The next section discusses several height sample problems observed in the literature. Section three describes the data sample used. Section four presents the quality analysis of these data. In section five, the results based on the descriptive statistics and regression analysis are presented and discussed. The final section includes a description of the type of data sources to be used in the remaining chapters.

3.1.Heaping, Rounding and Representativeness

Data quality analysis is one of the most developed areas in the field of anthropometric history. Several steps have been established in order to identify the problems that could affect correct height estimations. In particular, in his work 'How to (and How Not to) Analyse Deficient Height Samples', Komlos proposes a quality analysis route for army data that can be extended to all types of data sources.[62] Komlos explains that the first step in analysing the quality of height data is to conduct a visual inspection of histograms. The normality assumption of the population's height distribution, which is the starting point for several studies in the field, serves as the comparison reference for this visual inspection. In the army, where restricted access is common due to height requirements (HR), the visual inspection makes it possible to check if there are shortfalls in the sample's height distribution. In order to solve this problem, Komlos proposes some statistical methods to ensure that the estimated height trends (not necessarily levels) are correct.

For height data obtained from prison archives, as in the current chapter, HR is not a problem, as there is no HR for the purposes of imprisonment. Therefore, once this problem is discarded, the inspection can focus more on rounding. Another work by Komlos, in which he defends his findings on the Industrial Revolution puzzle, mentions the rounding

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[62] Komlos, 'How to (and How Not to) Analyse Deficient Height Samples'.

problem. In particular, he argues that this problem arises when 'numbers are not recorded exactly, but are rounded to a nearest preferred value. Even numbers, for example, are often favoured over odd ones'.[63]

In the particular case of convict data, in their study on Bavaria during the nineteenth century, Baten and Murray argue that data taken from jails have an advantage over army databases: as there is no HR for imprisonment, prisoner data do not suffer from truncation or potential bias with regard to average height estimations.[64] In another study by Nicholas and Oxley, on female living standards among the Irish and English population during the period 1795-1820, they also argue that prisoner data show no truncation problems, bias or measurement error for average height estimations.[65] Furthermore, in a study on the effects of smallpox on height stunting in London and Ireland during the nineteenth century, Oxley does not identify any truncation in the height distribution of the convict sample used.[66] She does, however, identify a distribution bias due to the 'peculiar age distribution of criminal offenders'.[67]

Baten and Murray, on the other hand, recognise other potential biases in data sources with no HR, such as student and prisoner samples: 'eighteenth- and 19th-century students tended to come from the middle and upper classes, while prisoners seem to have come from the working and lower classes'.[68] In the same way, in their study on female convicts,

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[63] Komlos, 'On the Nature of the Malthusian Threat in the Eighteenth Century', p. 734.
[64] Baten and Murray, 'Heights of Men and Women in 19th Century Bavaria: Economic, Nutritional and Disease Influences'.
[65] Stephen Nicolas and Deborah Oxley, "The Living Standards of Women During the Industrial Revolution, 1795-1820", *The Economic History Review* Vol. 46, no.4 (1993): 723-49.
[66] Oxley, '"The Seat of Death of Terror": Urbanization, Stunting and Smallpox', 623-53.
[67] Ibid., p. 634.
[68] Baten and Murray, 'Heights of Men and Women in 19th Century Bavaria', p. 354.

Nicholas and Oxley compare their sample with the occupational structure reported in the 1841 census. As a result, they conclude that 'the convict sample was broadly coincident with the working population, except for the over-representation in the number of domestic servants and agricultural workers and under-representation in the number of textile workers'.[69]

Another matter that arises with regard to height data analysis is that of the sample's age composition. Age heaping and rounding are potential problems, for a number of reasons. For example, these aspects can be related to illiteracy or low schooling levels. Such factors are potentially related to a lower socioeconomic status and, therefore, to potential disadvantages in terms of the biological standard of living that can bias the sample distributions. Another specific problem that arises with age heaping is that, given the fact that adult height reflects early childhood wellbeing, errors in reporting age can result in incorrect inferences of the *momentum* of height dynamics. Both age heaping and rounding can be solved by grouping individuals by birth cohort instead of single birth years – a strategy that diminishes the possibility of relating height with an economic and social period different to the one when the individuals were physically growing. It should also be noted that grouping individuals by birth cohort solves another potential problem: the lack of precision of the average height estimation due to a reduced number of observations in the sample.

Another problem related to prison sample characteristics is the gathering of observations of a few age groups. In this case, if archival research were to cover the reports published

[69] Nicolas and Oxley, 'The Living Standards of Women', p. 727.

in a lower number of years, the options for undertaking a longitudinal analysis would be limited. Moreover, the very fact of working with this type of sample eliminates the possibility of the latter being representative of the population. Finally, it should also be mentioned that, if the sample is biased towards a very young or old population, average height can be underestimated due to the fact that it is possible for the young population to still be physically growing, and the elderly individuals already to be shrinking.[70]

As previously mentioned, Oxley discusses the age composition of convict samples.[71] As can be observed in Figure 3.1, both samples used by Oxley have a high proportion of younger people. Hence, it should be noted that the higher age frequency here reflects an age range in which individuals, in the context of the nineteenth century, are probably still physically growing. Oxley also highlights that these samples were collected for a very narrow period: five years (1831-1835) for the convicts transported to New South Wales in Australia (NSW convict males), and a single year (1866) for the sample from Wandsworth prison in London. As a result, Oxley argues that such sample characteristics, plus the concentration of a few particular age ranges, become confounding factors between age and birth cohort. On the positive side, she argues that 'this eliminates the possibility of period effects, providing the two samples are dealt with separately'.[72]

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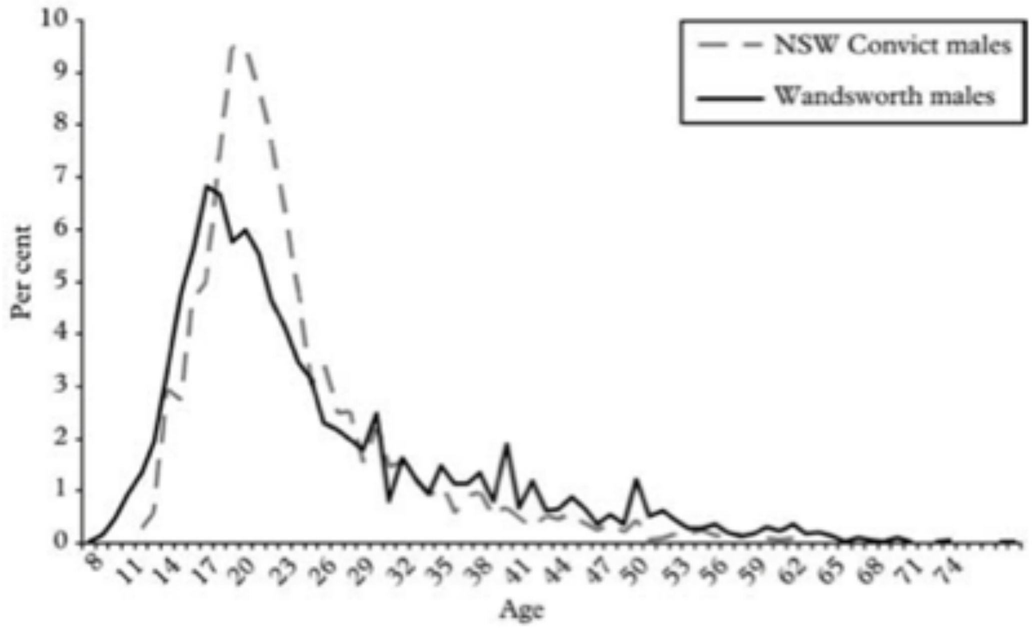
[70] I discuss this problem in chapter 2.
[71] Oxley, '"The Seat of Death of Terror"'.
[72] Ibid., p. 634.

Figure 3-1. Oxley's Study: Age Composition of Convict's Database



Source: Deborah Oxley, "'The Seat of Death of Terror'"

3.2.The Data Source

As previously mentioned, the height data referred to in the present chapter were obtained from the files of prisoners who had been incarcerated in Mexico City's jail. These files were accessed at the *Fondo de Cárceles* (Prison Fund) of the *Archivo Histórico de la Ciudad de México* (Historical Archive of Mexico City). The data are drawn from the archives' *Penitenciaría* (Penitentiary) section, which includes all prisoners' files from 1920 to 1976. After a random exploration, it was realised that files with height information were not available before 1970. Some, but not all, of these files include the *Laboratorio de Criminalística e Identificación* (the digital and anthropometric report), which contains information on physical characteristics, fingerprints, height, age, origin place, address, current work and criminal record, and was written closely after or at the moment when the convict was imprisoned.[73] Practically all files relate to male prisoners.[74]

In the Archive, certain search rules had to be followed. For example, scanning files was not allowed. Only a few photographs were permitted for use as file examples, and always under supervision. It was also compulsory to use a facemask and gloves during the search. As a result, I designed a template to capture the records' information (see Figure 3.2). While researchers were allowed to bring a laptop, typing with the compulsory gloves was not the most efficient way to capture information. Therefore, the template was filled in by hand with pencil (as pens were not allowed in either).

[73] Another report found in the prison records is the *Certificados e Informes*. This report was the result of the search for each prisoner's jail antecedents during the last 15 years. When antecedents were found, the report contained socioeconomic information, including education level. However, this information was available only for a few convicts. It should be noted that there were cases where the *Certificados e Informes* report was found even when the prisoner had no criminal antecedents, meaning that they were imprisoned and had to wait for longer periods before a judge was assigned to their case. While this may have been due to the type of crime they were accused of, it seems more likely that such a delay was the result of the inefficiency of the judicial system.
[74] Only a single report on a female prisoner was found during the search.

Figure 3-2. Form Template for Archival Research (AHDF: Fondo Cárceles)

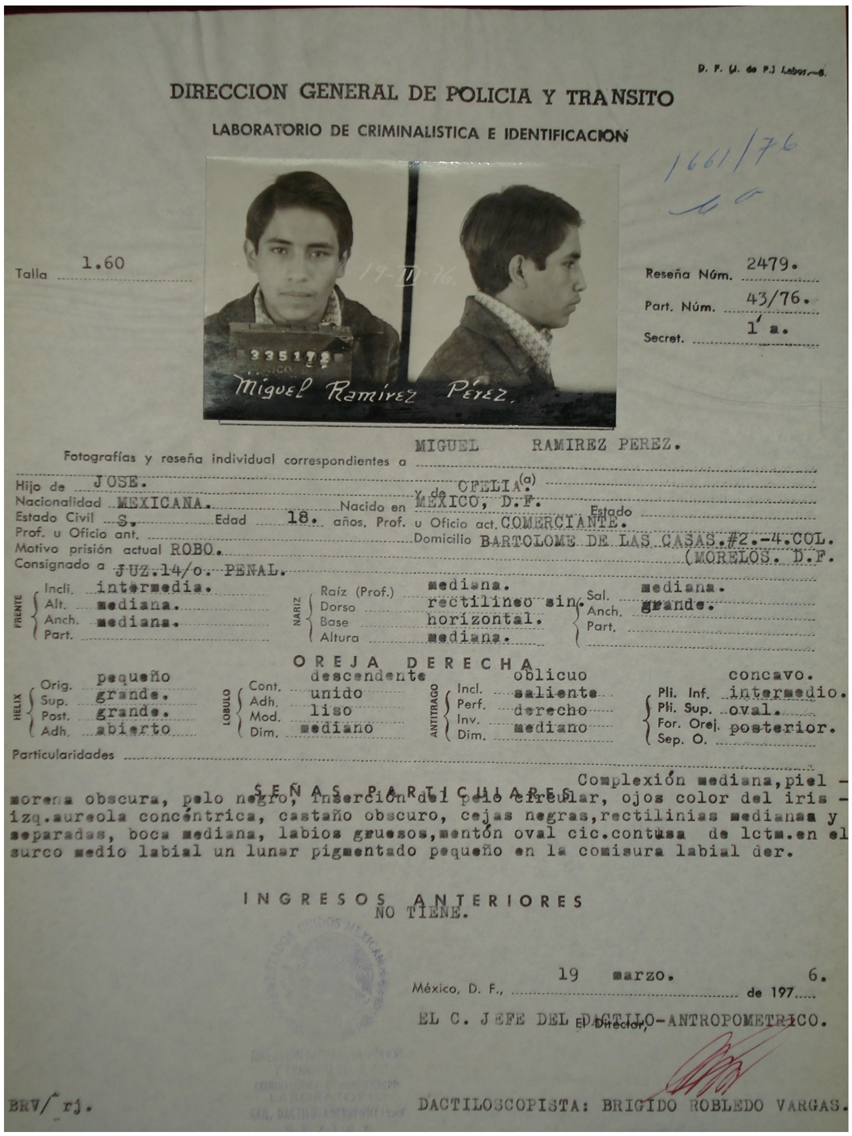
Capturista:		Fecha de Captura:
Caja:		
Año:		
Partida:		
(1) Nombre:	(2) Ap. Paterno:	(3) Ap. Materno:
	(4) Padre:	(5) Madre:
(6) Nacionalidad:	(7) Municipio:	(8) Estado:
(9) Estado Civil:	(10) Religión:	
(11) Domicilio		
(12) Estatura:	(13) Edad:	
(14) Escolaridad:		
(15) Prof. u Oficio Actual:	(16) Prof. u Oficio Anterior:	
(17) Motivo Prisión:	(18) Ingresos Anteriores:	
(19) Fecha Criminalística:	(20) Fecha Certificados:	(21) Fecha Ficha

The main information recorded for this sample was as follows:

1. Box Number (*Caja*): *3642*
2. File Number/Year (*Partida/Año*): *1661/76*
3. Height (*Estatura*): *1.60 cm*
4. Name (*Nombre*): *Miguel Ramirez Perez*
5. Place of Origin (*Municipio/Estado*): *Mexico, D.F.*
6. Marital/Civil Status (*Estado Civil*): *Single*
7. Age (*Edad*): *18*
8. Occupation (*Profesión u Oficio Actual*): *Salesman*
9. Current State of residence (*Domicilio*): *D.F.*
10. Reason for imprisonment (*Motivo Prisión*): *Theft*
11. Criminal Record (*Ficha Criminalística*): *Not previously imprisoned*
12. Date (*Fecha*): *19/March/1976*

Figure 3.3 shows a photograph of an anthropometric record.

Figure 3-3. Anthropometric Record Sample, Mexico City Jail



D. F. U. de P.J. Labor.—6.

DIRECCION GENERAL DE POLICIA Y TRANSITO

LABORATORIO DE CRIMINALISTICA E IDENTIFICACION

1661/76

Talla 1.60

Reseña Núm. 2479.
Part. Núm. 43/76.
Secret. 1ª.

335172

Miguel Ramirez Perez.

Fotografías y reseña individual correspondientes a MIGUEL RAMIREZ PEREZ.

Hijo de JOSE. y de OFELIA(a).
Nacionalidad MEXICANA. Nacido en MEXICO, D.F. Estado
Estado Civil S. Edad 18. años. Prof. u Oficio act. COMERCIANTE.
Prof. u Oficio ant. Domicilio BARTOLOME DE LAS CASAS.#2.-4.COL. (MORELOS. D.F.
Motivo prisión actual ROBO.
Consignado a JUZ.14/o. PENAL.

FRENTE: Incli. intermedia. Alt. mediana. Anch. mediana. Part.

NARIZ: Raíz (Prof.) mediana. Dorso rectilineo sin. Base horizontal. Altura mediana.

Sal. mediana. Anch. grande. Part.

O R E J A D E R E C H A

HELIX: Orig. pequeño Sup. grande. Post. grande. Adh. abierto

LOBULO: Cont. descendente Adh. unido Mod. liso Dim. mediano

ANTITRAGO: Incl. oblicuo Perf. saliente Inv. derecho Dim. mediano

Pli. Inf. concavo. Pli. Sup. intermedio. For. Orej. oval. Sep. O. posterior.

Particularidades

S E Ñ A S P A R T I C U L A R E S

Complexión mediana, piel - morena obscura, pelo negro, inserción del pelo circular, ojos color del iris - izq.aureola concéntrica, castaño obscuro, cejas negras, rectilinias medianas y separadas, boca mediana, labios gruesos, mentón oval cic.contusa de lctm.en el surco medio labial un lunar pigmentado pequeño en la comisura labial der.

I N G R E S O S A N T E R I O R E S

NO TIENE.

México, D. F., 19 marzo. de 1976.

EL C. JEFE DEL DACTILO-ANTROPOMETRICO.
El Director,

BRV/rj.

DACTILOSCOPISTA: BRIGIDO ROBLEDO VARGAS.

As mentioned above, no anthropometric reports were found previous to the 1970s files. Therefore, the final search strategy was defined as covering the period 1970-1976 (see Table 3.1). The files were not digitalised and needed to be recorded from their original version. They were grouped into boxes, each of which contained around 100 records.

Given the time and financial limitations of undertaking this archival research, a decision had to be made as to where to concentrate the search efforts.

Table 3-1. Historical Archive of Mexico City; Prison Fund; Section: Penitentiary, 1970-1976

Year	Box Numbers	Number of Files
1970	2818-2919	9500
1971	2919-3069	13277
1972	3069-3214	11721
1973	3214-3360	13201
1974	3360-3497	13596
1975	3497-3626	13242
1976	3626-3693	8322

Source: D:\AHDF Octubre 2006\Fondo Cárceles\Penitenciaria Inventario.pdf (Accessed 24/09/2007)

In the first stage of the research (first journey to Mexico in 2007), 38 boxes containing files from 1970 were inspected, with only 169 anthropometric records found out of 3723 files (the total number of files for 1970 was 9500). By the end of this stage, one box of 1976 files had also been inspected, with 49 out of 105 files including an anthropometric record (see Table 3.2).[75]

[75] The 1976 archive included a total of 8322 prisoners' files.

Table 3-2. Anthropometric Data: Checked Files During Archives' Work in Mexico City (2007)

Year	Box Number	Number of Files	No. of Files Including Anthropometric Report	Year	Box Number	Number of Files	No. of Files Including Anthropometric Report
1970	2819	95	7	1970	2840	89	1
1970	2820	95	7	1970	2841	117	4
1970	2821	84	4	1970	2842	102	4
1970	2822	96	3	1970	2843	95	6
1970	2823	102	4	1970	2844	96	5
1970	2824	108	4	1970	2845	101	3
1970	2825	98	3	1970	2846	90	4
1970	2826	91	3	1970	2847	95	4
1970	2827	109	5	1970	2848	84	3
1970	2828	110	4	1970	2849	105	2
1970	2829	91	5	1970	2850	89	2
1970	2830	106	7	1970	2851	93	6
1970	2831	105	3	1970	2852	112	6
1970	2832	112	4	1970	2853	80	4
1970	2833	95	7	1970	2854	108	9
1970	2834	112	4	1970	2855	87	8
1970	2835	106	5	1970	2856	82	3
1970	2836	100	4	*Subtotal*		*3723*	*169*
1970	2837	93	3				
1970	2838	105	4	1976	3627	105	49
1970	2839	85	5	*Total*		*3828*	*218*

Given this first stage archival research result, a different strategy was planned for the second journey to Mexico in 2008. As shown in Table 3.3, during this second round only files from 1976 were inspected, using a random selection of boxes. By the end, due to time limitations, not all of the planned boxes had been inspected, and a total sample of 972 (169 from the first journey plus 803 from the second one) male records was obtained (plus one female record not reported in Table 3.3).[76] However, for the present analysis, only records for prisoners aged between 18 and 49 years were included, for a total sample of 907 males.

[76] The difference in the number of files containing anthropometric data between 1970 and 1976 is significant. While for 1976, heights were found for 49 males in a single one box, only 4.45, on average, were found per box for 1970. The difference in the number of measured prisoners between those years can be explained by improvements in the bureaucratic processes of the judicial system.

Table 3-3. Anthropometric Data: Checked Files During Archives' Work in Mexico City (2008)

	Box Number	Number of Files	No. of Files Including Anthropometric Report		Box Number	Number of Files	No. of Files Including Anthropometric Report
1	3627	105	49	35	3661	107	
2	3628	114		36	3662	105	46
3	3629	102		37	3663	103	
4	3630	98	52	38	3664	94	
5	3631	116		39	3665	109	Out of Time
6	3632	112	61	40	3666	115	
7	3633	88		41	3667	105	56
8	3634	108		42	3668	86	
9	3635	101	47	43	3669	105	
10	3636	95		44	3670	92	Out of Time
11	3637	98	47	45	3671	106	
12	3638	101		46	3672	95	69
13	3639	101		47	3673	96	
14	3640	101	50	48	3674	111	
15	3641	112		49	3675	119	Out of Time
16	3642	106	58	50	3676	109	
17	3643	106		51	3677	113	49
18	3644	105		52	3678	106	
19	3645	101	33	53	3679	115	
20	3646	101		54	3680	115	Out of Time
21	3647	105	47	55	3681	105	
22	3648	101		56	3682	116	20
23	3649	99		57	3683	114	
24	3650	104	Out of Time	58	3684	110	
25	3651	97		59	3685	111	Out of Time
26	3652	92	49	60	3686	113	
27	3653	94		61	3687	124	27
28	3654	105		62	3688	123	
29	3655	111	Out of Time	63	3689	119	
30	3656	108		64	3690	127	Out of Time
31	3657	105	43	65	3691	134	
32	3658	105		66	3692	137	0
33	3659	86		67	3693	51	
34	3660	104	Out of Time		Total	*7077*	
					Total (Selected)	*2911*	*803*

First Round

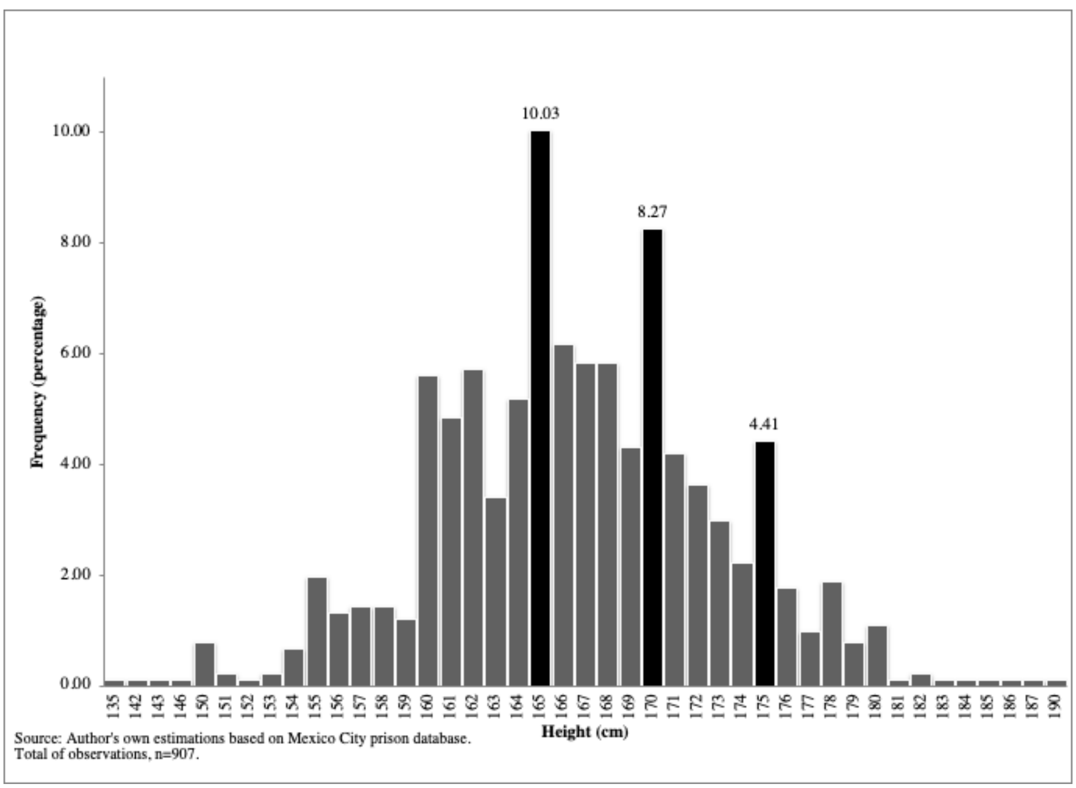
Second Round

3.3.Distribution Quality Analysis and Defined Categories

3.3.1. Quality Analysis

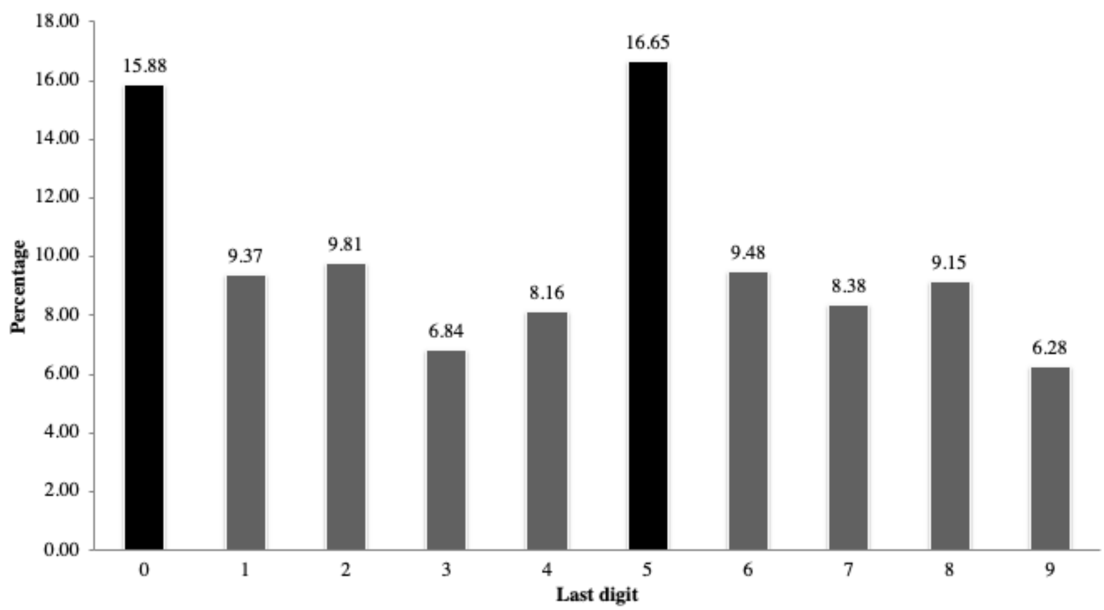
In order to analyse the quality of the recorded data, it was necessary to check for potential problems, such as the ones described in section 2 of the present chapter. First of all, a visual inspection was conducted. Figure 3.4 presents the height distribution of the sample. Given the type of source – as expected due to there being no HR – there were no shortfalls. As can be seen the most frequently reported value is 165 cm (10%), followed by 170 cm (8.27%). Based on this inspection, the frequencies for 170 cm and 175 cm (4.41%) suggest the presence of height rounding. This is also the case if less frequent values ending in 0 or 5 are taken into account: 155 cm and 180 cm.

Figure 3-4 Height Distribution, 18 to 49 Years Old.



In order to analyse the observed rounding in greater detail, the frequency of the heights' last digit was plotted and is presented in Figure 3.5. As can be seen, the frequency of 0 and 5 is higher than all others. This characteristic would be a problem were the rounding to be biased in favour or against a specific group, such as a single birth cohort or social group. However, this was not the case for the current sample.

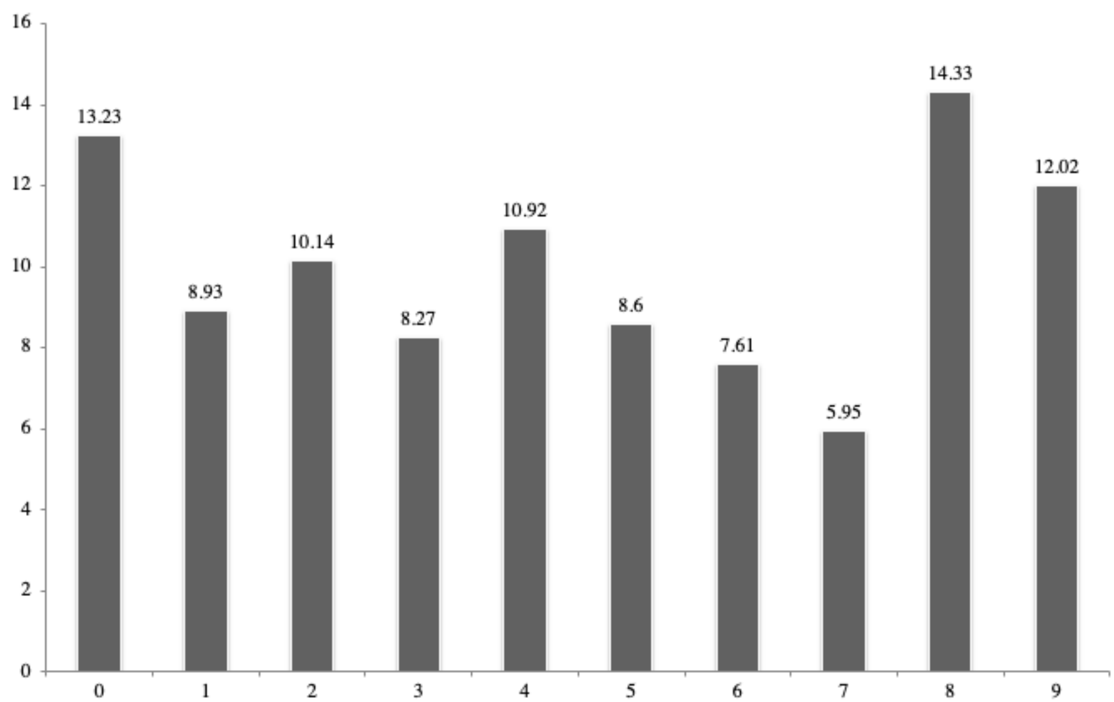
Figure 3-5. Last Height Digit Distribution (in cm), Birth Cohort: 1922-1958



Source: Author's own estimations based on Mexico City prison database.
Total of observations, n=907.

The second potential problem with rounding concerns the rounding of reported age. In this case, the last digit distribution for all ages is presented in Figure 3.6. As seen here, if the frequencies of ages ending in 0 or 5 are added in, they represent around 20% of the sample, which is exactly the expected percentage for two out of 10 possible values for the last digit distribution. As a result, no potential problem with age rounding was identified in the present case.

Figure 3-6. Last Age Digit Distribution, Birth Cohort: 1922-1958



Source: Author's own estimations based on Mexico City prison database.
Total of observations, n=907.

Another problem that arose with the sample was the fact that a significant proportion of the prisoners were young. In itself, this characteristic would not be a problem if those individuals had already reached their final height, but in the present case it became one due to the fact that only files for two close together years were recorded: 1970 and 1976. As a result, and as shown in Table 3.4, a high proportion of prisoners were born in a very short period of time and, therefore, the total number of years by birth cohorts was limited. Moreover, this type of age composition in the sample resulted in a non-homogeneous size of birth cohorts, in turn leading to a lower estimation precision for those cohorts with a lower number of observations.

Table 3-4. Observations by Age (18-49) and Birth Cohorts, 1922-1958

Age	1922 - 1933	1934 - 1945	1946 - 1958
18			75
19			69
20			58
21			52
22			58
23			50
24			66
25		1	52
26		4	34
27		4	35
28		7	30
29		8	16
30		8	36
31		19	
32		23	
33		20	
34		23	
35		18	
36		22	
37	3	8	
38		12	
39	2	8	
40	5	13	
41	2	8	
42	1	10	
43	5		
44	10		
45	7		
46	9		
47	4		
48	6		
49	6		
Total	60	216	631

Source: Based on prison's database.
*n= 907.

3.3.2. Defined Categories

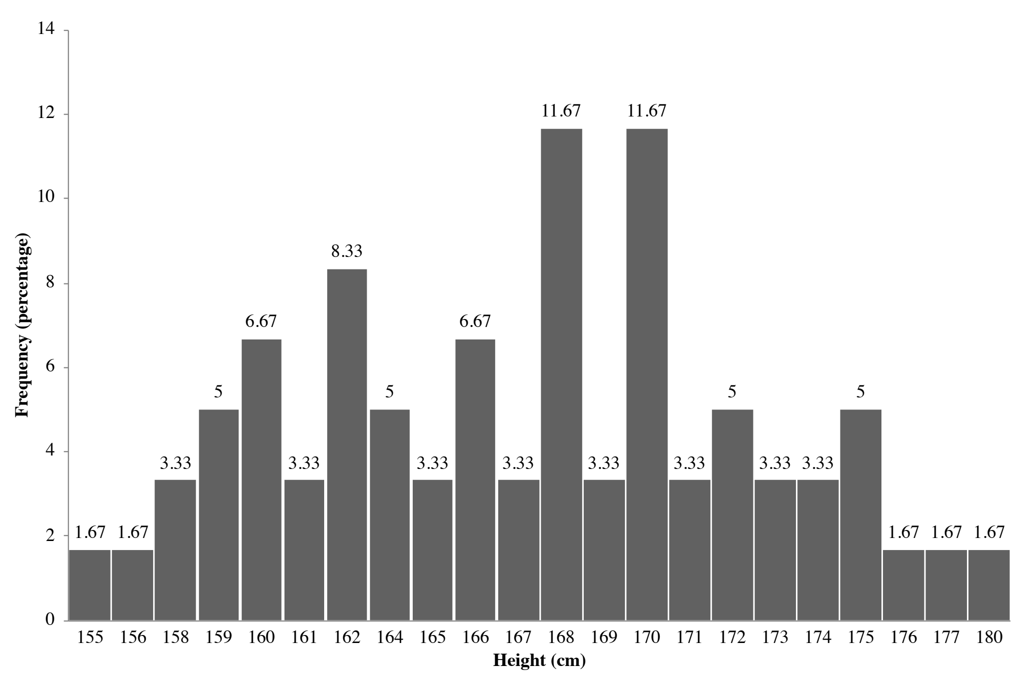
Once quality was checked for the whole sample, in order to proceed with the analytical work on height it was necessary to define categories for the available sample information. Such categories depend on the type of information. In the present case, the database allowed for an analysis of heights with respect to at least three basic categories: birth cohort, place of origin and occupation. As previously mentioned, the prisoners' ages are reported in the anthropometric records. As a result, their heights can be compared and differentiated by controlling for birth years. Secondly, and in addition to this 'time' or 'period' categorisation, the data include information on place of origin, making it possible to compare prisoners' heights both in longitudinal terms and across space, i.e., regions. Finally, in order to compare these heights by socioeconomic status, the data on current occupation (previous to being imprisoned) were also reported. It should be noted that once these categories were defined, it was necessary also to analyse the quality of the height data for each sub-sample.

Birth Cohorts

The final sample was divided into three birth cohorts. The birth year was calculated by the difference between the reported age of the prisoner and the reported year in the anthropometric report. Three birth cohorts of 12-13 years each were defined: 1922-1933, 1934-1945 and 1946-1958. As shown in Table 3.4, given the fact that all of the collected data were concentrated in records for only two single years – 1970 and 1976 – the analysis by birth cohort was biased by age composition: 44.5, 34.4 and 22.9 years old, on average, respectively by birth cohort (the sample average being 27). As a result, a higher and very significant proportion of the sample was concentrated in the 1946-1958 birth cohort: 631 out of 907 individuals.

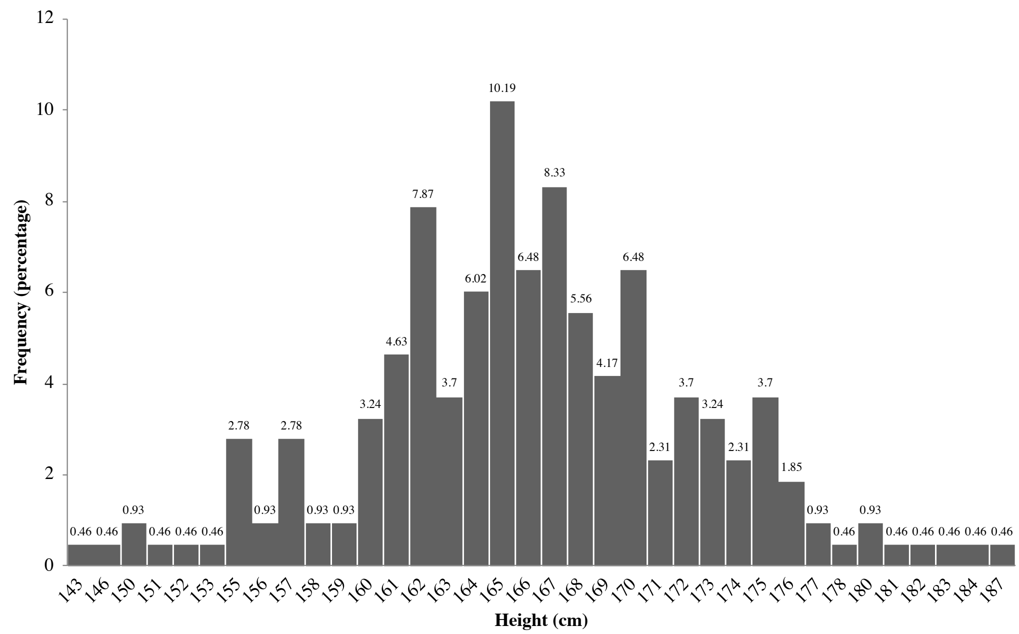
When the height distributions were plotted by birth cohort, like in the case of the whole sample, no shortfalls were observed for two birth cohorts: 1934-1945 and 1946-1958 (Figures 3.8 and 3.9). In the case of the third birth cohort, 1922-1933 (Figure 3.7), there is not a clear, normally shaped distribution for heights. In particular, besides 168 and 170 cm being more frequent values, no values below 155 cm can be observed. For the 1934-1945 and 1946-1958 birth cohorts, even though the shape of the height distribution is not a perfect normal one, it should be noted that no specific bias is observed.

Figure 3-7. Height Distribution, Birth Cohort: 1922-1933



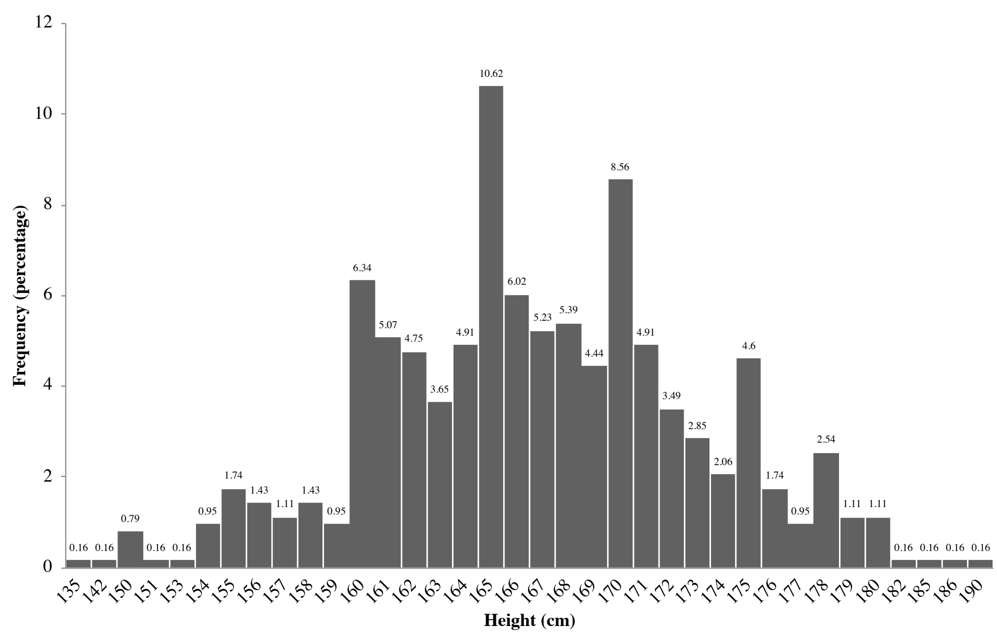
Source: Author's own estimations based on Mexico City prison database.
Total of observations, n=60.

Figure 3-8. Height Distribution, Birth Cohort: 1934-1945



Source: Author's own estimations based on Mexico City prison database.
Total of observations, n=216.

Figure 3-9. Height Distribution, Birth Cohort: 1946-1958



Source: Author's own estimations based on Mexico City prison database.
Total of observations, n=631.

Regions

Table 3.5 presents the reported state of origin in the sample composition, including the following four regions:

1. *South-Southeast*: Oaxaca, Veracruz, Yucatan, Campeche, Chiapas, Guerrero, Quintana Roo and Tabasco.
2. *Centre*: Estado de Mexico, Morelos, Puebla, Hidalgo and Tlaxcala.
3. *Distrito Federal*
4. *Other (north of Distrito Federal)*: Guanajuato, Jalisco, Michoacan, Aguascalientes, Colima, Nayarit, Queretaro, San Luis Potosi, Zacatecas, Coahuila, Durango, Nuevo Leon, Chihuahua, Tamaulipas, Baja California Sur, Sinaloa, Sonora and Baja California.

As can be expected due to the fact that the jail was located there, a higher proportion of the sample includes natives from Distrito Federal: 527 out of 907. When the individuals were grouped by region and birth cohort, this generated a sample size problem with the oldest birth cohort (which contained sub-samples of fewer than 30 observations), which practically eliminated the possibility of good estimation precision. For the other two birth cohorts, even though the sample included a higher proportion of Distrito Federal natives, each regional sample contained over 30 observations.

Table 3-5. Prisoners' Sample Distributed by Region and Birth Cohort, 1922-1958

	Centre	South – Southeast	Distrito Federal	Other
1922 – 1933	11	9	29	11
1934 – 1945	37	34	94	51
1946 – 1958	76	65	404	86
Total	124	108	527	148

Source: Author's own estimations based on Mexico City prison database.
Total of observations= 907.
*South-Southeast: Oaxaca, Veracruz, Yucatán, Campeche, Chiapas, Guerrero, Quintana Roo, Tabasco
*Centre: Edomex, Morelos, Puebla, Hidalgo, Tlaxcala
*Other: Guanajuato, Jalisco, Michoacán, Aguascalientes, Colima, Nayarit, Querétaro, San Luis Potosí, Zacatecas, Coahuila, Durango, Nuevo León, Chihuahua, Tamaulipas, Baja California Sur, Sinaloa, Sonora, Baja California.

Occupational Status

A macro class sociological approach was followed to determine socioeconomic status. Given the type of available data in the sample, it was decided that an occupational status classification could be used. To do so, the class scheme devised by Jonsson, Grusky, Di Carlo, et al. was followed (see Table 3.6).[77] These authors argue that the advantage of such a classification, and which includes 82 occupations, is that it 'captures many of the fundamental boundaries in the division of labour that are socially recognised and defended'.[78] At the more aggregated level, two major classes were identified under this scheme. Within the first one, the non-manual class, three macro classes were defined: (I) professional-managerial, (II) proprietor and (III) routine non-manual. For the second one, the manual class, a further two macro classes were identified: (IV) manual and (V) primary. It should be noted that the macro classes could be disaggregated into so-called meso classes. Namely, the professional-managerial macro class was divided into (A) classical professions, (B) managers and officials, and (C) other professions; the routine

[77] Jonsson, Grusky, Di Carlo, Reinhard, and Brinton, 'Microclass Mobility: Social Reproduction in Four Countries'.
[78] Ibid., p.14.

non-manual class was divided into (A) sales workers and (B) clerks; and, finally, the (IV) manual class was divided into (A) craft, (B) lower manual, and (C) service workers.

Table 3-6. Macro and Meso Classes of Manual and Non-Manual Occupations

Non-Manual classes			Manual classes	
I. Professional managerial	II. Proprietors	III. Routine non-manual	IV. Manual	V. Primary
A. Classical professions		A. Sales	A. Craft	
B. Managers and officials		B. Clerical	B. Lower manual	
C. Other professions			C. Service workers	
Source: Author's own elaboration based on Jonsson et al., 'Micro-class Mobility: Social Reproduction in Four Countries'				

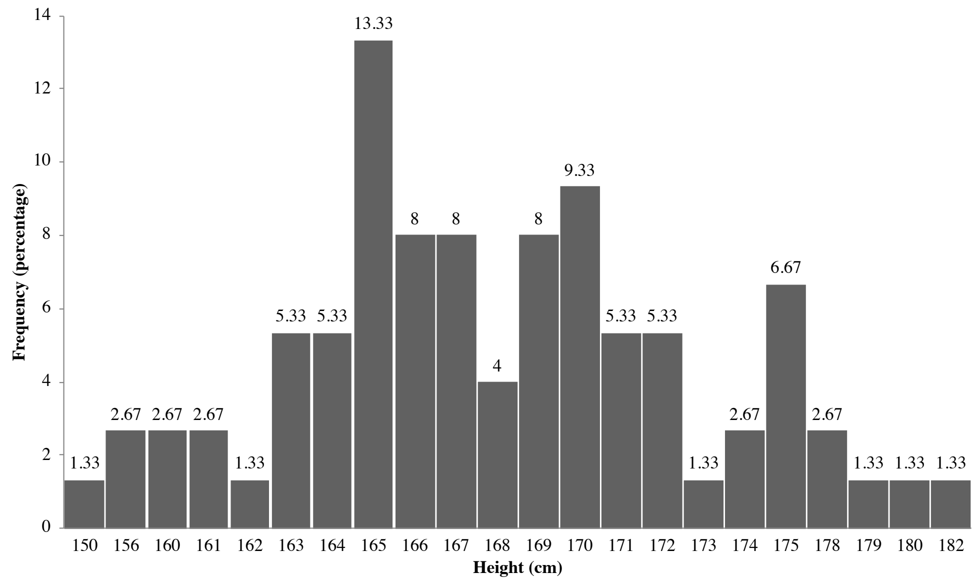
For the database used in the present analysis, each prisoner was classified in terms of the 82 categories in the occupational catalogue (see Table 3.10 in the chapter annex for the whole categories), with the intention of grouping them by macro and meso classes respectively.[79] However, it was not possible to identify enough observations for the latter. Moreover, 75 observations were classified beyond the macro class scheme as ‘students’. As a result, the final classification used for the present analysis included five occupational categories: students, professional managerial, routine non-manual, manual and primary. Some examples of reported occupations are the following ones: accountants (professional managerial), federal employee (routine non-manual), electrician (manual), and *machetero* (primary).

[79] This classification has previously been applied to the case of Mexico by Huerta and Espinosa. I adapted a version of their classification for use in the present exercise. Huerta-Wong and Espinosa, ‘Procesos de estratificación social e inversiones educativas hacia hombres y mujeres’.

A simple comparison with census data shows that occupational composition of the convicts' database is class downward bias ((see Table 3.11 in the chapter annex). On one hand, and as it is expected for a Metropolitan area such as the one around Mexico City, the primary category is under-represented in terms of the national numbers: 2.4% (convicts' sample) versus 39.4% (1970 census). On the other hand, the manual category is far overrepresented: 60.3% (convicts' sample) versus 25.8% (1970 census). Such proportion of individuals in the manual category reflects that the convicts' sample is more representative of the population in the bottom of the social ladder.

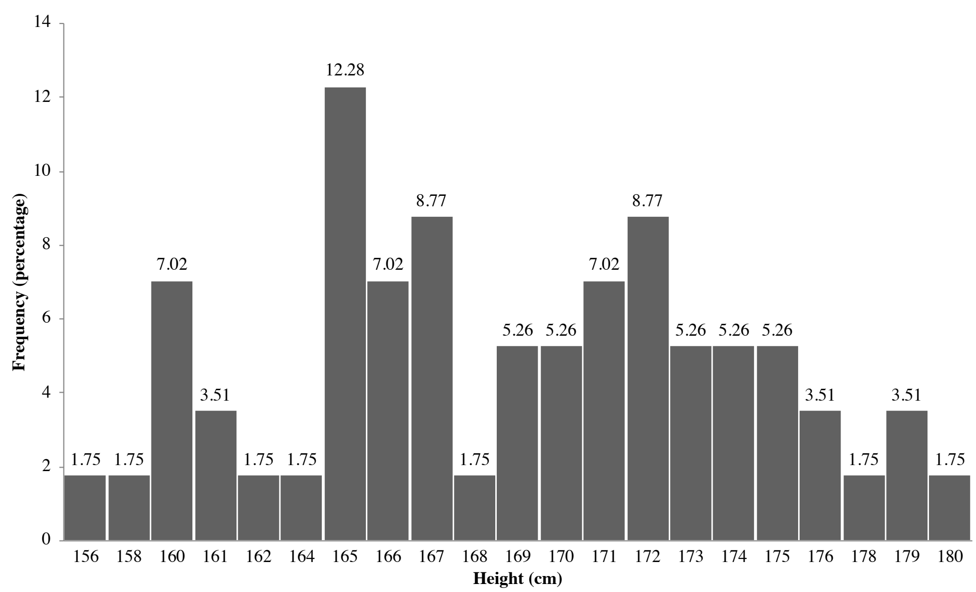
No shortfalls were observed when the height distributions were plotted by occupation (Figures 3.10 to 3.14). As can be seen, sample size matters in getting histograms to resemble a normal distribution more closely. A clear sample size problem for the single descriptive analysis emerged, and will be presented for the primary category (20 observations). Also, with the growth of the sample size, it can be seen that the distributions grow closer to an approximate normal distribution (see routine non-manual and manual categories: 253 and 502 observations, respectively).

Figure 3-10. Height Distribution of Students



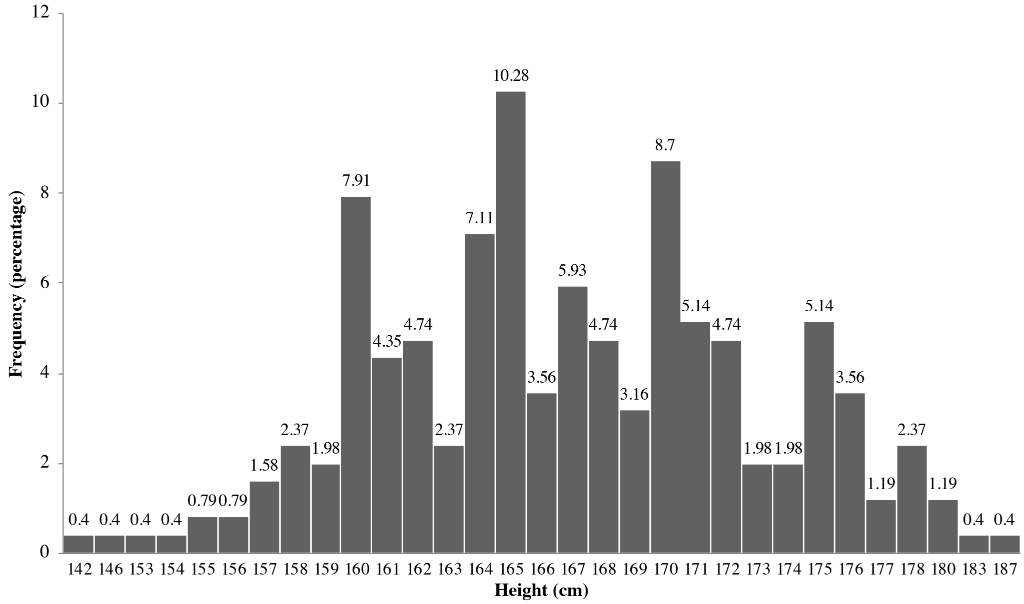
Source: Author's own estimations based on Mexico City prison database.
Total of observations, n=75.

Figure 3-11. Height Distribution of those in Professional Managerial Occupations



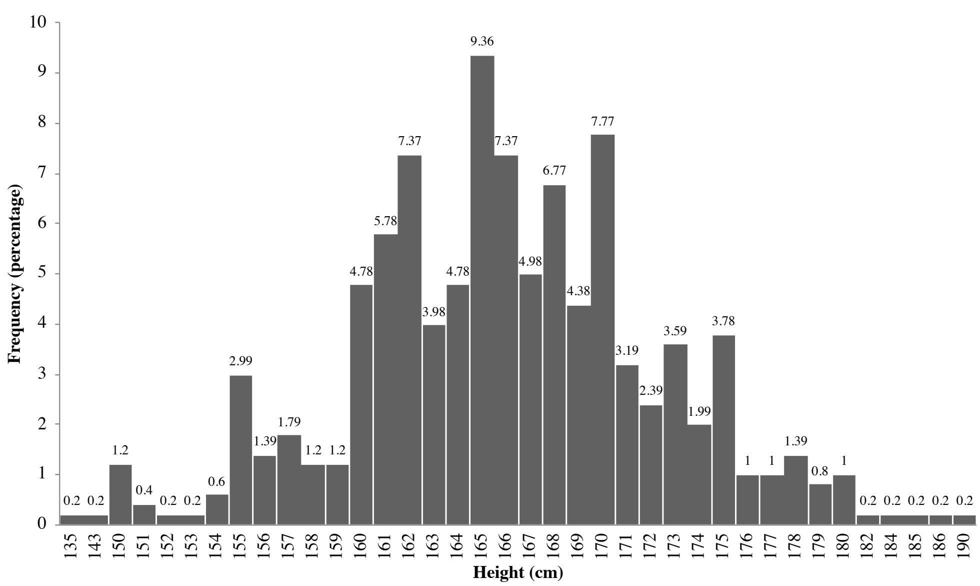
Source: Author's own estimations based on Mexico City prison database.
Total of observations, n=57.

Figure 3-12. Height Distribution of those in Routine Non-Manual Occupations



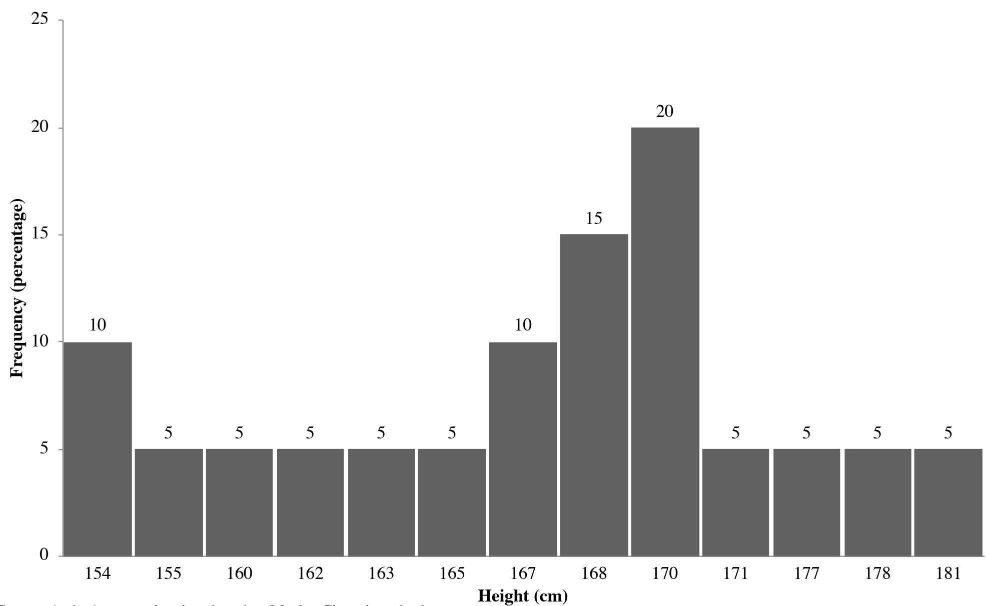
Source: Author's own estimations based on Mexico City prison database.
Total of observations, n=253.

Figure 3-13. Height Distribution of those in Manual Occupations



Source: Author's own estimations based on Mexico City prison database.
Total of observations, n=502.

Figure 3-14. Height Distribution of those in Primary Occupations



Source: Author's own estimations based on Mexico City prison database.
Total of observations, n=20.

3.4.Height Estimations

Once the distribution quality was analysed and the limitations of the defined categories were identified, the next step dictated by conventional analysis was to calculate average height and, therefore, undertake a multivariate analysis. This involved two stages of analysis. In the first, descriptive statistics were used in order to compare the heights between groups by specific characteristics such as age, region and occupation. In the second stage, a multivariate estimation was conducted, following a type of econometric method as is common.

Table 3.7 presents the results on average height for each region. As can be seen, the simple averages suggest a height difference in favour of those born in the northern states (region category = other), followed by those born in Distrito Federal. The sample sizes for each region were good enough to make comparisons: from 108 individuals in the South-Southeast to 527 in Distrito Federal. However, once the regions were compared by controlling for the previously defined birth cohorts, some sub-samples became inadequate in terms of the number of observations. It should, however, be noted that as demonstrated in Figure 3.15, the previously inter-regional height ranking remains almost the same for each birth cohort.

Table 3-7. Average Height (in cm) by Region, Birth Cohort: 1922-1958

Region	Minimun	Maximun	Average	Standard Deviation	Average Age	Observations
Centre	142	181	165	6.98	28.7	124
South-Southeast	150	180	165.8	6.37	29	108
Distrito Federal	135	190	166.9	6.3	25.6	527
Other	155	185	167.7	6	29.5	148
Total	135	190	166.6	6.4	27	907

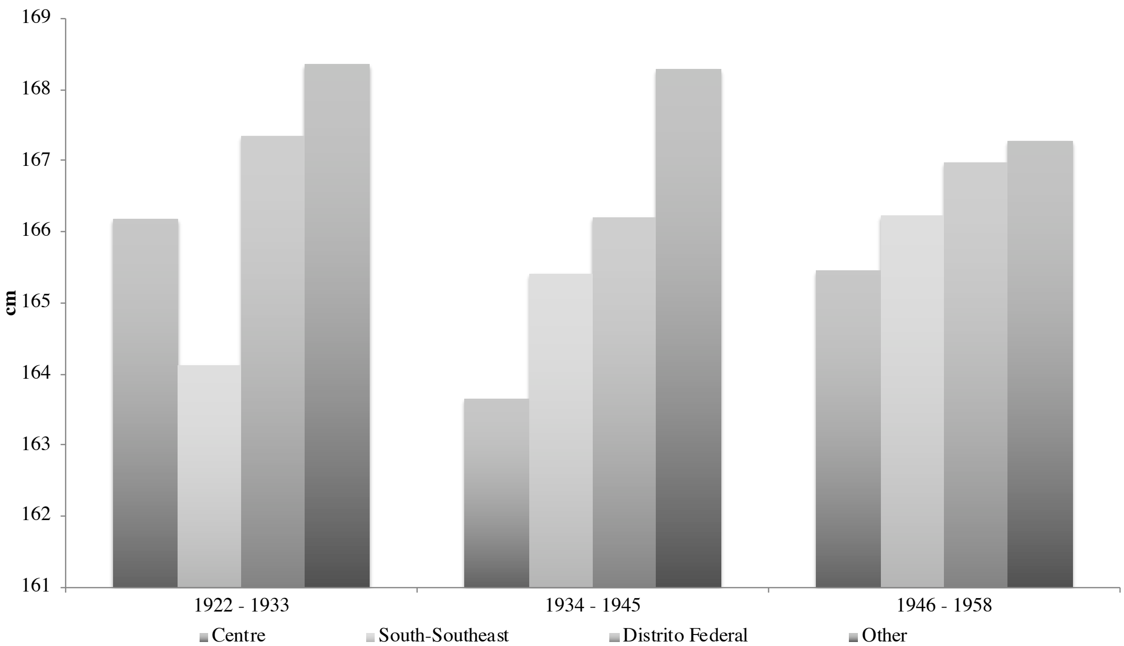
Source: Author's own estimations based on Mexico City prison database.
Total of observations= 907.

*South-Southeast: Oaxaca, Veracruz, Yucatán, Campeche, Chiapas, Guerrero, Quintana Roo, Tabasco

*Centre: Estado de Mexico, Morelos, Puebla, Hidalgo, Tlaxcala

*Other: Guanajuato, Jalisco, Michoacán, Aguascalientes, Colima, Nayarit, Querétaro, San Luis Potosí, Zacatecas, Coahuila, Durango, Nuevo León, Chihuahua, Tamaulipas, Baja California Sur, Sinaloa, Sonora, Baja California.

Figure 3-15. Average Height (cm) by Region and Birth Cohort: 1922-1958



Source: Author's own estimations based on Mexico City prison database.
Total of observations= 907.
*South-Southeast: Oaxaca, Veracruz, Yucatán, Campeche, Chiapas, Guerrero, Quintana Roo, Tabasco
*Centre: Estado de Mexico, Morelos, Puebla, Hidalgo, Tlaxcala
*Other: Guanajuato, Jalisco, Michoacán, Aguascalientes, Colima, Nayarit, Querétaro, San Luis Potosí, Zacatecas, Coahuila, Durango, Nuevo León, Chihuahua, Tamaulipas, Baja California Sur, Sinaloa, Sonora, Baja California.

On the other hand, when the heights were compared by occupational status, the results show the expected ranking for all but the primary occupation class. As presented in Table 3.8, those classified as professional-managerial were found to be the tallest, followed by students. The estimated averages also suggest that those in the manual class were the shortest individuals. For those in the primary class, it should be noted that the sample only includes 20 individuals and the height standard deviation is the largest one among all the defined classes. Therefore, for this sub-sample, the results on average height should be read with caution.

Table 3-8. Average Height (in cm) by Macroclass, Birth Cohort: 1922-1958

Occupational Category	Minimun	Maximun	Average	Standard Deviation	Average Age	Observations
Professional managerial	156	180	168.8	5.63	26.8	57
Students	150	182	167.9	5.57	20.3	75
Primary	154	181	166.9	7.43	24.4	20
Routine nonmanual	142	187	166.9	6.34	28.6	253
Manual	135	190	166	6.51	27.4	502
Total	135	190	166.6	6.4	27	907
Source: Author's own estimations based on Mexico City prison database.						

Once the descriptive statistics were presented, the next step was to conduct a simple regression analysis in order to obtain the height estimations. For this purpose, the previously defined categories were included as explanatory variables for height. In addition, certain controls were included. Among these, a dummy variable was defined for age in order to control for cases in which younger individuals were still growing (by determining a threshold for all those aged below 20). Also, two controls for local contexts were included: population size in the state of origin, and distance in kilometres from the state of origin to Distrito Federal. The proposed model is presented in equation 1.

$$Height = H(Birth\ Cohort, Regions, Occupational\ Class,\ Controls) \qquad (1)$$

Given the fact that no truncation or systematic bias was observed in the sample, a simple OLS estimation was done. For the dummy variables, the reference population comprised those born between 1945-1958 in Distrito Federal, who were working in a routine-non manual occupation and were 20 years old or above. The results are presented in Table 3.9. Column I presents all the explanatory variables (birth cohorts, regions and occupational class) and controls (dummy for those older than 19 years old, population for each 10,000 inhabitants in State of origin, and distance in kilometres from State of origin to Mexico

City) included in the regression. Here, it can be seen that, firstly, the coefficients for those born in the South-Southeast and the Centre regions are negative and significant, i.e., these individuals are shorter than those born in Distrito Federal. Secondly, statistically significant coefficients were obtained for occupational status among those in managerial-professional and manual activities. In the case of the former, it can be seen that they are taller than those in routine-non-manual activities by almost two centimetres. Conversely, those in a manual activity are shorter than the reference group by almost one centimetre. Thirdly, the coefficients for both birth cohorts and controls are not statistically significant. Column II highlights that, when regions are not included in the regression, the coefficients for occupational status do not change, but the birth cohorts remain non-significant. Once the regions are, once again, included in the regression and birth cohorts are excluded, both regions and occupational status remain significant (column III). Finally, as shown in column IV, the size of the significant coefficients for occupational status remains almost the same when both birth cohorts and regions are excluded from the regression.

For controls, population is only significant in column IV. The State with the biggest population is Mexico City: 4.87 million people. As a result, population size for those from Mexico City adds them, on average, 0.18 cm. In the case of distance (in kilometres) to Mexico City, the coefficient for all regressions is not significant.[80] Finally, it has to be noted that similar regressions to those reported in Table 3.9 were estimated by including

[80] If it was the case of a statistically significant coefficient for distance in kilometres, the maximum effect should be observed for those coming from the state of Baja California (2,319 km) by almost 4cm in regression of column II.

birth cohorts or the age dummy alone. In such cases, neither birth cohorts nor the age dummy become statistically significant.

In terms of the explanatory power of the regression, the R-squared is quite low. Two facts should be noted in this regard. On one hand, the R-squared for height regressions is, in general, low. This characteristic is due to the fact that an important proportion of height variation among populations can be explained by natural reasons. On the other hand, in the specific, present case the explanatory power of the regression is below the observed standard. This result is due to several reasons. One is related to the size and composition of the sample, i.e., that the sample size is small and unbalanced in terms of the available characteristics such as birth cohorts, regions, and even occupational status. Another potential reason is related to the representativeness of the sample: even if it were possible to differentiate among several occupations, prison samples in general include a higher proportion of the lower-class population, thus further reducing potential height variance.

Table 3-9. Heights' Model (OLS), Mexico, 1922-1958

VARIABLES	I	II	III	IV
Birth Cohort				
1922 – 1933	0.3686	0.7563		
	(0.971)	*(0.941)*		
1934-1945	-0.4366	-0.1556		
	(0.600)	*(0.581)*		
1945-1958 (omitted)				
Regions				
Distrito Federal (omitted)				
South-Southeast	-1.6065*		-1.5694*	
	(0.964)		*(0.946)*	
Centre	-1.6730*		-1.6123**	
	(0.848)		*(0.805)*	
Other	0.6176		0.6483	
	(0.948)		*(0.925)*	
Occupational Class				
Macro_class1: Students	0.9725	0.9792	0.999	0.9954
	(0.891)	*(0.894)*	*(0.890)*	*(0.893)*
Macro_class2: Professional Managerial	1.8035*	1.7861*	1.8373**	1.7912*
	(0.935)	*(0.935)*	*(0.933)*	*(0.933)*
Macro_class3: Routine Non-Manual (omitted)				
Macro_class4: Manual	-0.9527*	-0.8545*	-0.9486*	-0.8507*
	(0.491)	*(0.492)*	*(0.491)*	*(0.492)*
Macro_class5: Primary	0.4041	0.1945	0.3931	0.1939
	(1.485)	*(1.491)*	*(1.483)*	*(1.490)*
Age				
20 years old or more (omitted)				
Less than 20 years old	-0.8354	-1.1511	-0.817	-1.1236
	(0.692)	*(0.677)*	*(0.689)*	*(0.676)*
Other				
Population (by State of origin, for each 10,000 inhabitants)	0.0007	0.0039	0.0011	0.0036*
	(0.003)	*(0.002)*	*(0.002)*	*(0.001)*
Distance to Distrito Federal (in km.)	0.001	0.0017	0.001	0.0016
	(-0.001)	*(0.001)*	*(0.001)*	*(0.001)*
Constant	167.1***	165.8***	166.9***	165.9***
	(1.115)	*(0.792)*	*(0.871)*	*(0.636)*
Observations	907	907	907	907
R-squared	0.0356	0.0222	0.0345	0.0212

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In conclusion, even though the data sources do not show a systematic error in terms of rounding or heaping, the explanatory power of the regression analysis is below the conventional standard observed in the literature. In order to increase this, and by using the present type of data source, a potential solution was to obtain more observations from the archives. By increasing the size of the sample, one of the main aims was to increase the size of the birth cohort sub-samples. Finally, in terms of the sample representativeness, for further research two options can be considered in order to obtain comparison groups. One would be to establish an archival search strategy that yields larger sub-samples by occupation and region. A second alternative would be to search for a sample not from the jail archive, but from a different source yielding a clearly different comparison group in terms of social class.

3.5.Data Sources to Be Used

Contrary to the present one, the remaining chapters detail the use of data from contemporary surveys that include anthropometric information. Surveys offer some advantages over historical data obtained from archives, for several reasons:

1. Measurement is becoming better and more standardised, meaning that measurement error is reduced and comparability guaranteed.
2. The statistical design of data collection methods enables the specification of – and, in several cases, access to – nationally representative information.
3. Contrary to historical periods, it is now more common to gain access to information for both males and females, as well as for other types of substrata such

as regions. This, then, makes it possible to conduct analyses in more detail, and to observe dynamics and make comparisons for a larger number of population strata.

4. Sample sizes are significantly larger and, therefore, estimations are more accurate.

With regard to primary sources, the remaining chapters use anthropometric data taken from nationally representative Mexican surveys, including the following:

a. Chapter 4. The data were obtained from cross-section surveys conducted in three different years: 2000, 2006 and 2012. All of them – the Mexican National Health Survey 2000 (MxNHS-2000), and the Mexican National Health and Nutrition Survey 2006 and 2012 (MxNHNS-2006 and MxNHNS-2012), include data on adult height. The MxNHS-2000 is a national probabilistic survey at household level that was conducted between September of 1999 and March of 2000.[81] This survey was conducted by the *Instituto Nacional de Salud Pública*. It was designed in order to obtain information on the accessibility, quality, coverage and use of health services. In addition, it includes information on hepatitis, and infectious and sexually transmitted diseases. Anthropometric measures such as height and weight are also captured.[82] While the survey was conducted in the 32 Mexican States, it is not representative at state level. The MxNHNS-2006 and MxNHNS-2012 are also national probabilistic surveys with sample designs similar to the one of the MxNHS-2000. Both

[81] The sample design of the survey is stratified and clustered.
[82] Individuals were measured using a stadimeter.

surveys were conducted by the *Instituto Nacional de Salud Pública*. The surveys are representative at national, urban and rural level and, contrary to the MxNHS-2000, are both representative of the 32 Mexican States. The collected data include information on the health and nutrition of the Mexican population. As in the case of the MxNHS-2000, the surveys include anthropometric measures such as height and weight.[83]

b. Chapter 5. The anthropometric data were taken from a longitudinal Mexican study. In particular, I used the first two waves of the *Mexican Family Life Survey* (MxFLS-1 and MxFLS-2). The MxFLS is a panel that includes economic, demographic and health information. It was designed by two Mexican academic institutions: *Centro de Investigación y Docencia Económicas (CIDE)* and *Universidad Iberoamericana (UIA)*. The design of the MxFLS uses probabilistic, stratified, multistage and cluster sampling, where the unit of observation is the household. The survey is representative at the national, regional, urban and rural level. The first round of the survey (MxFLS-1) was conducted in 2002 and the second (MxFLS-2) in 2005.

c. Chapter 6. The data for the analysis were taken from Vélez-Grajales, Stabridis and Minor, who built a single database by doing a simple matching exercise between two nationally representative data sources: the

[83] As in the case of the MxNHS-2000, individuals were measured using a stadimeter.

2011 ESRU Social Mobility Survey in Mexico (*Encuesta ESRU de movilidad social en México 2011*, ESRU-EMOVI 2011), and the aforementioned MxNHNS-2012. Adult height data were drawn from the latter. The ESRU-EMOVI 2011 is a nationally representative survey that was conducted by the Espinosa Yglesias Research Centre.[84] It was designed in order to analyse intergenerational social mobility in Mexico and includes information on respondents' socioeconomic characteristics. Additionally, this cross-section also includes retrospective information on parental household assets and services when the interviewee was 14 years old. In this way, the ESRU-EMOVI 2011enables the observation of wealth status for two generations: the interviewees' household (25-64 years old), and their parents' one (when the interviewee was 14 years old).

[84] The ESRU-EMOVI 2011 is available at http://www.ceey.org.mx (accessed 2/11/2015).

3.6. *Annex*

Table 3-10. 82 occupations for Manual and Non-Manual Categories

I. Professional-managerial	II. Proprietors	III. Routine nonman.	IV. Manual	V. Primary
A. Classical professions	*1. Proprietors*	*A. Sales*	*A. Craft*	1. Fishermen
1. Jurists		1. Real estate	1. Craftsmen , n.e.c.	2. Farmers
2. Health professionals		agents	2. Foremen	3. Farm laborers
3. Professors and		2. Agents, n.e.c.	3. Electronics service and	
instructors		3. Insurance	repair	
4. Natural scientists		agents	4. Printers and related	
5. Statistical and social		4. Cashiers	workers	
scientists		5. Sales workers	5. Locomotive operators	
6. Architects		*B. Clerical*	6. Electricians	
7. Accountants		1. Telephone	7. Tailors and related workers	
8. Authors and		operators	8. Vehicle mechanics	
journalists		2. Bookkeepers	9. Blacksmiths and machinists	
9. Engineers		3. Office workers	10. Jewelers	
B. Managers and officials		4. Postal clerks	11. Other mechanics	
1. Officials, govt. and			12. Plumbers and pipe-fitters	
non-profit orgs.			13. Cabinetmakers	
2. Other managers			14. Bakers	
3. Commercial			15. Welders	
managers			16. Painters	
4. Building managers			17. Butchers	
and proprietors			18. Stationary engine operators	
C. Other professions			19. Bricklayers and carpenters	
1. Systems analysts and			20. Heavy machine operators	
programmers			*B. Lower manual*	
2. Aircraft pilots and			1. Truck drivers	
navigators			2. Chemical processors	
3. Personnel and labor			3. Miners and related workers	
relations workers			4. Longshoremen	
4. Elementary and			5. Food processing workers	
secondary teachers			6. Textile workers	
5. Librarians			7. Sawyers	
6. Creative artists			8. Metal processors	
7. Ship officers			9. Operatives and kindred,	
8. Professional and			n.e.c.	
technical, n.e.c.			10. Forestry workers	
9. Social and welfare			*C. Service workers*	
workers			1. Protective service workers	
10. Workers in religion			2. Transport conductors	
11. Nonmedical			3. Guards and watchmen	
technicians			4. Food service workers	
12. Health			5. Mass transportation	
semiprofessionals			operators	
13. Hospital attendants			6. Service workers, n.e.c.	
14. Nursery school			7. Hairdressers	
teachers and aides			8. Newsboys and deliverymen	
teachers and aides			9. Launderers	
			10. Housekeeping workers	
			11. Janitors and cleaners	
			12. Gardeners	

Source: Jonsson, Grusky, Di Carlo, Reinhard, and Brinton, 'Microclass Mobility: Social Reproduction in Four Countries'.

Table 3-11. Occupational Categories: Convicts' Sample versus Mexican Census

Macroclass	**Convicts Database (Students were not included)**		**Census**	
	Total of observations	%	1970 [5]	1980 [5]
Professional managerial[1]	57	6.9%	19.8%	13.1%
Primary[2]	20	2.4%	39.4%	25.8%
Routine nonmanual[3]	253	30.4%	9.2%	8.0%
Manual[4]	502	60.3%	25.8%	23.8%
Total	*832*	*100.0%*	*94.2%*	*70.8%*

Source: Own estimations, INEGI: Estadísticas Históricas de México.

[1] Considers services and government classification occupations.

[2] Considers agriculture, livestock, forestry, fishing and hunting activities classification occupations.

[3] Considers commerce classification occupations.

[4] Includes transportation, building, generation and distribution of electric power, transformation industry, oil and extractive industry classification occupations.

[5] The percentages of occupations do not add up to 100% due to not specified classifications considered in the data. The information for INEGI refers to the population 12 years old and over.

4. Height as a Mirror of Inequality: The Hypotetical Mexican Kuznets Curve (1951-1992)

How has inequality changed in Mexico over the second half of twentieth century? The main purpose of the present chapter is to trace inequality in Mexico during the period 1951-1992.[85] As previously mentioned, in terms of population groups, changes in average height are negatively related to inequality. Kuznets contended that industrialisation is accompanied by a process of urbanisation. For his income distribution analysis, he assumes that income per capita and inequality would be lower for rural than for urban populations. Firstly, Kuznets suggests that once industrialisation starts, the urban population grows as a percentage of the total; therefore, inequality also grows. Secondly, relative differences between urban and rural income per capita do not necessarily decrease, meaning that inequality should increase even more. In fact, Kuznets found that inequality decreases.[86] An explanation of this result is that changes in factor productivity generate higher inequality during the first stages of industrialisation. However, in the subsequent periods, the spread of modernisation to a larger share of the labour force reduces those differences.

As mentioned in Chapter 2, urbanisation and industrialisation are related to several socioeconomic improvements such as income, education, healthcare and sanitation, with a positive impact on average height. However, other effects of urbanisation and

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[85] The present chapter is an extension of the work by López-Alonso and Vélez-Grajales, 'Measuring Inequality in Living Standards'.
[86] Kuznets, 'Economic Growth and Income Inequality'.

industrialisation such as unemployment, food shortages in cities, and consumption substitution effects can negatively affect average height.

In the case of Mexico, the process of urbanisation is more a twentieth century phenomenon. By 1878, only Mexico City had a population of over one hundred thousand inhabitants. By 1900, Guadalajara joined this standing. By 1940, six cities had populations of over one hundred thousand and one of them, Mexico City, had reached a population of over one million. Finally, by 1990, there were 78 cities with populations of over one hundred thousand people, and six of these had populations of over one million.[87] This urbanisation process took place in a country where the total population increased over 10 times in 140 years. In 1850, Mexico's total population was 7.5 million people. This number doubled by 1910, just before the civil war. By the end of the *Revolución*, the population was around 14 million (by 1921), but then increased again and reached 25 million people in 1950, and 81 million people by 1990.[88]

On the other hand, Mexico experienced a late industrialisation process. After the country's incipient industrialisation process was truncated by the *Revolución*, a more consolidated process began just after the Great Depression. 1940-1980 was a period of constant economic growth, which stopped due to the 1980s Mexican crisis. The country's process of economic growth was accompanied by improvements in education, life expectancy and poverty reduction. However, even though income inequality decreased, it remained high and regional differences persisted. Under this specific national context, the main objective

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[87] INEGI, 'Estadísticas históricas de México: Tomo II'.
[88] INEGI, "Estadísticas históricas de México: Tomo I".

of the present chapter is to observe the dynamics of adult average height in Mexico during the period of constant economic growth and the remaining decade after the 1982 economic crisis.

To do so, the *National Health Survey 2000* (MxNHS-2000) and the *National Health and Nutrition Surveys 2006* and *2012* (MxNHNS-2006 and MxNHNS-2012) were used to estimate a simple OLS model, in order to estimate average height for the period 1951-92. In terms of height series, the difference with respect to López-Alonso and Vélez-Grajales, is that including the MxNHNS-2102 enabled the extension of the height series for six additional years, up to 1992.[89]

Lopez-Alonso reports that Mexican male heights decreased constantly since the 1850s until the late *Porfiriato*, during which, after a short time of a positive trend among those that were born during the Mexican civil war (1910s), mean height stopped growing and decreased again among those that were born during the 1920s. It was only after the 1920s that average height increased again.[90] Since then, a constant positive trend has taken place, but as it will be shown for the studied period, a deficit with respect to other similar and developed economies still exists. In the case of females, Mexicans also show a height deficit.

This chapter is divided into five sections. Section one briefly described the existing long-term height series for Mexico. Section two presents the international context in terms of

[89] Ibid.
[90] Lopez-Alonso, 'Growth with Inequality'.

height. Next, the data sources for the post-1950 period are described, the quality of anthropometric data is analysed and height estimations are presented. In the fourth section, factors explaining the slow height improvements during the second half of the twentieth century are discussed. Finally, the chapter presents some conclusions and further research requirements.

4.1. Previous Long-Term Series for The Mexican Case

Previous to the contemporary estimations, which are based on national surveys, there were two long-term series on average height for adult males in Mexico. These series cover over 200 hundred years (c. 1730-1950).[91] Challú, in his study on the agricultural crisis and biological wellbeing, reports a series for the period 1732-1837. Data were taken from the soldiers' recruitment forms (*filiaciones*) found in the *Archivo General de la Nacion*.[92] López-Alonso, on the other hand, built a series for the period c.1850-1950.[93] Data were taken from the Mexican Army records and passport records from the archives of the Mexican Foreign Affairs Ministry. Here, only the trend on soldiers' estimated average heights is reported.

For Challu's study, there is a pronounced negative trend in heights during 1730-1840. He suggests that such a pattern can mainly be explained by climate factors and increasing

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[91] Challú, 'Agricultural Crisis and Biological Well-Being in Mexico'; Lopez-Alonso and Porras-Condey, 'The Ups and Downs'; Lopez-Alonso, 'Growth with Inequality'. For a case study on height for 18th century (in two localities of the Mexican State of Puebla), see Grajales-Porras and López-Alonso, 'Physical Stature of Men in Eighteenth Century Mexico'. For another case study on the 18th century central region of Mexico, see Dobado-González and Garcia-Hiernaux, 'Two Worlds Apart'.
[92] Challú, 'Agricultural Crisis and Biological Well-Being in Mexico'.
[93] Lopez-Alonso, 'Growth with Inequality'.

food prices. For a different region of the country and a shorter time span (1750s and 1760s), Dobado-González and Garcia-Hiernaux find as well a negative trend in average height.[94] However, and given the larger size of their sample (almost 20,000 individuals), it has to be noted that their estimations show that individuals were taller than those from Challu's study. For López-Alonso's study, the 1850-1950 period shows a W-shape trend. To explain this pattern, she argues that the benefits of economic growth during the *Porfiriato* (c.1880-1910) were not enjoyed by the bulk of the Mexican population (*labouring classes*). As a result, it was only after the end of the Mexican civil war (c. 1920) when the trend in average height became positive.[95]

4.2. The International Context

Regarding the second half of the twentieth century, data for two Latin American countries, Colombia and Brazil, are presented in Table 4.1. The average heights for females are available for Colombia. Brazil and Colombia, which are countries with some regional and economical similarities to Mexico, show an increase for both males and females of around 2 centimetres for the whole reported period. Both Brazilian and Colombian increases were not sufficient in order for them to converge to European levels. The extreme case is Denmark, where the 1980s males' generation is 13 centimetres taller than both youngest male cohorts of Colombians and Brazilians.[96] On the other extreme, Turkey shows the same average male height than these couple of countries.[97] In the case of Brazil, a former

[94] Dobado-González and Garcia-Hiernaux, 'Two Worlds Apart'.
[95] These series are mainly taken from Lopez-Alonso, 'Growth with Inequality'.
[96] A'Hearn, B., 'The Anthropometric History of the Mediterranean World'.

[97] Ibid.

colony of Portugal, the gap gets in favour of Portugal by almost 1.5 centimetres.[98] In the case of Colombia, a former colony of Spain, the gap gets in favour of Spain by 5 centimetres.[99] In the case of females, it is interesting to note how Colombian height almost stagnates during the 1960s and the first half of the 1970s. But, more importantly, the youngest female Colombians still show an average height deficit of more than 11 centimetres with respect to Dutch females.[100]

For a set of 15 European countries, Hatton and Bray report for the period 1951-1980 an average height increase per decade of 1.26 centimetres. In the case of Brazil and Colombia, such average was 0.72 and 0.80 centimetres, respectively (see last row of Table 4.1.). Moreover, for Portugal and Spain, the average increase per decade was of 1.73 and 2.53 centimetres, respectively.[101] Clearly, these two Latin American countries are not catching up to the European levels. The results presented for Mexico in the following sections will be analysed with regard to this international context.

[98] Ibid.
[99] Ibid.
[100] Data for The Netherlands is taken from Niewenweg, Smit, Walenkamp, and Witt, 'Adult Height Corrected for Shrinking'.
[101] Hatton, T. J. and Bray B. E., 'Long Run Trends in the Heights of European Men'.

Table 4-1. Trends in the Physical Stature of Adults during the Second Half of Twentieth Century, by Birth Cohort, Brazil and Colombia, 1950-1984

Birth Cohort	Brazil[1]	Colombia[2]	
	Males	Males	Females
1950-1954	168.18	167.84	156.4
1955-1959	168.52	168.07	156.81
1960-1964	168.93	168.47	157.17
1965-1969	169.29	169	157.34
1970-1974	169.87	168.91	157.21
1975-1979	170.23	169.66	157.81
1980-1984	170.71	170.64	158.65
Average increase per decade (cm)	0.72	0.80	0.64

Sources:
[1] Based on data provided by Leonardo M. Monasterio. See Leonardo M. Monasterio, Luiz Paulo Nogueról and
[2] Adolfo Meisel and Margarita Vega, 'A Tropical Success Story'.

4.3. Post-1950 Mexican Heights: Sources, Methods and Estimations

As already mentioned, a simple cross-section data source is sufficient for the purposes of conducting a longitudinal analysis. As mentioned in Chapter 3, for the present analysis three comparable cross-section surveys were used in order to construct adult height series for both males and females: MxNHS-2000, MxNHNS-2006 and MxNHNS-2012. The first two surveys were used by López-Alonso and Vélez-Grajales to estimate average height for the period 1951-1986. In this chapter, the MxNHNS-2012 is included in order to extend height estimations to 1992.

In this case, and due to the fact that in contemporary populations physical maturity is reached earlier than in pre-industrialised economies, heights were taken for those individuals who were at least 20 years old. Individuals older than 49 were excluded due to the high probability of the height shrinking process beginning to take place from this age onwards.[102] Once individuals were sorted by birth year, information was yielded with which to build a longitudinal series for males and females from 1951 to 1992. In order to control for age rounding and to obtain adequate sub-sample sizes, seven different cohorts composed of six birth years were used for the analysis: 1951-1956, 1957-1962, 1963-1968, 1969-1974, 1975-1980,1981-1986 and 1987-1992.[103]

In order to avoid double accountability, the MxNHS-2000 was used only to obtain data for the oldest birth cohort (1951-1956), the MxNHNS-2006 for the 1957-1962 cohort, and the MxNHNS-2012 for the remaining one, 1963-1992.[104] In the end, there were 14815 observations for males and 20721 for females (see Table 4.2). While López-Alonso and Vélez-Grajales proceed in a similar way, contrary to the present chapter their estimations take the MxNHS-2000 data for the oldest birth cohort and the MxNHNS-2006 data for the remaining birth cohorts up until 1986. As will be shown, the results in the present chapter coincide with the previous ones. In this way, the comparison between these two exercises validates the similarity and quality of the data.

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[102] Adults do not start to shrink exactly at the same age and, moreover, there is no strong evidence to argue that shrink rates shown by same-gender people are homogeneous. For more details on the human shrinking processes, see Bogin, 'Patterns of Human Growth'; Tanner, 'Foetus into Man'; Sorkin, C. Muller, and Andres, 'Longitudinal Change in Height'; and Niewenweg, Smit, Walenkamp, and Witt, 'Adult Height Corrected for Shrinking'.

[103] Less educated or older individuals (due to memory loss), tend to mis-report and usually 'round' their age. In surveys, it is not unusual to find a higher proportion of reported ages ending in five or zero: 20, 25, 30, 35, 40, and so on.

[104] Given the fact that the three surveys are nationally representative, and in order to correctly use the surveys' weights, it was decided not to mix the data when they were available in both surveys.

Table 4-2. Sample Sizes for Adults 20-49 Years Old, by 6 Years Birth Cohorts

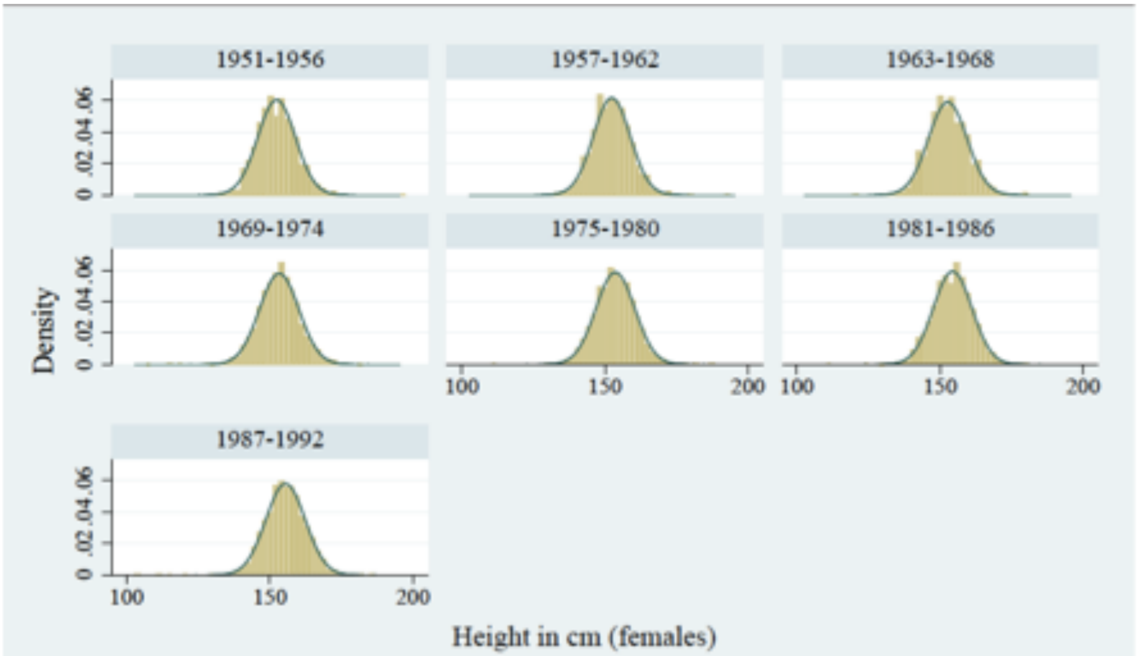
Birth Cohort	**Observations**	
	Females	**Males**
1951-1956	2,987	1,512
1957-1962	2,119	1,467
1963-1968	2,742	2,083
1969-1974	3,360	2,576
1975-1980	3,689	2,495
1981-1986	3,007	2,219
1987-1992	2,817	2,463
Total	20,721	14,815
Sources: Based on MxNHS-2000, MxNHNS-2006 and MxNHNS-2012		

Regarding quality, even when anthropometric data come from official national surveys, it is always necessary to check for this feature.[105] As found in the literature, an approximately normal height distribution is to be expected among homogeneous populations.[106] Therefore, prior to conducting any estimation, it is necessary to undertake a visual inspection of height histograms in order to check for shortfalls or any strange height distribution shapes.[107] Secondly, in order to tackle a second source of bias, potential rounding should also be analysed.[108] In the current case, firstly, no shortfalls were found.[109] Secondly, despite not all of the histograms matching perfectly in terms of the shape of the plotted normal distribution (line), there was no evidence of distributions skewed to the same side (see Figures 4.1 and 4.2). Also, no 'jump-falls' of frequencies

[105] As mentioned in Chapter 3, an excellent general guide for checking the quality of height samples can be found in Komlos, 'How to (and How not to) Analyse'.
[106] Baten, 'Economic Development and the Distribution'; Komlos, 'How to (and How not to) Analyse'; and Tanner, 'Foetus into Man'.
[107] Shortfalls are not expected for nationally representative samples, such as the ones used in the present study. Shortfalls are more common when measured individuals are subject to height requirements. Such requirements are usually found in military samples. Once a shortfall is found, it is necessary to control for the potential bias in the estimated average height. For more details on this type of problem and how to deal with it, see Komlos and Han Kim, 'Estimating Trends in Historical Heights'.
[108] As mentioned in Chapter 3, rounding height measures is also common. The problem arises when height rounding is not symmetric (for example, there is selectivity by social stereotypes). A good example of rounding problems is explained by Komlos, 'On the Nature of the Malthusian Threat'.
[109] Sample weights were applied to these histograms.

around similar measures were detected.[110] To sum up, there was no systematic bias identified for the whole set of cohorts.

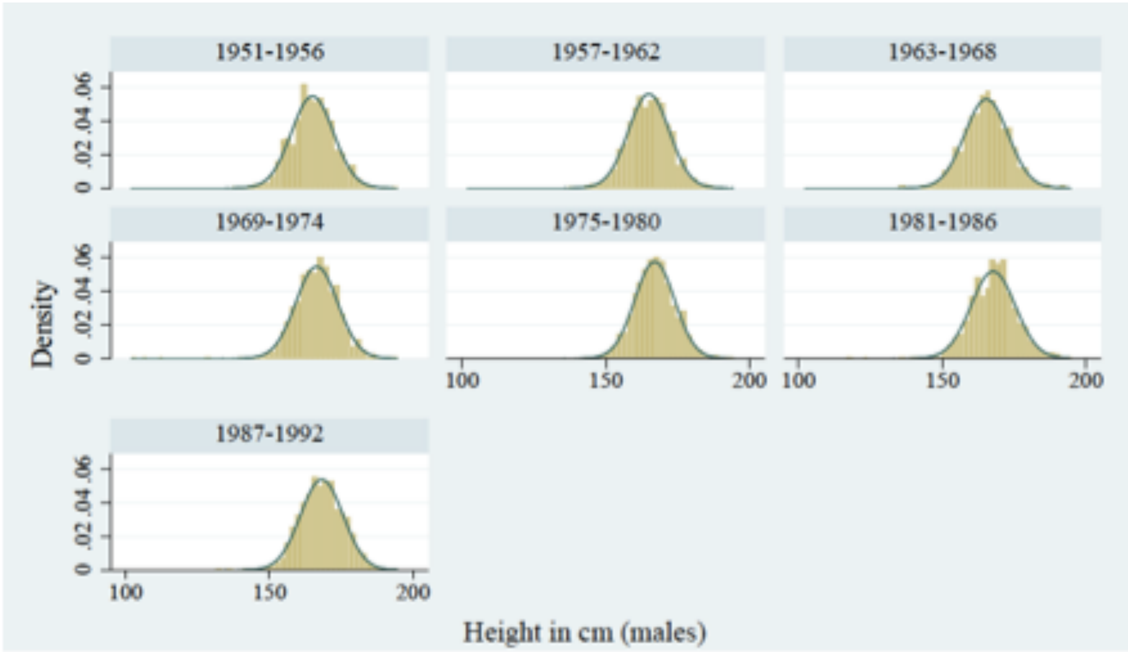
Figure 4-1. Histograms for Mexican Females, by Birth Cohort: 1951-1992



Source: see text.

[110] Statistical tests rejected normality for some distributions. The test was run using the command *sktest* of the statistical software STATA, Version 11.0. It was based on the combination of one test for skewness and another for kurtosis.

Figure 4-2. Histograms for Mexican Males, by Birth Cohort: 1951-1992



Source: see text.

In the case of rounding, the frequencies for the first decimal (millimetres) of the height records are presented in Table 4.3. As expected, the frequencies are higher for those measures ending in zero or five (the sum of these frequencies accounts for more than 30 percent). Strictly speaking, rounding is present. However, the frequency levels for both females and males do not show any serious problem. In fact, the frequency patterns are similar among females and males. It can, therefore, be concluded that height rounding was not a source of bias for the present analysis.

Table 4-3. Rounding in Adult Heights' Measuring

Last Digit	Females		Males	
	Percent	Cum.	Percent	Cum.
0.0	24%	24%	24%	24%
0.1	7%	31%	6%	30%
0.2	10%	41%	10%	41%
0.3	8%	49%	8%	49%
0.4	8%	57%	8%	57%
0.5	15%	72%	15%	72%
0.6	8%	80%	7%	79%
0.7	6%	86%	6%	86%
0.8	7%	93%	8%	94%
0.9	7%	100%	6%	100%

Sources: Based on MxNHS-2000, MxNHNS-2006 and MxNHNS-2012

Once the data quality was checked, a simple model of individual height determinants could be estimated in order to obtain predicted average heights for the period 1951-1992. Once birth cohort dummies were controlled for, the variables for education attainment and current residence were included as determinants of height (see Table 4.4). As reported, birth cohorts do not make a significant difference. However, the regression shows a negative and significant coefficient for females born in 1963-1974 (with respect to those born in 1951-1956). For education, higher levels result in taller individuals. Moreover, the effect of education is bigger for females. On this result, it has to be noted that average schooling years in Mexico increased from 2.6 in 1960 to 6.5 in 1990.[111] And finally, current urban residence results as well in taller individuals.[112] Such result suggests the existence of a rural penalty.

[111] INEGI, 'Estadísticas de Educación'.

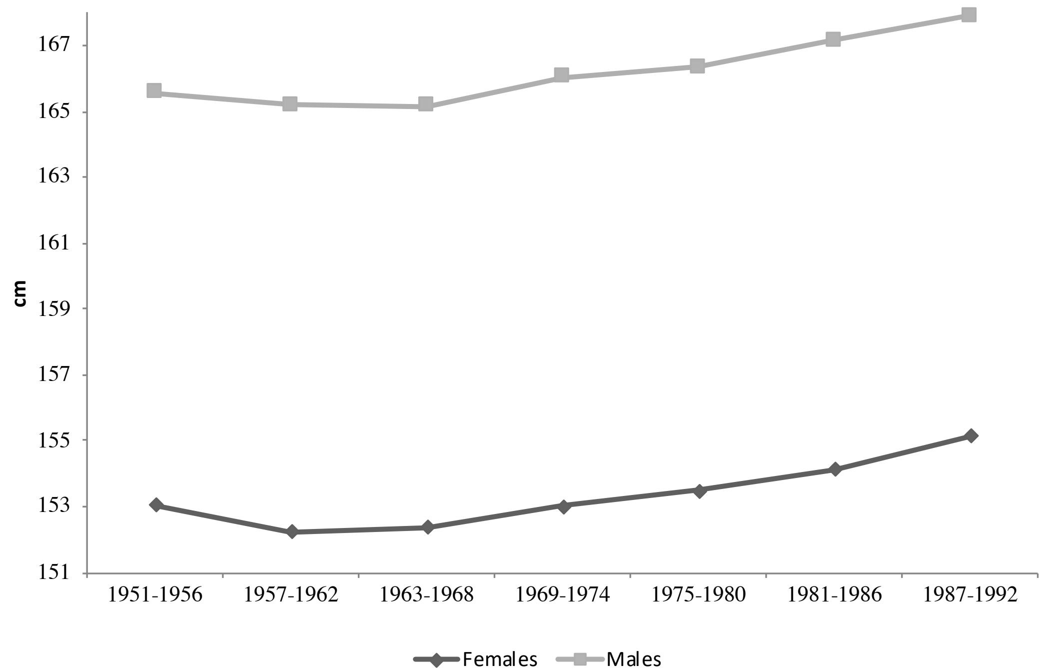
[112] In height estimation models, R^2s in regressions are always low. This happens because most of the variation in adult height is natural (genetic) and unexplained. Komlos and Lauderdale, 'Spatial Correlates of US Heights', p.63.

Table 4-4. Regression Results for Female and Male Heights

	Females	Males
Birth cohort		
1951-1956 (omitted)	…	…
1957-1962	-0.179	-0.083
	(0.196)	(0.286)
1963-1968	-0.649***	-0.411
	(0.187)	(0.275)
1969-1974	-0.453***	0.319
	(0.180)	(0.265)
1975-1980	-0.123	0.643**
	(0.177)	(0.270)
1981-1986	0.268	1.157***
	(0.187)	(0.277)
1987-1992	0.873***	1.641***
	(0.193)	(0.274)
Education		
Incomplete Primary	2.268***	1.767***
	(0.234)	(0.3745)
Complete Primary	4.374***	2.887***
	(0.224)	(0.359)
Secondary	5.399***	3.981***
	(0.228)	(0.360)
High School	6.957***	6.094***
	(0.238)	(0.371)
Bachelor	8.255***	7.160***
	(0.290)	(0.412)
Graduate Studies	9.208***	7.016***
	(1.056)	(1.087)
No school (omitted)	…	…
Current Residence		
Dummy for Rural (1)	-0.898***	-0.805***
	(0.109)	(0.149)
Intercept	148.926***	162.122***
	(0.244)	(0.394)
R-squared	0.104	0.080
N	19649	12797

Note: OLS regression.
* p<0.1, ** p<0.05, *** p<0.01
Standard errors in parentheses
Source: own estimations

Figure 4-3. Predicted National Height (in cm) by 6 Year Birth Cohorts, Mexico, 1951-1992 (National Surveys)



Source: Based on Table 4.5

Figure 4.3 shows both female and male height series. In both cases, after a stagnation process during the '50s and '60s, a constant and positive growth in height took place.

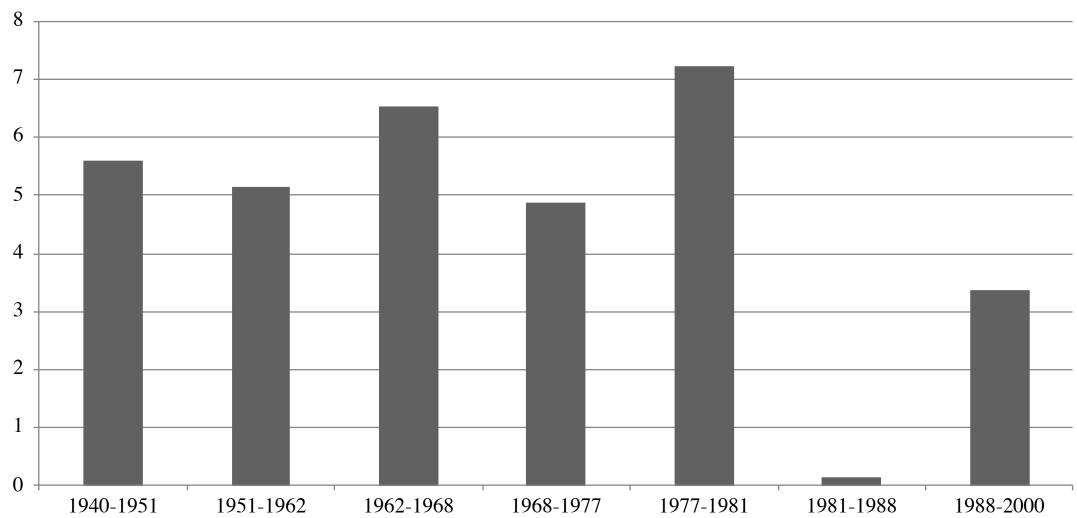
4.4.Discussion

After the Great Depression, an industrialisation process took place in Mexico. The country experienced a 40-year period of sustained economic growth. In particular, from the 1940s onwards, the country showed GDP annual average growth rates of over 4 per cent (see

Figure 4.4). It was not until the economic crisis in the 1980s that this positive trend stopped. As previously reported, heights also experienced a positive trend since the end of the 1960s. National improvements were not limited to economic growth. Life expectancy at birth, for example, grew from 34 years in 1930 to 49 in 1950, reaching 71 years by 1990.[113] In terms of education, the national literacy rate in 1950 was 64 per cent and reached 87 per cent by 1990.[114] In terms of population growth, the child-woman ratio (children per each 1000 fertile females) decreased from 725.6 in 1960 to 489.2 in 1990; reduced family size should have been good for human growth.[115] Finally, as Székely reports (see Figure 4.5), food poverty – one of the official government poverty lines during the 2000s – decreased in an important way during the 1960s.[116] On this matter, it is interesting to note that such decrease came before the increase on average height. In fact, such increase process happened at the time when food poverty stopped to decrease. On the other hand, the height increase coincides with a period of a constant decrease in the Gini index from 1963 to 1984 (see Figure 4.5).

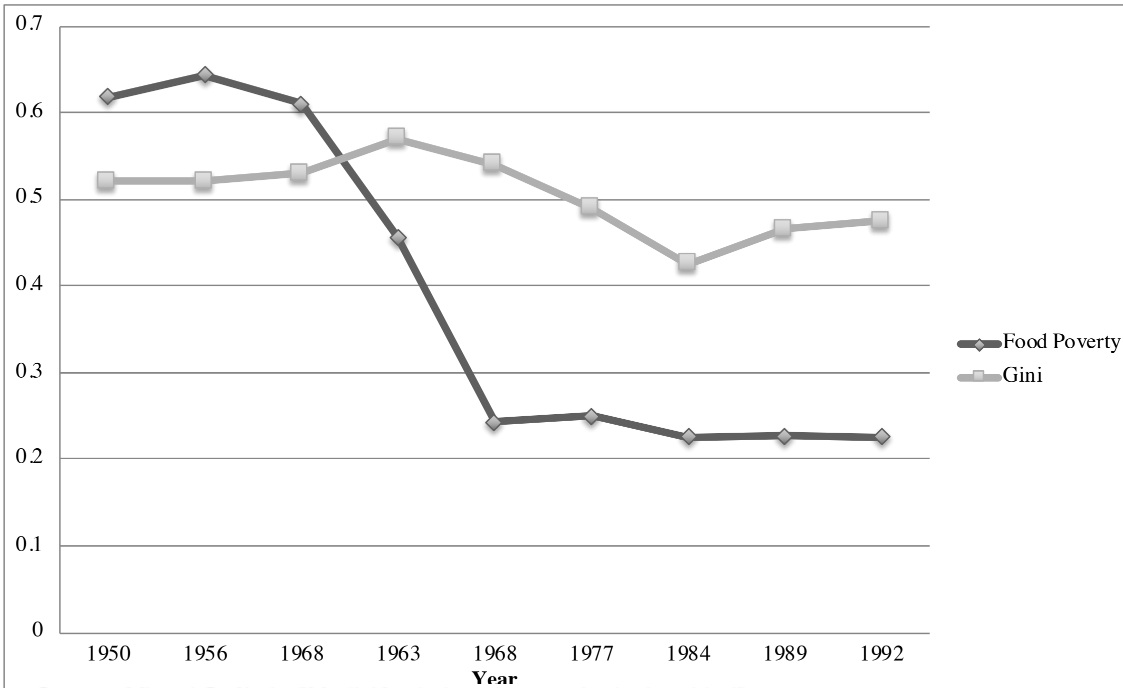
[113] INEGI, 'Indicadores sociodemográficos de México (1930-2000)'.
[114] PNUD, 'Informe sobre desarrollo humano 2002'.
[115] INEGI, 'Indicadores sociodemográficos de México (1930-2000)'.
[116] Székely, 'Pobreza y Desigualdad en México entre 1950 y 2004'.

Figure 4-4. Annual Average GDP Growth Rate, 1921-2000 (percentage)



Source: Graciela Márquez, "Evolución y Estructura del PIB, 1921-2010". In Sandra Kuntz Ficker (coord.), *Historia económica general de México. De la colonia a nuestros días*. El Colegio de México/Secretaría de Economía, 2010.

Figure 4-5. Poverty Proportion and Gini Index, Mexico, 1950-1992



Source: Miguel Székely, "Medición de la pobreza y la desigualdad"

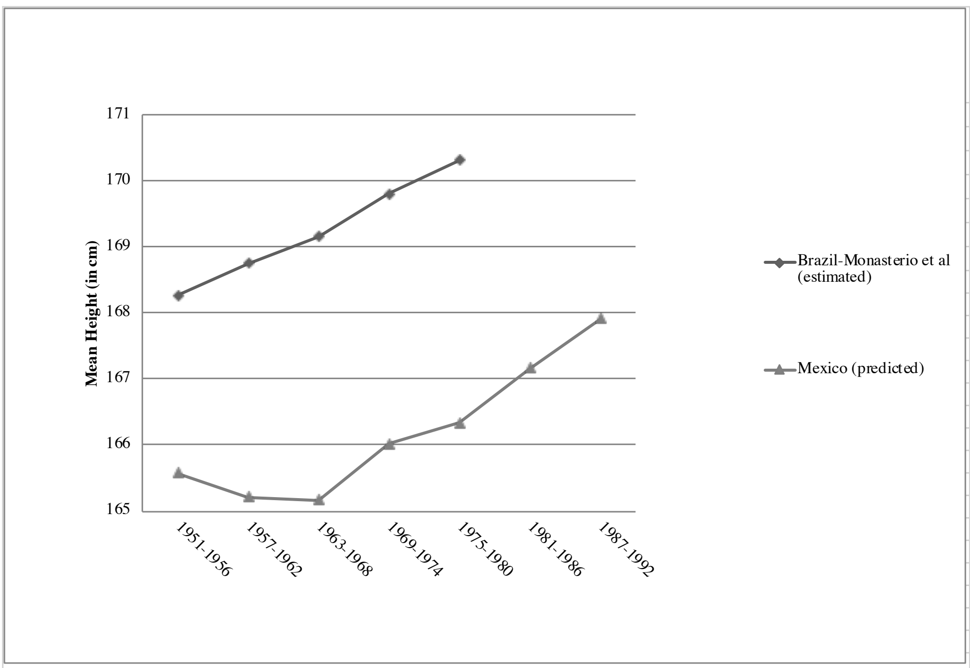
But how good was this performance? Was it sufficient for Mexico to converge or improve more than other countries' height levels? Here, a simple comparison is made with the afore mentioned two Latin American countries: Brazil and Colombia. As we can see in Figure 4.6, Brazilian males were, and still are, taller than Mexicans. In the case of Colombia, there are two possible sources for comparison. The first option is the average height presented in Table 4.1. In such case, both males and female Colombians were, and still are, taller than Mexicans. It has to be said, however, that such averages were estimated based on heights that were registered in national ID cards. The second option, on the other hand, are average heights estimated by Acosta and Meisel from a similar source than the ones used in the present chapter: the *2011 National Survey of the Nutritional Situation in Colombia*.[117] In such case, average heights for both males and females are very similar to the Mexican ones from early 1950s until early 1990s.

In the case of females, the youngest female Mexican cohort (1987-1992) shows a height deficit of 15.5 centimetres with respect to Dutch females.[118] In the comparison with European countries as the one presented for Brazil and Colombia in section 4.2, the Mexican youngest cohort is shorter than male Danes by 15.3 centimetres. Secondly, as a former colony of Spain, youngest Mexican males show a height deficit of 7.7 centimetres with respect to 1980s Spanish males' generation. Finally, it is important to note that males' average height increase per decade for the period of study was of 0.56 centimetres. Such

[117] Acosta, K and Meisel Roca, A., 'Diferencias étnicas en Colombia'.
[118] Data for The Netherlands is taken from Niewenweg, Smit, Walenkamp, and Witt, 'Adult Height Corrected for Shrinking'.

average is lower than the one for Brazil and Colombia (0.72 and 0.80 centimetres, respectively), and even much lower than the one for both Europe (1.26 centimetres) and Spain (2.53 centimetres).[119] In the particular case of the comparison with Spain, both the absolute difference and post 1950s rate of growth in average height is consistent with some other differences between these countries. As Dobado, Gómez-Galvarriato and Márquez explain, Spanish per capita income (PPP) more than double the Mexican one. Spain also shows significant better results for health and education results. Moreover, as these authors point out, income inequality is much greater in Mexico (Gini index of 0.5) than in Spain (Gini index of 0.3).[120] Clearly, Mexico is not a successful story at international level.

Figure 4-6. Adult Male Height Comparison: Brazil and Mexico, by Birth Cohort



Source: Mexico: own estimations; Brazil: Monasterio, Leonardo M., Luiz Paulo Ferreira Nogueról, and Claudio Djissey Shikida. "Growth and Inequalities of Height in Brazil, 1939-1981." In *Living Standards in Latin America History: Height, Welfare and Development, 1750-2000*, by Ricardo Salvatore, John H. Coatsworth and Amilcar E. Challu. Cambridge, MA: David Rockefeller Center Series for Latin American Studies/Harvard University Press, 2010.

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119 Data for European countries are taken from Hatton, T. J. and Bray B. E., 'Long Run Trends in the Heights of European Men'.

120 Dobado, R., Gómez-Galvarriato, A. and Márquez, G., 'Introducción'

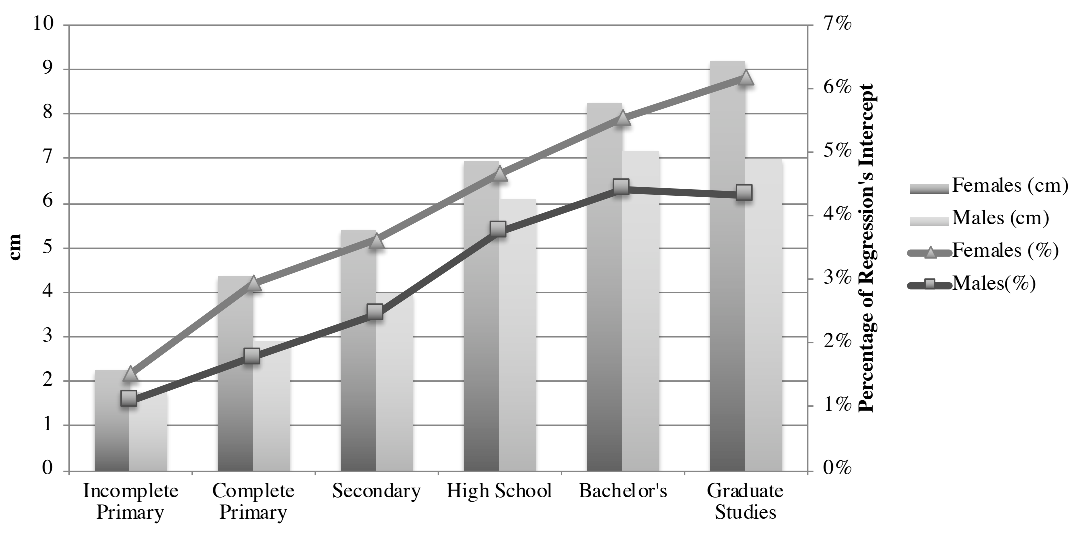
The explanation of the Mexican performance can be related to inequality. Despite the aforementioned improvement on income inequality during 1963-1984, such process was reversed during the 1980s and, by 1992, its level was still very high: 0.475 on the Gini index (Figure 4.5). Moreover, another type of inequalities stayed high in Mexico. That is the case at regional level. In 1950, the highest state GDP per capita was over six times higher than the lowest one. By 1990, this difference was reduced, but was still significant at a proportion of almost five to one.[121] In the case of literacy, in 1950 the highest state level rate was more than double the lowest one: 86 versus 39. By 1990, this difference had also decreased but still remained significant: 96 versus 70 per cent.

For the present analysis, it should be noted that the MxNHS-2000, MxNHNS-2006 and MxNHNS-2012 were not designed to obtain retrospective information. Moreover, they do not include origin information such as birthplace. Dimensions such as age, education and location are, however, commonly good predictors of adult height. As a result, the OLS regression for heights in Table 4.4 includes a set of dummy variables: birth cohorts, educational attainment and current rural-urban residence. The results show that socioeconomic differences, approximated mainly by the education and location variables, are reflected in heights. The estimation shows that both rural females and rural males are shorter by around 0.8 centimetres. Even more so, educational disparities exert a very significant difference. As can be seen in the columns of Figure 4.7, females with no schooling are shorter than those with incomplete primary education by 2.3 centimetres. This penalty reaches 9.2 centimetres when the comparison is made between the no

[121] Based on Esquivel, G., ‘Convergencia Regional en México’.

schooling and graduate studies groups. For males, the differences in both cases are 1.8 and 7 centimetres, respectively. While absolute differences are larger among females, these differences are even bigger when they are estimated in relative terms (lines in Figure 4.7). This result suggests that the socioeconomic inequality captured by school attainment differences is even more pronounced for females, but at the same time, that education returns were bigger for them. In such a matter, national statistics show that absolute increases in school attainment were more significant for females than for males. In 1970, 17% of 15-19 years old Mexican females (versus 26% of males) attained more than primary education. By 1995, such percentage reached 65.9% of 15-19 years old females (versus 66.3% of males).[122]

Figure 4-7. The Education Penalty: No Schooling versus Other Education Levels



Source: Based on Table 4.5

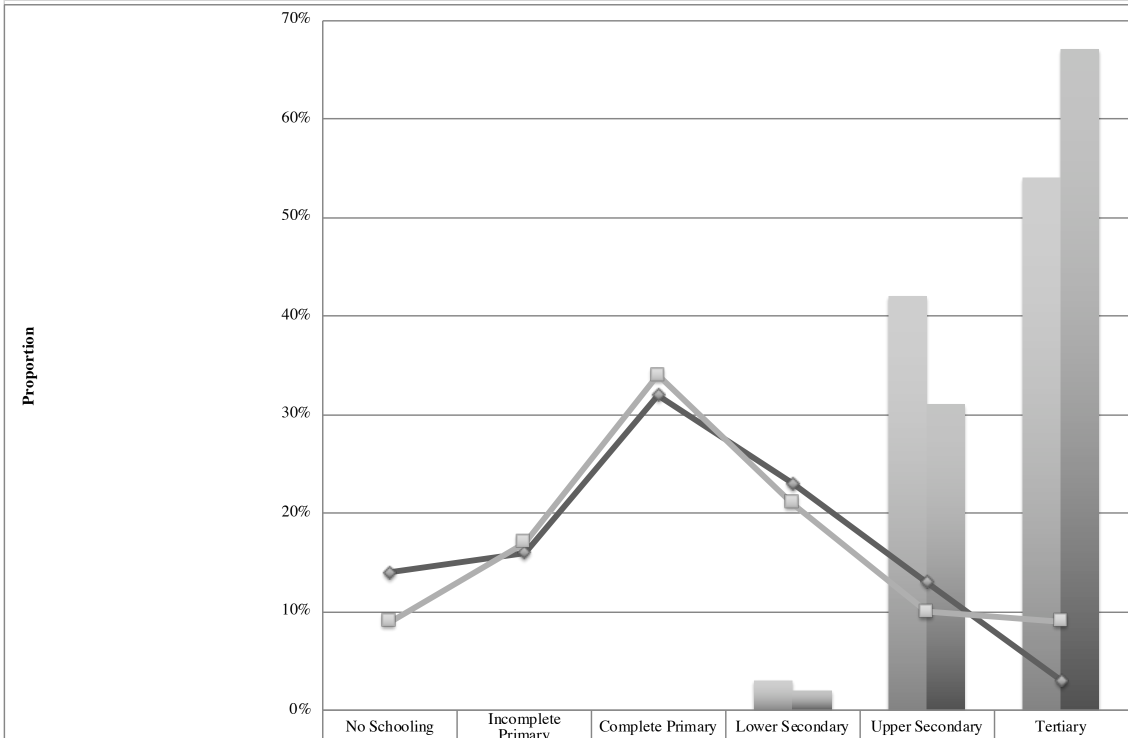
122 Parker and Pederzini, 'Género y educación en México'

The following question, however, remains: has Mexico been capable of tackling the schooling inequality problem? One way of measuring the effect of public policy on this matter is by estimating the intergenerational mobility of education, i.e., if individuals' educational achievement is correlated with their parents' level of education. As reported by Vélez, Campos and Huerta, '[e]ducational coverage has widened over recent decades, and absolute educational opportunities for the Mexican people have increased along with it. However, it becomes apparent that educational mobility in Mexico is limited at particular levels. For the first levels of education, primary and lower secondary school, socioeconomic origin has hardly any influence on achievement in higher levels of education. However, socioeconomic origin does affect achievement in upper secondary school and even more so in tertiary education'.[123] Moreover, as the estimations of intergenerational mobility presented in Figure 4.8 show, at the lower (lines) and higher (columns) ends of the spectrum, the probability of educational achievement conditional to the father's education level is lower for females than for males. These results suggest that the status quo, including gender inequality, has persisted in Mexico.[124] In particular, firstly, there exists a barrier related to socioeconomic origin that limits the options of reaching upper secondary/tertiary education for those coming from the lower end of the spectrum. Secondly, females coming from the lower end are less capable than similar males of overcoming this barrier. Thirdly, even females originating at the higher end of the spectrum show a lower achievement rate than males of the same group. Once these results

[123] Vélez Grajales, Campos Vázquez, and Huerta Wong. *Informe Movilidad Social en México 2013. Imagina tu futuro*, pp. 32-4.
[124] Ibid.

are translated into height trends, and given the social stratification characterising Mexico, it is easier to understand why the country's average height increases have been moderate.

Figure 4-8.Educational Attainment by Father's Education Level in Mexico, by Gender: Birth Cohort, 1947-1986



	No Schooling	Incomplete Primary	Complete Primary	Lower Secondary	Upper Secondary	Tertiary
Females (father with tertiary education)	0%	0%	0%	3%	42%	54%
Males (father with tertiary education)	0%	0%	0%	2%	31%	67%
Females (father no schooling)	14%	16%	32%	23%	13%	3%
Males (father no schooling)	9%	17%	34%	21%	10%	9%

Source: Data taken form Vélez Grajales, Campos Vázquez, and Huerta Wong. Informe Movilidad Social en México 2013. Imagina tu futuro

4.5.Conclusions

As an extension of the height estimations made by López-Alonso and Vélez-Grajales for the period 1850-1986, the present chapter analyses Mexico's height dynamics during the period 1951-1992. This exercise was conducted by estimating average height with a set of nationally representative surveys. The results show a positive height trend. This shape can be explained through the lens of the Kuznets curve, whereby four main processes were taking place in Mexico: (1) an urbanisation process that did not start until the twentieth century; (2) late industrialisation that was accompanied by constant economic growth during the period 1940-1980; (3) a reduction in poverty and inequality during the second half of the twentieth century; and (4) the significant reduction in the Mexican family size.

However, international comparisons show that Mexico was not a successful case in terms of average height. In particular, even though several socioeconomic improvements were experienced during the second half of the twentieth century, some barriers to wellbeing such as the proportion of the population living in food poverty and income inequality, remained high.

A positive trend in heights was found up until the end of the analysed period. However, a deficit with respect to other similar and developed economies still existed for both males and females. The positive trend on average height that happened since the 1960s was preceded by improvements in socioeconomic factors such as economic growth, life expectancy and food poverty. Such trend also coincides with income inequality reduction until 1984, and some other factors such as average school attainment. Observed higher education returns for females in the estimated heights' model can be related to more intense absolute improvements on school attainment and changes in population growth: child-woman ratio decreased during the period, meaning smaller families, less resource dilution, an improvement in gender-based intrahousehold distribution of resources, and perhaps healthier women. However, backwardness with respect to other economies can be explained as well by the size of the gap in height captured by the model in terms of school attainment differences. Moreover, in the case of Mexico, given that the composition of educational inequality has persisted across generations, social stratification has not been reduced. In the end, such characteristics translate into a poorer performance of Mexican average height.

5. The Height Penalty of Urbanisation: The Case of Mexico (1953-1982)

The previous chapter analysed the height dynamics for Mexico during the period 1951-1992. In terms of the historical context, three factors were highlighted: (1) a proper process of urbanisation that did not start until the twentieth century; (2) a late process of industrialisation, but which was accompanied by constant economic growth during the period 1940-1980; and (3) inequality remaining high despite such growth and the observed reduction in poverty. In terms of the height trend during the second half of the twentieth century, the results show a positive but not outstanding performance. In this context, one of the main characteristics of the post-WWII industrialisation process in Mexico was the resulting high concentration of the population around a few metropolitan areas. As a result, the main interest of the present chapter is to analyse the effects of urbanisation on height. For this purpose, the chapter focuses on the case of Mexico during the period c.1953-1982, just before the Mexican economic crisis.

As it was discussed in chapter 2, Komlos argues that urbanisation and industrialisation affect height positively through improvements in income, education, healthcare and sanitation. He also notices, however, there exist other economic disaggregate effects of such processes that have a potential negative impact on physical stature.[125] Among them he discusses potential negative effects of unemployment and underemployment, generalised food shortage in cities, and food substitution. For the case of Mexico, studies by Challú (c. 1730-1840) and Dobado-González and Garcia-Hiernaux (c. 1750s and

[125] Komlos, 'Shrinking in a Growing Economy?'

1760s) show the existence of an urban penalty on heights.[126] However, such result happens under a completely different economic and environmental context than the one of Mexico after mid 20th century.

In particular, in the present chapter it is argued that the agglomeration of population around metropolitan areas as a result of public investment in favour of industry and, specifically, in favour of Mexico City, slowed down the improvements in physical stature over the following decades. It could be assumed that internal migration would play a key role in balancing economic development. However, the few (or only one) urban options to migrate limited the positive effects of urbanisation on height, whereby the negative effects of the economies of overcrowding counteracted the benefits of industrialisation.

In the twentieth century, economic expansions caused by industrialisation processes were accompanied by massive migrations to the industrial centres. On one hand, the population concentration around a single or few metropolitan areas generated economies of scale that reduced the costs of several public services, such as healthcare and education systems. On the other hand, however, this high concentration generated several social costs. Firstly, population growth and increasing rural-to-urban migration left people subject to labour market cycles. As a result, unemployment and underemployment arose as two of the most serious problems in metropolitan areas. Secondly, the concentration of government action around urban areas left other regions unattended. Finally, the *side* effects of urbanisation

[126] Challú, 'Agricultural Crisis and Biological Well-Being in Mexico'; Dobado-González and Garcia-Hiernaux, 'Two Worlds Apart'.

such as higher stress, less physical activity and pollution had a potential negative impact on health.

The question can then be asked: does the urbanisation process show positive but decreasing marginal returns on average height? Mexico turns out to be a good case study with which to answer this. First of all, it was during the 1950s and 1960s when the Mexican government, through the reinforcement of an import substitution policy, promoted the consolidation of the country's industrialisation process. Secondly, along with such industrialisation process, the country experienced an epidemiological transition that was mainly carried out by universal vaccination. In such a way, it can be said that in the present analysis and contrary to those of previous centuries it is controlled for the potential effect of the disease environment on heights. Thirdly, it was also during this period when Mexico City became one of the biggest and most overcrowded cities of the world. Fourthly, Mexico is a member of the region that experienced the highest income inequality in the world during the second half of the twentieth century.[127] Finally, anthropometric, and both current and retrospective socioeconomic data, became available in the *Mexican Family Life Survey 2002 and 2005* (MxFLS-1 and MxFLS-2).[128]

[127] Deininger and Squire report that Latin America and the Caribbean has been the region with the highest Gini coefficient since the 1960s, with an overall decadal average of 0.50. In comparison, the countries classified as industrial countries and high-income developing show a decadal average of 0.34. Deininger and Squire, 'A New Data Set'. For the case of Mexico, Székely has estimated income Gini coefficients for several years during the period 1950-2004. In 1950, the coefficient was 0.52, and it was not until 1977 when it dropped below 0.5. Székely, 'Pobreza y Desigualdad'. In a previous study, Altimir argues that there is an underestimation of income in household surveys. After performing some adjustments, he reports that the Gini coefficient in Mexico was 0.606 for 1963 (0.53 with no adjustment), and 0.518 for 1977 (0.482 with no adjustment). Altimir, 'Income Distribution Statistics'.
[128] These data are available online at: http://www.radix.uia.mx/ennvih/ (Accessed 04/02/2008).

As mentioned in chapter 4, urbanisation in Mexico was a twentieth century phenomenon. The way in which this process took place, however, suggests an unbalanced pattern of development in the country. During the period, the population became more concentrated around Mexico City. Other cities such as Monterrey in the North, Guadalajara in the West, and Puebla in the Centre of the country also started to grow, but stayed far from the absolute increases experienced in the country's capital. As shown in Table 5.1, rural areas in 1950 had a higher population than urban ones. In that year, the share of the total population living in Mexico City was 12%, a number that also represented 28% of the total urban population. In 1970, however, the urban population came to represent 58% of the total, with Mexico City's share also higher – 19% with respect to the total and 32% of the total urban population.

Table 5-1. Shares of Urban and Rural Population, Mexico, 1940-1970

	1940	1950	1960	1970
Urban Population[1/]	35.1%	42.6%	50.7%	57.8%
Rural Population[2/]	64.9%	57.4%	49.3%	42.2%
Cities with more than 500000[3/]				
Mexico City	9.2%	12.2%	15.0%	18.6%
Monterrey			2.0%	2.6%
Guadalajara			2.1%	2.5%
Puebla				1.2%
Total	9.2%	12.2%	19.2%	25.0%

Source: Estimations based on data taken from: http://biblioteca.itam.mx/recursos/ehm.html#sector (13/04/2007)
1/ Population living in places with more than 2500 inhabitants.
2/ Population living in places with less than 2500 inhabitants
3/ Population of cities with more than 500000 citizens as percentage of total population. Mexico City refers to the whole metropolitan area.

As also mentioned in chapter 4, the industrialisation process that started after the Great Depression resulted in constant economic growth and significant improvements in several dimensions of living standards during the period 1940-1980. Such improvements were not necessarily widespread, nor even within metropolitan areas. In principle, increasing wages in industry (see Table 5.2) and changes in the composition of GDP in favour of manufacturing and against the primary sector (see Figure 5.1), could explain rural-to-urban migration.[129] However, wages in commerce – primarily an urban economic activity – did not show any significant increase and were almost caught up by GDP per capita in agriculture.[130] The attractiveness of metropolitan areas, particularly Mexico City, thus basically consisted of their relative advantage in terms of social and physical infrastructure.[131] For example, in 1950, the Human Development Index for Mexico City was 35% above the national level. In 1980, Mexico City still had an advantage of 15% with respect to the national level. In particular, for life expectancy at birth, in 1950 Mexico City was above the national level by almost 8 years (57 and 49 years, respectively). In 1980, such advantage was reduced, but it was still of 3 years (70 and 67 years, respectively.[132] In terms of public services, hospitals are a good example of the advantage of metropolitan areas and in particular of Mexico City. The Mexican Social Security

[129] In Graph 5.1, 'Other Economic Activities' includes mines, construction, and electricity, gas and water.

[130] While GDP per worker does not perfectly reflect what is happening with wage levels in agriculture, the positive trend shows that productivity (which also includes labour productivity) is increasing.

[131] The evolution of the national road system is a good example of Mexico City's superior physical infrastructure. The original interest in facilitating exports to the USA during WWII and, in general, the country's industrialisation, accelerated the construction of the main national roads. During this process, however, some regions remained isolated. In the 1940s, efforts were concentrated on building longitudinal trunk lines (North-South); in the 1950s, the government also started investing in cross-sectional ones (West-East). As a result, by the 1970s the system included four longitudinal and two cross-sectional trunk lines. While these six main roads were traced in distinct directions, they have something in common: all of them cross through Mexico City. In the end, 'all roads lead to Rome'. Angel Bassols Batalla, 'México, Formación de Regiones', pp.243-8.

[132] Both HDI and life expectancy at birth are obtained from PNUD, 'Informe sobre desarrollo humano 2002'. In a different approach that includes urbanization, number of medical doctors per each 10,000 inhabitants, enrolment rate and literacy rate, Campos-Vázquez, Domínguez-Flores and Márquez report an HDI at regional level for the period 1895-2010. In 1950, the HDI for Mexico City almost double the next region in the national ranking (Northeast). In 1980, such gap was reduced, but it was still significant. Campos-Vázquez, Domínguez-Flores and Márquez, 'Desarrollo humano en México a largo plazo'.

Institute (IMSS) was founded in 1943. By 1954 and as part of IMSS, the first hospital (*La Raza*) of tertiary care level in whole Latin America was established in Mexico City.

Table 5-2. Output and Wages per Worker by Sector, Mexico, 1940-1980

(USD at 1970 prices)

Year	GDP[1/]	GDP in Agriculture[2/]	GDP in Manufacturing[2/]	Wages in Industry[3/]	Wages in Commerce[4/]
1930	694	185	909		
1940	805	243	1583	846	611
1950	1111	309	1814	919	
1960	1463	429	1903	1040	640
1970	2140	577	2943	1343	583
1980	2552	603	3767	1396	642

Source: GDP, Agriculture and Manufacturing estimations are based on data taken from OxLAD. http://oxlad.qeh.ox.ac.uk/ (12/09/2006). Wages in Industry and Commerce estimations are based on data taken from *Encuesta Anual de Trabajos y Salarios Industriales* and *Censo Comercial y de Servicios from* http://biblioteca.itam.mx/recursos/ehm.html#sector (13/04/2007)

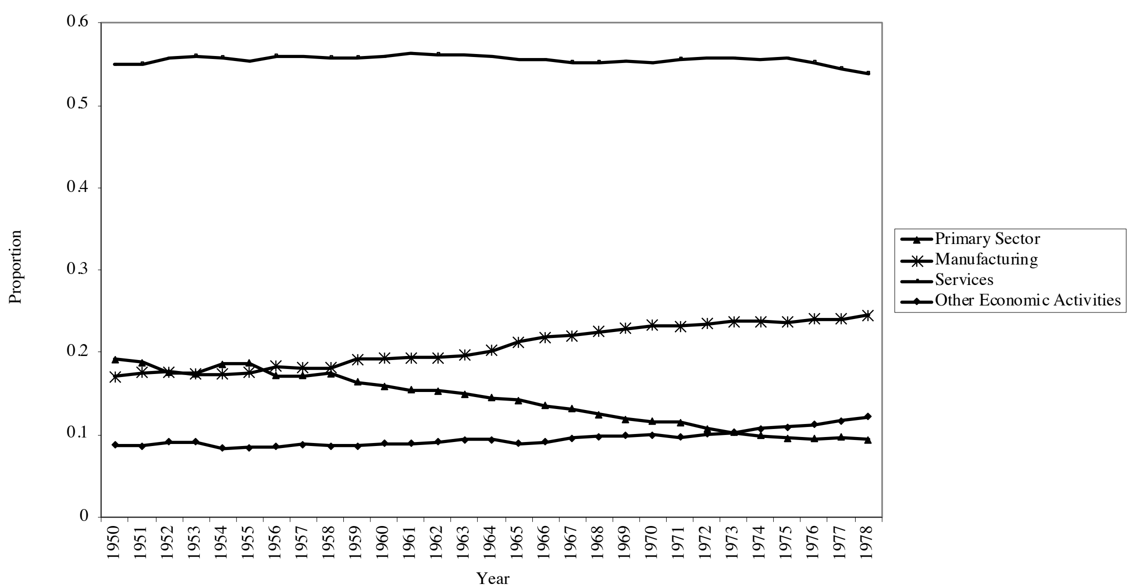
1/ GDP is divided by the Economically Active Population (EAP).

2/ Output of the sector is net of intermediate inputs (value-added). Total value-added is divided by the sector's estimated EAP.

3/ Original data are presented in mean weekly nominal pesos per worker. Data are converted into 1970 prices and multiplied by 52 to get annual values.

4/ Original data inlcude number of people working in commerce units and the total nominal pesos used for salaries during the year. Total value of wages is divided by the number of workers and converted into 1970 prices. Data do not include specific information on proportions of full-time and part-time workers.

Figure 5-1. GDP Composition by Economic Activity, Mexico, 1950-1978



Source: Estimations based on data taken from: http://biblioteca.itam.mx/recursos/ehm.html#sector (Accessed: 28/03/2007)

In order to test the hypothesis of positive but decreasing marginal returns on average height in Mexico, three simple ordinary least squares' (OLS) models were estimated. After controlling for factors like education attainment and individuals' fathers' first job, it was found that the size of the place of origin was positively correlated with both women's and men's heights. Also, by applying shares of urbanisation at state level, it emerged that urbanisation was positively correlated, but at a decreasing rate, with both women's and men's heights. This result suggests that urbanisation had a positive effect on heights but that, at the same time, there were costs that reduced the net effect of those benefits. This also suggests that part of the economic and social benefits of the high concentration of economic activity around metropolitan areas were overcompensated for by the negative effects of overcrowding.

The remainder of this chapter is divided into five sections. Section two presents the theoretical framework and analyses the potential effects of urbanisation and industrialisation on height. The third section describes the data sources and analyses their quality. Next, three models with which to analyse the influence of individual and local factors on height are proposed, and the results of these discussed in relation to the hypothesis of the costs of urban overcrowding. The final section discusses the conclusions and implications for future research.

5.1. Theoretical Framework

Livas and Krugman suggest that a low or high concentration of population and economic activity depend on the selection of trade policy. They argue that a policy oriented towards the domestic market (import substitution), plus the existence of economies of scale generates a 'self- reinforcing process of agglomeration' that overcompensates for the diseconomies of overcrowding (high costs of land and wages, pollution, etc.).[133] Basically, agglomeration occurs owing to two reasons: (1) population concentration facilitates firms' access to consumers; and (2) the establishment of plants in a single place reduces production and distribution costs. According to Livas and Krugman, increases in urban concentration continue until the economies of scale no longer compensate for the diseconomies of overcrowding.

Following Livas and Krugman, the present chapter argues that, assuming a controlled disease environment, urbanisation/overcrowding has a positive effect on height but, at the same time, with costs that reduce the net effect of these benefits.

The height function can be defined as follows:

$$H = H(UB, UC, Z) \qquad (1)$$

Where H refers to height, UB refers to urbanisation/overcrowding benefits, UC are the urbanisation/overcrowding costs and Z refers to all other height determinants. In

[133] Livas Elizondo and Krugman, 'Trade Policy', p. 5.

mathematical terms, the first derivatives of height with respect to the urbanisation/overcrowding benefits/costs are:

$$\frac{\partial H}{\partial UB} > 0 \text{ and } \frac{\partial H}{\partial UC} < 0 \tag{2}$$

The second derivative of height with respect to urbanisation/overcrowding benefits is:

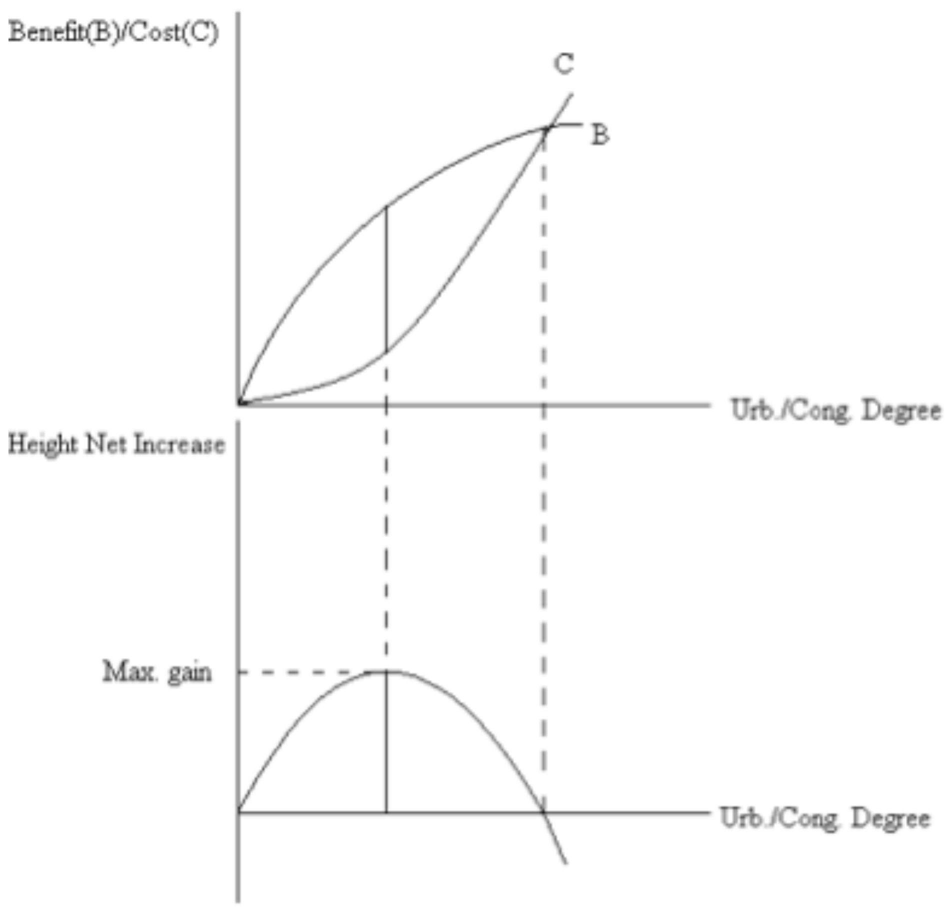
$$\frac{\partial^2 H}{\partial UB^2} < 0 \tag{3}$$

As Steckel contends in terms of the effect of income on height, there are no 'giants' among rich people.[134] In the case of urbanisation/overcrowding costs, while it is not clear if marginal changes are constant or increasing, the results from the pollution studies previously cited suggest the latter (see upper panel of Figure 5.2). As a result (even if it is assumed that the second height derivative with respect to urbanisation/overcrowding costs is null), net height increases due to urbanisation/overcrowding show an inverted-U shape relationship (see lower panel of Figure 5.2). There is an optimal urbanisation/overcrowding degree, where the difference between total benefits and total costs reaches its maximum. We cannot point out any specific potential level of maximum average height for Mexico, however, there are a couple of possible population references for the country: Mexican Americans and Spanish population. As mentioned in previous chapter, current male average height of Spanish population is well above the Mexican one.

[134] Steckel, 'Height and Per Capita Income'.

On the left side of the inverted-U, the total benefits of urbanisation can be seen to be growing more than costs. On the right side of the curve, however, the total costs start to reduce the maximum net benefit of urbanisation/overcrowding. Moreover, there is a degree of urbanisation/overcrowding where the benefits no longer compensate for costs and individual height becomes lower than the hypothetical, non-urbanised one. The shape of the inverted-U is, presumably, location specific; therefore, the resulting interest for regional development and policy implications lies in identifying where individual countries/regions stand with respect to maximum gain in the lower panel of Figure 5.2.

Figure 5-2. Theoretical Framework: Urbanisation/Congestion Degree vs. Height Increases



5.2.Data

As mentioned in Chapter 3, anthropometric data were taken from the first two waves of the *Mexican Family Life Survey* (MxFLS-1 and MxFLS-2). As previously stated, this survey is a panel representative one at the national, regional (see Table 5.3), urban and rural levels. The first round of the survey (MxFLS-1) was conducted in 2002 and included approximately 8,440 households. The second round (MxFLS-2) was conducted in 2005, included 7,572 of the original households (an attrition rate of around 10%), and added 866 new households.[135] The current analysis considers the single and not repeated measures for individuals in both rounds.

*Table 5-3. Regionalization of the Country**

South-Southeast	West-Centre	Centre	Northeast	Northwest
States Included in the MxFLS-1 and MxFLS-2				
Oaxaca	Guanajuato	Distrito Federal	Coahuila	Baja California Sur
Veracruz	Jalisco	Estado de Mexico	Durango	Sinaloa
Yucatan	Michoacan	Morelos	Nuevo Leon	Sonora
		Puebla		

Note: Mexico has 32 States. In the case of the MxFLS-2, there were also included Chiapas, Queretaro, Quintana Roo and Tamaulipas. However, for those four States there are only 23 observations. In the end, such observations are not included in the analysis.

As in Chapter 4, only adults who were between 20 and 49 years old at the time of being measured were included for the present analysis. It should be noted that 1982 was the last birth year used in the analysis. Therefore, 461 individuals between 20 and 22 years old from the MxFLS-2 who were born later were left out of the final sample. In addition, once the samples were selected by controlling for place of origin, 3.7% of individuals were

[135] Data and documents about the survey designs are available online at: http://www.ennvih-mxfls.org/ (Accessed 13/12/2011).

allocated in states not included in the sampling design of the survey. As a result, there was a small sample of 'leavers' with no counterpart of 'non-leavers' for those states. To avoid a migration bias, this sample was also excluded.[136] In the end, there were 5142 observations for males and 6816 for females, distributed across six birth cohorts composed of the following birth years: 1953-1957, 1958-1962, 1963-1967, 1968-1972, 1973-1977 and 1978-1982. The size of the sample was not significantly different to that of other studies making use of contemporary surveys. Komlos and Lauderdale, for example, conducted an analysis of the US with a survey sample from 2002 (the same year as the MxFLS-1), where 1524 males and 2903 females were divided into five birth cohorts of seven years each.[137]

Firstly, the quality of the data was analysed.[138] As the MxFLS is representative at national level, it was expected that there would be no shortfalls in the sample. In the specific case of the present chapter and contrary to the previous one, due to the fact that the MxFLS sample was smaller, the decision was made to analyse the sample both as a whole and individually for each birth cohort. Figures 5.3 and 5.4 present histograms by birth cohort.[139] None of the distributions show any shortfall. However, once a normal distribution is plotted over the histograms, it can be seen that the most frequent heights are not always located around the peak of the bell (around the mean of a normal

[136] The whole sample, including adults from states with 'leavers' but no 'remainer' counterparts, consisted of 7071 females and 5348 males.
[137] Komlos and Lauderdale, 'Spatial Correlates of US Heights'.
[138] Sample weights were not applied for the data quality analysis. In any case, the results with weights were similar.
[139] Weights were not applied for these histogram samples.

distribution).[140] Another evident characteristic of the sample consists of unexpected jumps or falls in the frequency of some heights.[141]

Figure 5-3. Histograms for Mexican Females, by Birth Cohort: 1953-1982

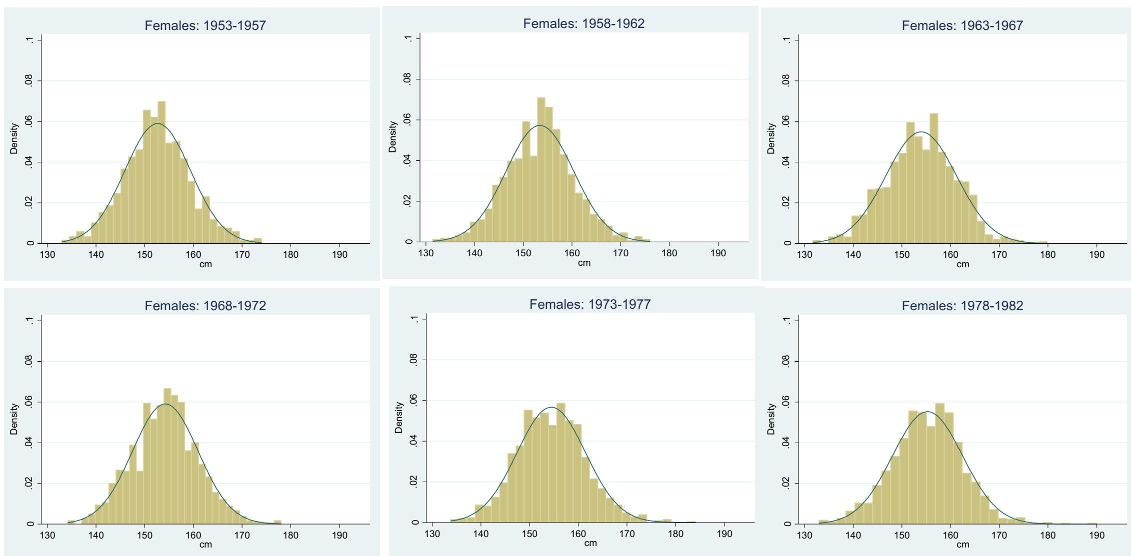
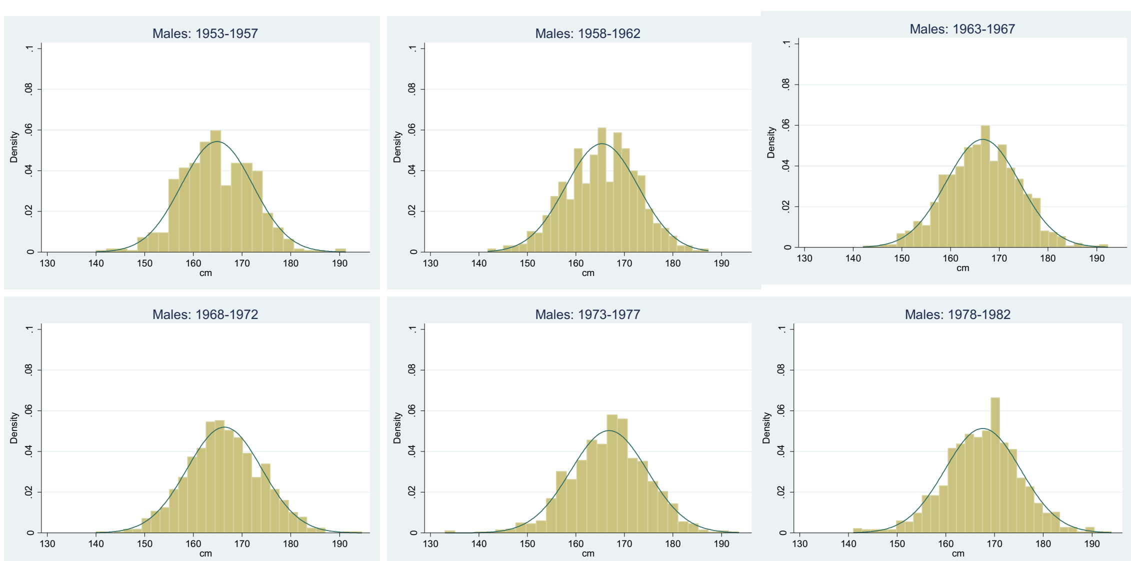


Figure 5-4. Histograms for Mexican Males, by Birth Cohort: 1953-1982



[140] In fact, as was to be expected from the visual inspection, the statistical tests rejected normality for all the distributions. The test was run using the command *sktest* in STATA statistical software, Version 11.0. This was based on the combination of one test for skewness and another for kurtosis.
[141] While birth cohorts are commonly used in anthropometric history studies, it is possible that individuals could misreport their age. One solution to this is to find a distribution with a high frequency of rounded ages, i.e., ages ending in five or zero. However, this problem was not present in the current survey.

One way of identifying a systematic error in the sample is to compare the distributions among birth cohorts. Firstly, as the results show, not all the distributions are skewed to the same side; and, secondly, the 'unexpected' jumps or falls in the frequency of some heights are not around the same measures for all birth cohorts. Therefore, even though almost 50% of the height measures end in zero or five (see Table 5.4), the rounding is symmetrical and not the result of any selection bias.[142]

Table 5-4. Rounding in Heights' Measurging

Last Digit*	Females			Males		
	Freq.	**Percent**	**Cum.**	**Freq.**	**Percent**	**Cum.**
0.0	2,409	35.3	35.3	1,841	35.8	35.8
0.1	454	6.7	42.0	326	6.3	42.1
0.2	611	9.0	51.0	466	9.1	51.2
0.3	465	6.8	57.8	350	6.8	58.0
0.4	444	6.5	64.3	344	6.7	64.7
0.5	963	14.1	78.4	712	13.9	78.6
0.6	428	6.3	84.7	306	6.0	84.5
0.7	334	4.9	89.6	241	4.7	89.2
0.8	435	6.4	96.0	331	6.4	95.6
0.9	273	4.0	100.0	225	4.4	100.0
Total	**6,816**	**100.0**		**5,142**	**100.0**	

* Refers to millimetres
Source: see text.

In conclusion, there was no significant evidence to argue for systematic errors in the data sample, making it unnecessary to correct for any bias. As a result, it can be said that height estimations for this sample (once the sample weights were applied) are representative of the Mexican population.

[142] It would be expected that each last digit captures 10 percent of the sample (there are ten different options: 1, 2, 3….9 and 0). If that were the case, the sum of measures ending in 0 or 0.5 should capture 20 percent of the sample. Sample weights were not applied for this exercise.

5.3. Empirical Strategy and Estimations

In a study on the US case, Komlos and Lauderdale analyse the effect of local environmental conditions on the biological standard of living on the population born between 1937 and 1983. Median income, unemployment rate, poverty rate and population density at the zip code geographical level are included as independent variables in their econometric analysis. The results show a significant and negative correlation of population density with height, even after controlling for individual socioeconomic characteristics (current income, education attainment, etc.), which also have potential effects on height.[143] In the present chapter, after controlling for individual characteristics and the potential benefits of urbanisation, the differences in population density are used to show whether the potential negative effects of urbanisation/overcrowding are significant or not in terms of the biological standard of living in Mexico. For that purpose, the exercise undertaken by Komlos and Lauderdale was replicated with some differences in the variables' definitions.

Least squares (OLS) regression estimations of height were estimated. As the main determinants of height, both individual and local conditions were included in the model. As an individual characteristic, information on the sector of the respondents' fathers' first job was included as an independent variable. When people in the survey were asked about their father's first job, it is probable that their answer referred to what first came to their mind: their father's job when they were children. In this case, their answers would reflect

[143] Komlos and Lauderdale, 'Spatial Correlates of US Heights'.

the household economic condition during the individual's period of physical growth. Education, which is mainly determined by family background (but also by local conditions), was also included as a height determinant. In terms of local conditions, two types of variables were included: (1) size of individual's place of origin, and (2) share of the urban population at state level, by birth cohort. In the case of the size of the place of origin, the survey respondents reported the type of place they were born in a: city, town, rural community, etc. It should be noted that the survey does not specify individuals' municipal place of birth (or the name of the city, town or community of origin). In the case of the share of urban population, information by birth cohort was included in order to capture the specific effect on height of the differences in local conditions not only across space, but also time.[144] In all estimations, birth cohort was controlled for. To sum up, three different models were estimated:

Model I: $H = H(Cohort, Edu, Fwork)$ (4)

Model II: $H = H(Cohort, Edu, Fwork, Dcity)$ (5)

Model III: $H = H(Cohort, Edu, Fwork, Urb, Urb^2)$ (6)

Where *Cohort* refers to dummies for birth cohorts, *Edu* denotes dummies for education attainment, *Fwork* refers to the sector of the work activity of respondents' fathers, *Dcity*

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[144] Ibid. Like Komlos and Lauderdale, in other estimations not reported here I also used the log transformation of population density (the state densities range from 0.97 persons per km^2 to 5954.87 persons per km^2), as well as the log transformation of GDP per capita and life expectancy at birth.

is a dummy for the size of individuals' place of origin, *Urb* refers to the share of urbanisation at state level (one share for each birth cohort by state), and Urb^2 is the square of the share of urbanisation.

Model I was estimated in order to capture the effect of predetermined individual characteristics on height. Model II, on the other hand, was estimated to identify if urbanisation has a positive effect on physical stature. Finally, Model III was estimated in order to test differences in the magnitude of urbanisation, as well as its potential effect un terms of the main study's hypothesis; i.e., that urbanisation has a positive but decreasing effect on height.

Model I

The regressions for individual characteristics are presented in Table 5.5. As can be seen, both women and men were found to be shorter when their father's first job was in agriculture (Column B).[145] Given the chosen definition of labour activity (agriculture vs. non agriculture), it is possible that the coefficient not only captured income effects, but some other urban-rural differences. Education also makes a difference, as those who received less formal education can be seen to be shorter. Women with no school attainment, for example, are shorter by 7 cm with respect to females who completed upper secondary school education (Column B).

[145] Jobs are classified as follows: (1) Agriculture: *campesino, jornalero rural* or *peon de campo*; (2) Non-agricultural worker: *obrero* or *empleado no agropecuario*; (3) Self-Employed or Employer: *trabajador por cuenta propia, patron, empleador* or *propietario de un negocio*; (4) Other: unspecified.

Table 5-5. Regression Results for Height as a Function of Individual Determinants

	Women A	Women B	Men A	Men B
Birth Cohort				
1978-1982 (omitted)	…	…	…	…
1953-1957	-0.31	0.49	-1.13**	-0.48
	(-0.96)	(1.25)	(-2.90)	(-0.89)
	(0.32)	**(0.39)**	**(0.39)**	**(0.54)**
1958-1962	0.12	1.09**	-0.70	0.24
	(0.41)	(2.97)	(-1.85)	(0.45)
	(0.30)	**(0.37)**	**(0.38)**	**(0.53)**
1963-1967	0.27	1.39***	-0.08	0.57
	(0.94)	(3.84)	(-0.22)	(1.09)
	(0.29)	**(0.36)**	**(0.36)**	**(0.52)**
1968-1972	0.28	0.91*	-0.44	0.31
	(1.01)	(2.56)	(-1.27)	(0.61)
	(0.28)	**(0.35)**	**(0.35)**	**(0.51)**
1973-1977	-0.19	0.95**	0.33	0.43
	(-0.70)	(2.59)	(0.95)	(0.81)
	(0.28)	**(0.37)**	**(0.35)**	**(0.53)**
Education				
Incomplete Primary	1.45***	1.63***	-0.89	-0.64
	(3.98)	(4.04)	(-1.47)	(-0.89)
	(0.36)	**(0.40)**	**(0.61)**	**(0.71)**
Complete Primary	3.28***	3.11***	1.29*	1.16
	(9.06)	(7.59)	(2.13)	(1.64)
	(0.36)	**(0.41)**	**(0.60)**	**(0.71)**
Incomplete Secondary	4.98***	4.68***	1.69*	1.32
	(9.97)	(8.26)	(2.42)	(1.59)
	(0.50)	**(0.57)**	**(0.70)**	**(0.83)**
Complete Lower-Secondary	6.01***	5.70***	2.60***	2.87***
	(16.71)	(13.75)	(4.34)	(4.00)
	(0.36)	**(0.42)**	**(0.60)**	**(0.72)**
Complete Upper-Secondary	7.02***	7.02***	4.84***	4.32***
	(15.98)	(13.56)	(7.43)	(5.47)
	(0.44)	**(0.52)**	**(0.65)**	**(0.79)**
Some Year of Tertiary	7.53***	6.56***	5.65***	5.08***
	(18.92)	(13.60)	(9.33)	(6.97)
	(0.40)	**(0.48)**	**(0.61)**	**(0.73)**
No School (omitted)	…	…	…	…
Father's First Work				
Non-Agricultural Worker		1.19***		2.03***
		(5.09)		(6.88)
		(0.23)		**(0.30)**
Self-Employed or Employer		1.08***		1.88***
		(3.47)		(4.75)
		(0.31)		**(0.40)**
Other		-1.24		4.42**
		(-1.21)		(2.85)
		(1.02)		**(1.55)**
Agriculture (omitted)	…	…	…	…
Intercept	148.89***	147.62***	163.40***	161.86***
	(392.77)	(323.31)	(266.42)	(204.74)
	(0.38)	**(0.46)**	**(0.61)**	**(0.79)**
R-squared	0.1155	0.1231	0.0938	0.1138
N	6,522	4,663	4,791	3,268

Note: Regression were estimated with STATA's OLS command. Analytic weights are applied.
* p<0.05, ** p<0.01, *** p<0.001
t statistics in parentheses; standard errors in parentheses and bold

It is interesting to note how relative height differences by school level are greater for women than for men. Schooling returns in terms of heights look like one of the main options for women to reduce gender gaps. On the other hand, however, not all females have the option to choose, given the fact that several intra-household decisions are still based on conventional role models. As a result, not all females are able to take advantage of such returns.

Model II

The results in Table 5.6 shows that to be born in a city has a positive and significant effect on height. Also, once the dummies for the father's first job were included (Column B), both women's and men's coefficients of school attainment remain significant. However, it is only in the case of men that the dummies for the father's first job stay significant. In general, these results suggest that in more urbanised areas, more people have access to public services, so it can be expected that such access positively impacts the net nutritional status. In the specific case of women, the fact that almost all of the dummies of the father's first job become insignificant once the city dummy is included, suggests that women's biological wellbeing depends, on average, more on local than on individual or family characteristics. The magnitude of the city dummy observed for females suggests that urban areas are places where women have more opportunities, i.e., labour market, healthcare, etc.

Table 5-6. Regression Results for Height as a Function of Individual and Local Determinants

	Women A	**Women B**	**Men A**	**Men B**
Birth Cohort				
1978-1982 (omitted)	…	…	…	…
1953-1957	-0.23	0.56	-1.01*	-0.29
	(-0.69)	(1.40)	(-2.54)	(-0.52)
	(0.33)	**(0.40)**	**(0.40)**	**(0.56)**
1958-1962	0.14	1.03**	-0.34	0.59
	(0.47)	(2.72)	(-0.86)	(1.08)
	(0.31)	**(0.38)**	**(0.39)**	**(0.55)**
1963-1967	0.41	1.34***	-0.01	0.79
	(1.40)	(3.60)	(-0.02)	(1.46)
	(0.30)	**(0.37)**	**(0.37)**	**(0.54)**
1968-1972	0.21	0.85*	-0.26	0.59
	(0.74)	(2.34)	(-0.72)	(1.12)
	(0.28)	**(0.36)**	**(0.36)**	**(0.53)**
1973-1977	-0.23	0.82*	0.36	0.61
	(-0.82)	(2.16)	(0.99)	(1.11)
	(0.28)	**(0.38)**	**(0.36)**	**(0.55)**
Education				
Incomplete Primary	1.23***	1.53***	-0.94	-0.74
	(3.32)	(3.69)	(-1.50)	(-1.00)
	(0.37)	**(0.41)**	**(0.63)**	**(0.75)**
Complete Primary	2.97***	2.99***	1.07	1.09
	(8.00)	(7.09)	(1.71)	(1.46)
	(0.37)	**(0.42)**	**(0.62)**	**(0.74)**
Incomplete Secondary	4.05***	4.12***	1.35	1.30
	(7.86)	(7.05)	(1.87)	(1.51)
	(0.52)	**(0.58)**	**(0.72)**	**(0.86)**
Complete Lower-Secondary	5.16***	5.30***	2.20***	2.68***
	(13.81)	(12.34)	(3.55)	(3.56)
	(0.37)	**(0.43)**	**(0.62)**	**(0.75)**
Complete Upper-Secondary	5.73***	6.12***	3.96***	4.13***
	(12.49)	(11.38)	(5.80)	(4.97)
	(0.46)	**(0.54)**	**(0.68)**	**(0.83)**
Some Year of Tertiary	6.18***	5.84***	4.70***	4.73***
	(14.66)	(11.63)	(7.41)	(6.16)
	(0.42)	**(0.50)**	**(0.63)**	**(0.77)**
No School (omitted)	…	…	…	…
Father's First Work				
Non-Agricultural Worker		0.29		1.71***
		(1.12)		(5.24)
		(0.26)		**(0.33)**
Self-Employed or Employer		0.34		1.37**
		(1.04)		(3.22)
		(0.33)		**(0.43)**
Other		-2.17*		4.37**
		(-2.08)		(2.78)
		(1.04)		**(1.57)**
Agriculture (omitted)	…	…	…	…
New Variables				
Dummy for city (1)	2.27***	2.22***	1.83***	0.90**
	(11.88)	(8.84)	(7.63)	(2.84)
	(0.19)	(0.25)	(0.24)	(0.32)
Intercept	148.62***	147.57***	162.95***	161.57***
	(381.18)	(314.56)	(255.87)	(195.73)
	(0.39)	**(0.47)**	**(0.64)**	**(0.83)**
R-squared	0.1322	0.137	0.105	0.1182
N	6,090	4,364	4,424	3,027

Note: Regression were estimated with STATA's OLS command. Analytic weights are applied.
* p<0.05, ** p<0.01, *** p<0.001
t statistics in parentheses; standard errors in parentheses and bold

Model III

A final model was estimated in order to test the hypothesis on the decreasing benefits of urbanisation due to the costs of overcrowding. Assuming that Mexico is still on the left side of the inverted-U presented in Figure 5.2, the expectation was that a positive coefficient would be obtained for the share of urbanisation and a negative one for its square.

As shown in Table 5.7, once all the variables of birth cohort, education and father's first job were controlled for, the coefficient for the share of urbanisation emerges as positive and significant. Secondly, the coefficient for the square of the share of urbanisation is significant and negative. For gender comparisons, once again, the magnitude of the effect of urbanisation is larger for females than for males. Moreover, the net positive effect (after the square of the share of urban population is included) stays larger for females.

In general, these results suggest, firstly, that the assumption of Mexico's position still being on the left side of the heights' growth curve (Figure 5.2) is correct, i.e., that Mexico is still below its total height growth potential. Secondly, the results support the urbanisation/overcrowding argument, i.e., assuming a controlled disease environment, urbanisation/overcrowding has a positive effect on height, but at the same time there are costs that reduce the net effect of those benefits. In any case, and in order to analyse Mexico's position along the inverted-U curve, further research is needed in order to confirm that there exists an optimal urbanisation/overcrowding degree, where the difference between the total benefits and total costs reaches its maximum.

Table 5-7. Regression Results for Height as a Function of Urbanisation and Individual Determinants

	Women	Men
Urbanization		
Share of urban population	24.69***	16.86***
	(7.96)	(4.12)
	(3.10)	**(4.10)**
Square of the share of urban population	-17.55***	-10.68**
	(-7.10)	(-3.28)
	(2.47)	**(3.26)**
Birth Cohort		
1953-1957	1.50***	0.44
	(3.69)	(0.79)
	(0.41)	**(0.56)**
1958-1962	1.65***	0.97
	(4.44)	(1.79)
	(0.37)	**(0.54)**
1963-1967	1.67***	1.05*
	(4.63)	(2.00)
	(0.36)	**(0.53)**
1968-1972	0.97**	0.52
	(2.74)	(1.02)
	(0.35)	**(0.51)**
1973-1977	0.92*	0.53
	(2.52)	(1.01)
	(0.37)	**(0.53)**
1978-1982 (omitted)	…	…
Education		
Incomplete Primary	1.22**	-0.76
	(3.03)	(-1.07)
	(0.40)	**(0.71)**
Complete Primary	2.57***	0.95
	(6.24)	(1.34)
	(0.41)	**(0.71)**
Incomplete Secondary	4.18***	1.03
	(7.38)	(1.24)
	(0.57)	**(0.83)**
Complete Lower-Secondary	5.02***	2.56***
	(11.92)	(3.57)
	(0.42)	**(0.72)**
Complete Upper-Secondary	6.45***	3.99***
	(12.43)	(5.06)
	(0.52)	**(0.79)**
Some Year of Tertiary	6.11***	4.76***
	(12.63)	(6.53)
	(0.48)	**(0.73)**
No School (omitted)	…	…
Father's First Work		
Non-Agricultural Worker	1.07***	1.78***
	(4.51)	(5.95)
	(0.24)	**(0.30)**
Self-Employed or Employer	1.05***	1.71***
	(3.35)	(4.30)
	(0.31)	**(0.40)**
Other	-1.36	4.17**
	(-1.34)	(2.69)
	(1.01)	**(1.55)**
Agriculture (omitted)		
Intercept	140.13***	156.06***
	(140.25)	(107.55)
	(1.00)	**(1.45)**
R-squared	0.1372	0.1227
N	4,663	3,268

Note: Regression were estimated with STATA's OLS command. Analytic weights are applied.

* p<0.05, ** p<0.01, *** p<0.001; t statistics in parentheses; standard errors in parentheses and bold

5.4.Conclusions

As mentioned in chapter 4, during the 1950s, 1960s and 1970s, socioeconomic indicators such as GDP per capita, life expectancy at birth and adult literacy rate improved in Mexico. The previous chapter demonstrated that average adult height experienced a moderate increase. The import substitution policy followed in the country during those years generated a high concentration of economic activity around the metropolitan areas. Evidence shows how public investment was, first and foremost, allocated to Mexico City. The latter also led the country during the whole period in terms of socioeconomic performance.

The current chapter presented an econometric analysis that included specific individual and local environmental conditions. Three models were estimated. In the first, it was shown that individual characteristics, such as higher levels of education attainment and individuals whose fathers worked in a non-agricultural sector of economic activity, positively impacted height. In the second model, a dummy for city as the place of individuals' origin was added to the first model. In this case, once the dummies for the father's first job and the dummy for the city were included in the same estimation, the coefficient of fathers' economic activity became insignificant. This result suggests that improvements in women's biological wellbeing depends, on average, more on local than on individual or family characteristics. Such a result reinforces the important role that accessibility to public services can play in order to reduce the gender gap.

Finally, model III tested the hypothesis on the decreasing benefits of urbanisation due to the costs of overcrowding. For the regressions, the decision was made to include the share of urbanisation at state level and its square as indicators of the high concentration of economic activity and population. After controlling for birth cohort, education level and the first work activity of respondents' fathers, the effect of urbanisation on height was found to be significant and positive, and significant and negative for its square. These results support the proposed hypothesis, i.e., that urbanisation/overcrowding has a positive effect on height, but that at the same time there exist costs that reduce the net effect of those benefits. For the gender analysis, the difference in magnitude of the coefficients related to urbanisation shows that urban areas are opportunity places to reduce the gap.

The main contributions of the present chapter are twofold. Firstly, and related to the original interest of the study, results show that an unlimited concentration of economic activity and population is not optimal in reducing inequality and to improving human wellbeing. The results of the present analysis suggest that the 'self-reinforcing process of agglomeration', explained by Livas and Krugman, was not the best alternative with which to generate a balanced improvement in the Mexican population's biological standard of living. However, a second result arises from the regression analysis: urbanisation and its related effects on more and better public services and labour opportunities, show a positive and larger effect for females.

Some public policy lessons can be obtained.[146] An important one is that even the concentration of population and economic activity around one or a few metropolitan areas generates costs of overcrowding, with negative effects on citizens' biological wellbeing, urban areas impact positively and potentially reduce inequalities such as the gender ones. It also has to be noted, however, that an agglomeration strategy does not ensure the reduction of differences in standard of living within a country or region, even when people decide to migrate to the most developed areas.

The current analysis has some limitations. First of all, while the share of urbanisation at state level perfectly reflects the concentration in Mexico City, it is unable to capture differences between the citizens of different cities in the same state. Secondly, as a period of 30 years was analysed, it was thus not possible to capture inter-generational changes. Social patterns, such as the selection of children's diet, should not differ entirely between two immediate generations, even when a family migrates. If that is the case, not all changes in the local environment will affect adult children's height.

[146] *Op cit*.

6. Height and Socioeconomic Status in Mexico (1962-1986): Who is Moving Up and Down the Social Ladder?

Stern has argued that analyses on health inequalities among social strata have focused more on the relationship between some proxy of health condition and socioeconomic achievement, but less on the relationship between this condition and socioeconomic origin.[147] Therefore, by taking this argument into account, the aim of the present chapter is to analyse both relationships in terms of nutritional status. In this way, a variable such as adult height, which is mainly determined during childhood-adolescence, is expected to be correlated with socioeconomic origin and achievement. In particular, it is argued that socioeconomic origin determines net nutritional status (adult height), and that this status, in turn, determines socioeconomic achievement.

As mentioned in the first few chapters, adult height is a variable that refers to a net output mainly determined by natural and environmental (socioeconomic) conditions during early childhood and adolescence. For its part, the relationship between socioeconomic origin and achievement is mainly discussed in the literature on social mobility. In particular, intergenerational social mobility can be defined in relative terms, i.e., the relative change experienced with respect to the position that was occupied in the reference period.[148] Therefore, in order to measure intergenerational mobility, it is necessary to obtain information on an individual's position on the socioeconomic ladder at two different

[147] Stern, 'Social Mobility and the Interpretation of Social Class Mortality Differentials'.
[148] Erikson and Goldthorpe, 'Trends in Class Mobility. The Post-War European Experience'.

moments in life: origin (childhood-adolescence/socioeconomic origin) and destination (adulthood/socioeconomic achievement).

Most social mobility indicators in the literature are built using the variables of education, occupation and wealth. Depending on the selection of variables, these dimensions are not only output indicators, but determinants of social mobility in themselves. Among them, education has been proposed as one of the main potential drivers of upward mobility. This is the case because modern states have built national education systems that can be used as a redistribution mechanism and can, therefore, increase individuals' mobility options. However, there exist other potential mobility drivers that should be analysed, of which nutritional status is one.

In contemporary societies, universal vaccination is guaranteed and the Malthusian trap, in general, is no more. Conversely, social inequalities are still significant and their composition, furthermore, persists across generations.[149] As a result, and as Krueger proposed through the 'Great Gatsby Curve' analogy, a resulting lower rate of social mobility can be observed in more unequal societies.[150] On this matter, former US President, Obama, claimed that '[t]he combined trends of increased inequality and decreasing mobility pose a fundamental threat to the American Dream, our way of life, and what we stand for around the globe.'[151] In light of these observations, the dynamics

[149] PNUD, 'Informe Regional sobre Desarrollo Humano para América Latina y El Caribe 2010.'.
[150] Krueger, 'The Rise and Consequences of Inequality in the United States'.
[151] Obama, 'Remarks by the President on Economic Mobility'.

of the relationship between socioeconomic status and nutritional status have become crucial to identifying the sources of success or socioeconomic failure.

Krzyzanowska and Mascie-Taylor report that '[i]n general social mobility studies show that upwardly socially mobile individuals are, on average, taller and heavier than the non-socially mobile, while the downwardly socially mobile are, on average, shorter'.[152] The current chapter engages with two issues related to this statement. Firstly, the dynamics of the relationship between nutritional status and socioeconomic origin/achievement are analysed. Secondly, net nutritional status for the type of intergenerational mobility experienced is examined.

If it is assumed that nutritional status is endogenous to the socioeconomic dynamics of population groups, then it can be argued not only that nutritional status is determined by socioeconomic origin, but also that such a status is a determinant of individuals' socioeconomic achievement. On this matter, Cliquet argues that '[e]ven if social mobility is correlated with differences in anthropological variables this does not tell us the causes of the relationship between the social and the biological variability in a population. It does not explain social mobility either'.[153] It should, therefore, be noted that the results presented in the current chapter will not disentangle the factors behind this relationship but will, at least for very recent Mexican history, establish direction or causality.

[152] Krzyzanowska and Mascie-Taylor, 'Intra- and Intergenerational Social Mobility in Relation to Height, Weight and Body Mass Index in a British National Cohort', p. 612.
[153] Cliquet, 'Social mobility and the anthropological structure of populations', p. 17.

For the analysis, adult height for Mexican adults born during 1962-1986 was used as the proxy for net nutritional status. Socioeconomic origin/achievement was estimated using a wealth index built with a set of assets and household services identified at two moments in the aforementioned adults' lives: childhood-adolescence (their parents' households) and adulthood (current own households). To obtain this type of data from a single database, a simple matching exercise was undertaken for two different nationally representative surveys: the 2011 ESRU Social Mobility Survey in Mexico (*Encuesta ESRU de movilidad social en México 2011*, ESRU-EMOVI 2011) and the 2012 Mexican National Survey on Health and Nutrition (*Encuesta nacional de salud y nutrición 2012*, MXNHNS-2012). The ESRU-EMOVI 2011includes both current and retrospective information on assets and household services. The MXNHNS-2012 contains data on current assets/services for households and adult respondents' height.

Mexico, in the period 1962-1986, may be seen as a good case study for this kind of analysis. Firstly, as evidenced in all previous chapters, covering this period of study will fill the gap on recent Mexican anthropometric history. Secondly, to my understanding, there are no other studies on the case of Mexico using the approach proposed in the present chapter. The insights gained here will, therefore, not only fill the gap in the case of Mexico, but also in that of the relevant literature on Latin America. Finally, as mentioned in previous chapters, Mexican society was characterised by two factors during the period under study: positive trends in both economic growth and adult height, which could be observed during almost all of the years covered, but with a height increase that was not good enough to converge to the levels of other, similar economies. In order to understand this pattern, two dynamics were discussed: the persistence of high inequality and the potential effects of the country's industrialisation-urbanisation process.

For the present case, two econometric models were used for the analysis. The first estimated an OLS for heights. Origin and predetermined conditions, such as parents' wealth index and education, were included as explanatory variables. Controls such as birth cohort and urban-rural location were also included. In the second stage of the analysis, an ordered probit model was estimated for socioeconomic achievement, measured by current wealth index categories. The regression run to explain relative achievement included the predicted value of height from the OLS regression, thus controlling for endogeneity.

The results show a positive and significant effect of socioeconomic origin on height: on average, it was found that wealthier parents produce taller children. Secondly, even though height increases could be observed across the whole socioeconomic ladder, the differences between socioeconomic groups persisted. Thirdly, and once potential endogeneity was controlled for, the results of the ordered probit analysis showed a positive effect of height on relative socioeconomic achievement, i.e., that tallness increases the probability of reaching upper relative positions and reduces that of descending to lower ones.

The previous results were yielded in a context of low rates of intergenerational mobility, i.e., where the probability of moving out of one's original position (tercile, in the present case) was low. Economic growth was positive, and the highly correlated variables of net nutritional status, such as food production or food poverty, also demonstrated good performance. There was, therefore, the expectation of observing a reduction in the height differences among the socioeconomic strata, at least. However, these differences persisted. This result is consistent with the income distributional dynamics observed during both the origin and socioeconomic achievement periods. A vicious circle can thus be identified: the origin gap between socioeconomic groups translates into height inequality which, in turn, is reflected in high and constant levels of inequality of socioeconomic achievement, i.e., in Mexico, the socioeconomic status quo persists across generations.

The remainder of this chapter is divided into eight sections. Section two presents a review of the literature on the relationship between height and socioeconomic status of origin and destination. Section three describes the data sources, followed by the methodology in section four. In the fifth section, the empirical strategy is proposed and definitions of the two main variables of the analysis, socioeconomic status and height, discussed. Next, the results are presented in section six and discussed in terms of the historical context in section seven. Section eight concludes the chapter.

6.1.Literature Review

Cliquet identifies three different ways of analysing 'biological variation' in the literature according to socioeconomic status: (1) by socioeconomic origin (parents' status); (2) by socioeconomic destination (achievement during adulthood); and (3) by social mobility, i.e., 'change in socioeconomic status from one to another generation'.[154] For the first two

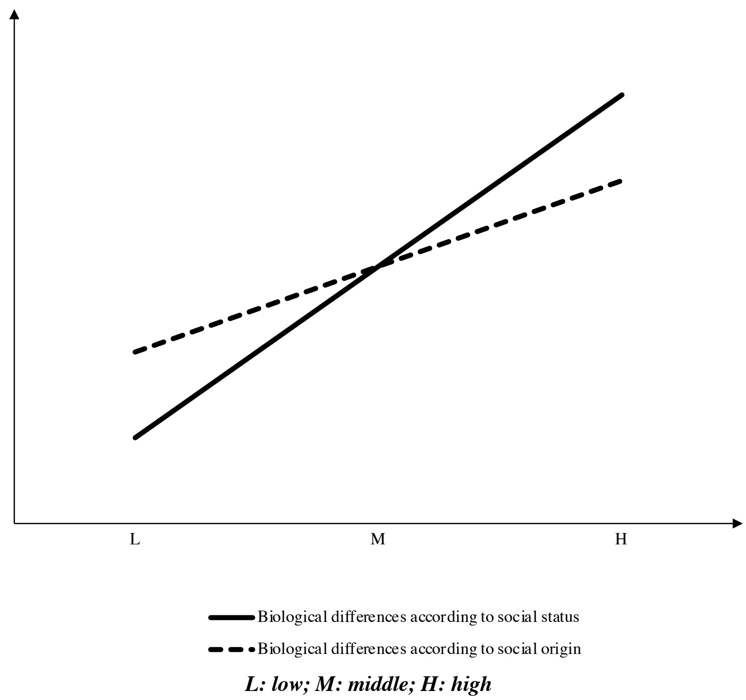
[154] Cliquet, *Biosocial Interactions in Modernisation*, p. 398.

cases, he argues that evidence shows a positive correlation. He also suggests, as shown in Figure 6.1, that the slope of the biological variation-socioeconomic condition relationship is steeper for achieved socioeconomic status than for origin. Most of the evidence for case one can be found in the economic history literature. With regard to case two, the economics literature has focused more on the matter.

Studies of economic history can be found in the so-called biological standard of living literature tradition. One of the main objectives of this body of literature is to explain the influence of the environmental/socioeconomic context on height. In his paper on height and social status in eighteenth-century Germany, Komlos argues that '[b]iologists have shown that the mean stature of a population of constant ethnic mix depends on food consumption net of such claims on the nutrients as work effort and the incidence of diseases. Because intake, in turn, depends on real income and because income correlates positively, and work intensity negatively, with socioeconomic status, human stature should be a good indicator of wellbeing and should also correlates positively with social status'. [155]

[155] Komlos, 'Height and Social Status in Eighteenth-Century Germany"', p. 609.

Figure 6-1. Schematic Presentation of Biological Differentials According to Social Status and Social Origin



Source: Robert Cliquet. *Biosocial Interactions in Modernisation*. Brno: Masaryk University Press, 2010.

Evidence shows a positive correlation between height and socioeconomic origin. A groundbreaking dataset used by Floud and Wachter, for example, demonstrates that boys from London's lower social classes who were enrolled in the Marine Society were very short.[156] Regarding their historical context description, Floud and Wachter argue that '[t]he professional and upper classes of Reform Era England, with no knowledge of per capita incomes or baskets of consumption goods, could see physical differences between themselves and the working classes'.[157] Komlos (1990), in the aforementioned case of

[156] Floud and Wachter, 'Poverty and Physical Stature: Evidence on the Standard of Living of London Boys 1770-1870'.
[157] Ibid, p. 424.

Germany, also finds that socioeconomic status as measured by fathers' occupation generates height differences between students.[158] As far as stature is mainly determined during early childhood, in these analyses the variables for original socioeconomic status are proposed as determinants of physical growth. However, a non-established objective in these studies has been to identify, by controlling for socioeconomic origin, the correlation between final adult height and socioeconomic achievement. In the case of France, Komlos (2003) reports a 7 cm height advantage among the students of the Ecole Polytechnique 'over the ordinary citizens of the Revolution'.[159] Finally, by taking the heights of the poor boys from Floud and Wachter and comparing them with the heights of wealthy boys enrolled in the Sandhurst Military Academy, Komlos finds an impressive difference of 15 to 22 cm, depending on the period under consideration (from the 1790s to the 1840s).[160]

For its part, the economics literature focuses more on measuring the effect of physical appearance on socioeconomic achievement, such as earnings in the labour market. In this case, and contrary to the aforementioned economic history literature, the objective is to identify if physical attributes are determinants of socioeconomic outcomes. Hamermesh and Biddle argue that there is a 'beauty premium' on earnings.[161] This study and the one by Mobius and Rosenblat explain the premium of physical attributes through two channels: discrimination and childhood-adolescence events.[162] With regard to discrimination, it is argued that the employer's distaste for specific physical attributes

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[158] Ibid.
[159] Komlos, 'An anthropometric history of early-modern France', p. 185.
[160] Floud and Wachter, 'Poverty and Physical Stature'; Komlos, 'On British Pygmies and Giants: the Physical Stature of British Youth in the 18th and 19th Centuries'.
[161] Hamermesh and Biddle, 'Beauty and the Labor Market'.
[162] Mobius and Rosenblat, 'Why Beauty Matters'.

causes a difference in earnings or, even more so, to whether or not candidates get the job. Concerning childhood-adolescence events, it is argued that phenotypic characteristics, such as being a 'good-looking' person, increase self-confidence and self-esteem (non-cognitive skills), and that this factor is then reflected in adulthood socioeconomic outcomes. Moreover, Mobius and Rosenblat also suggest that these types of phenotype-related occurrences can positively impact cognitive skills.

In particular, with regard to height and its relationship with wages as a measure of socioeconomic outcomes in the UK and the US, both Case and Paxson and Persico et al. find that each additional centimetre of height is reflected in a 0.4-1% increase in wages.[163] They offer different explanations for this relationship. Case and Paxson suggest that tallness reflects cognitive ability, for which the labour market pays more. On the other hand, Persico et al. find that height among teenagers makes a difference in terms of the formation of social skills and, therefore, future wages. In the latter case, and analogous to one of the channels proposed by Hamermesh and Biddle, and Mobius and Rosenblat, taller teenagers are more popular among their peers, which good fame helps them to improve their self-esteem and self-confidence, resulting in higher earnings during adulthood.[164]

The case of Germany has been also studied. Heineck finds that each additional centimetre in height is associated with 0.5% higher wages,[165] while Hübler finds a smaller effect:

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[163] Case and Paxson, 'Stature and Status: Height, Ability, and Labor Market Outcomes'; Persico, Postlewaite and Silverman, 'The Effect of Adolescent Experience on Labor Market Outcomes: The Case of Height'.
[164] Hamermesh and Biddle, 'Beauty and the Labor Market'; Mobius and Rosenblat, 'Why Beauty Matters'.
[165] Heineck, 'Up in the Skies? The Relationship between Body Height and Earnings in Germany'.

among men, each additional 10 cm in height results in a 2.5% wage increase.[166] There exist a few studies on this topic that concern developing countries. For Ghana and Brazil, Schultz finds a stronger association between height and wages than in developed economies. In both cases, an additional centimetre for men was found to result in 1.5% higher wages.[167] Examining the case of China, Gao and Smyth find a strong effect of height on wages: an increase of 4.5% in wage for each additional centimetre.[168] Finally, Vogl finds that each additional centimetre in height for Mexican men is associated with a 2.3% increase in hourly wage.[169]

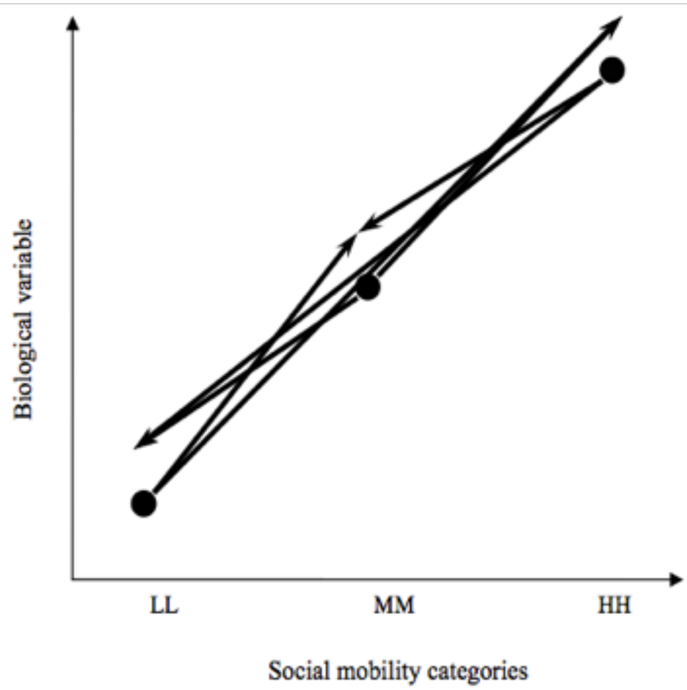
Finally, the relationship between height and intergenerational social mobility (case three, as defined at the start of this section), has been analysed in the field of social biology. As Cliquet explains, 'the modern social-biological approach to biosocial associations in within-population group variation conforms to the basic goal of social biology, namely the study of reciprocal relations between biological and social phenomena. Social biology today is empirical, it is bi-directionally oriented in its observation of associations between biological variation and social differentiation, and it considers both genetic and environmental mechanisms of biosocial interaction'.[170]

Figure 6.2 summarises what Cliquet claims to be evidence found in the literature, with mobility conditions classified as follows. The three nodes in the figure represent the non-

[166] Hübler, 'The nonlinear link between height and wages in Germany, 1985-2004'.
[167] Schultz, 'Wage Gains Associated with Height as a Form of Health Human Capital'.
[168] Gao and Smyth, 'Health Human Capital, Height and Wages in China'.
[169] Vogl, 'Height, skills, and labor market outcomes in Mexico'.
[170] Cliquet, *Biosocial Interactions in Modernisation*, p. 385.

mobile individuals by socioeconomic status: LL refers to those from a lower origin who remain in the same status; MM refers to those from a middle origin who remain in the middle status; and HH refers to those originating in the upper strata who remain in the same status. The lines with arrows refer to all individuals who have experienced intergenerational mobility, with the direction of the arrows indicating whether the individuals have experienced upward or downward mobility. As can be seen, the biological variable – in this case, height – differs by mobility condition: those who experienced upward mobility are taller than those with the same status of origin but with a non-mobile condition. Conversely, those who experienced downward mobility are shorter than those with the same status of origin but with a non-mobile condition.

Figure 6-2. Biological Differences according to Social Mobility



Note: Persistence in lower class (LL); persistence in middle class (MM); persistence in upper class (HH).
Black dots. Average value of low, middle and high groups.
Arrows. Indicate the direction and degree of upward or downward mobility.
Source: Robert Cliquet. *Biosocial Interactions in Modernisation*

As further evidence, several studies show a positive correlation between height and social mobility. In his study on 19 to 20-year old Flemish males born in 1940, Cliquet finds evidence to support the hypothesis stating that '[s]ocially mobile persons differ anthropologically from persons remaining in the categories from which they are moving away, and approach the characteristics of the categories into which they are being absorbed'.[171] In particular, height and occupational mobility between generations show a positive correlation in terms of both the direction (upward-downward) and the extent of the experienced occupational mobility. In a study based on educational mobility, Bielicki and Charzewski compare pairs of siblings and find, statistically significant for males, a higher proportion of better-off, educated siblings to be taller.[172] Bielicki and Waliszko also find a positive correlation between height and educational achievement for groups sharing a similar social background.[173] Based on these results, both studies offer three hypotheses as possible explanations for this relationship: genetic 'linkage', 'trump card' and the 'third factor'. Genetic 'linkage' refers to tallness as a characteristic that is genetically linked to the characteristics of intellect or personality. The 'trump card' refers to tallness as an advantage in certain social contexts. The 'third factor' refers to differences in the quality of parental care even within similar social groups. In a study of the Swedish population, Nyström Peck defines an observed/expected ratio of upward/downward mobility for three height groups in terms of intergenerational change in occupational class

[171] Cliquet, 'Social mobility and the anthropological structure', p.18.
[172] Bielicki and Charzewski, 'Body height and upward social mobility'.
[173] Bielicki and Waliszko, 'Stature, upward social mobility and the nature of statural differences between social classes'.

(from fathers to sons).[174] She finds that taller individuals are more upwardly mobile than expected, and that shorter individuals are more downwardly mobile. In a more recent study on England, Wales and Scotland, based on the intergenerational relationship between height and occupational class (Registrar General's 5-point occupational scale) for pairs of fathers and sons, Krzyzanowska and Mascie-Taylor find a positive correlation: downwardly mobile sons are shorter and upwardly mobile ones are taller.[175]

These three sets of studies are dissimilar in different ways. The ones in the economic history literature propose the models of height as being determined by socioeconomic background, but do not analyse whether height, in itself, determines socioeconomic achievement, i.e., that average height itself is the outcome variable. On the other hand, the economics literature analyses the height-wage (socioeconomic outcome) relationship. While some of these studies use instrumental variables (IV) models to deal with endogeneity, they do not analyse the relationship in terms of intergenerational and relative mobility. Finally, the human biology and biosocial science studies do analyse the relationship between height and social mobility between generations, but only by using descriptive statistics, thus not making it possible to test for causality.

The interest of the current chapter lies in incorporating all three approaches into a single one: (1) to model height as an output variable that is determined by the

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[174] Nyström Peck, 'Childhood environment, intergenerational mobility, and adult health – evidence from Swedish data'.

[175] Krzyzanowska and Mascie-Taylor, 'Intra- and Intergenerational Social Mobility'. In this study, data were taken from the National Cohort Study (NCDS) – a longitudinal study of all children born in the week 3-9th March 1958.

environmental/socioeconomic context of origin; and, after doing so, (2) to model relative socioeconomic achievement as a condition that is determined not only by environmental/socioeconomic context of origin, but also by height itself. To obtain strong enough results, it was necessary to deal with socioeconomic and nutritional status as mutually endogenous variables; that is, socioeconomic origin was expected to be a determinant of net nutritional status, and the latter to be a determinant of socioeconomic achievement once the former was controlled for. Fortunately, econometric methods enable us to deal with this type of problem.

6.2. Data Sources

The data for the analysis were taken from a database built by Vélez-Grajales, Stabridis and Minor.[176] These authors undertook a simple matching exercise of two nationally representative data sources: the 2011 ESRU Social Mobility Survey in Mexico (*Encuesta ESRU de movilidad social en México 2011*, ESRU-EMOVI 2011) and the 2012 Mexican National Survey on Health and Nutrition (*Encuesta nacional de salud y nutrición 2012*, MXNHNS-2012). As mentioned in chapter 3, the ESRU-EMOVI 2011 is a nationally representative survey that was designed in order to analyse intergenerational social mobility in Mexico, and it includes information on respondents' socioeconomic characteristics. Additionally, and crucially for the present study, this cross-section also includes retrospective information on parental household assets and services when the interviewee was 14 years old. In this way, the ESRU-EMOVI 2011 enables the observation

[176] Vélez Grajales, Stabridis Arana and Minor Campa, 'Still Looking for the Land of Opportunity: Regional Differences in Social Mobility in Mexico'.

of the wealth status of two generations: interviewees' (aged 25-64 years) own households and that of their parents (when the interviewee was 14 years old). The ESRU-EMOVI 2011 sample size includes 11,001 individuals. However, even though the ESRU-EMOVI 2011includes information on self-reported adult height, it is of low quality. The MXNHNS-2012, which has already been referred to in chapter 4, is a nationally representative survey that was conducted by the *Instituto Nacional de Salud Pública*. The MXNHNS-2012 sample size includes 96,031 respondents among 50,528 households. Due to its size and sample design, this survey is also representative for the 32 Mexican states. Contrary to the ESRU-EMOVI 2011, the MXNHNS-2012 captured height through the use of stadimeters by previously trained technicians. As a result, the adult height data in this source are of good quality. Nevertheless, one drawback of the survey in terms of the present chapter's interest is that retrospective information is not available. However, given the fact that both surveys were conducted at almost the same time (with one year's difference), the matching exercise conducted by Vélez-Grajales, Stabridis and Minor resulted in a single database from which it was possible to obtain information for adult height and both socioeconomic origin and achievement.[177]

6.3.Methodology

The aim here was to model the role played by height as a measure of net nutritional status in the relationship between socioeconomic origin and achievement. In order to do so, a set of socioeconomic determinant variables were used. As previously mentioned,

[177] Ibid.

socioeconomic status is defined in relative terms for both origin (when the adult individual was 14 years old) and achieved position (current household). Origin and achievement were then built based on the socioeconomic status of the two generations. Each of these was then obtained from a variable selection, as follows:

$$Wealth\_in_t = f(\boldsymbol{X}_t) \qquad (1)$$

$$Wealth\_in_{t+s} = f(\boldsymbol{W}_{t+s}) \qquad (2)$$

Where (1) refers to an origin wealth index (in time t) and (2) refers to an achieved (current) wealth index (after s years). Both of them were built with a set of variables reflecting permanent income characteristics by using certain multivariate analysis techniques. Vectors X and W are different due to the fact that the characteristics determining origin and achieved wealth are not the same. The wealth indices were expressed in quantiles in order to ensure comparability among them (they are not comparable in absolute terms). Therefore, the values of the indices can be expressed as follows:

$$Wealth\_in_{\boldsymbol{t}} = \boldsymbol{C_a}\ where\ C\ can\ take\ values{:}\ C_1, C_2, \ldots, C_k \qquad (3)$$

Where K defines the number of quantiles. The same applies for the achieved wealth index. As a result, relative intergenerational mobility could be constructed by comparing the origin quantile with the achieved quantile. There was upward mobility if the difference between the current and origin quantile was positive (representing a position improvement on the wealth ladder). On the other hand, there was downward mobility if this difference was negative. Finally, persistence (non-mobile condition) could also be experienced by maintaining the same quantile position.

$$IntMob_i = (Positive\ if\ C_m > C_r) \quad where\ m > r\ and\ C_i > 0,\ i = m, r \qquad (4)$$
$$(Negative\ if\ C_m < C_r) \quad where\ m > r\ and\ C_i > 0, \qquad i = m, r$$
$$(Persistence\ if\ C_m = C_r)\ where\ m = r\ and\ C_i > 0, \quad i = m, r$$

An alternative way of observing intergenerational mobility is by estimating a simple econometric model in which achieved wealth is explained, among other determinants, by the wealth index of origin. In such a way, it is possible to estimate the effect of all determinants, wealth of origin included, in order to identify the magnitude of intergenerational persistence. The achieved relative position in the econometric model of socioeconomic achievement is explained in the following equation:

$$Wealth\_in_i = \varphi_0 + \varphi_1 Wealth\_indorig_{1i} + \varphi_2 X_{2i} + \cdots + \varphi_K X_{Ki} + \varepsilon_i \quad (5)$$

In (5), each of the explanatory variables (Xs) is exogenous. In this way, the coefficients can be expressed as a causal effect of these variables on socioeconomic achievement.[178] On the other hand, in case one variable is not exogenous, it is seen as determined by another set of variables, as follows:

$$X_{2i} = \pi_0 + \pi_1 Z_{1i} + \pi_2 Z_{2i} + \mu_i \quad (6)$$

[178] For more details on causality, see Angrist and Pischke, *Mastering 'Metrics. The Path from Cause to Effect*.

This, then, implies that X_2 is endogenous. If equation (5) is estimated without taking into account the composition of X_2 in equation (6), biased and inconsistent estimators are obtained ($cov(X_2, \varepsilon) \neq 0$).[179] One way to correct for endogeneity is by using a two-stage estimation (or IV approach).[180] The two-stage estimation can be conducted as follows:

Stage one:

a. A variable (or set of variables) **Z** should be located that can explain the endogenous variable ($cov(X_2, Z) \neq 0$). This is known as the relevance condition.
b. The instrument **Z** should not be correlated with the dependent variable (in this case, $cov(Z, Wealth\_in) = 0$). This is known as the exogeneity condition.

When **Z** fulfils both conditions (a and b), it can be said that **Z** is a good instrument. The regression between the endogenous variable and the instruments is then estimated. From here, the predicted value of the endogenous variable can be calculated.

Stage two:

c. The regression of the dependent variable is estimated (in this case, socioeconomic achievement). The independent variables include the

[179] For more details on endogeneity, see Wooldridge, *Econometric Analysis of Cross Section and Panel Data*.
[180] When both the dependent and endogenous variables are continuous, a 2SLS can be followed.

predicted value of the endogenous variable and all other explanatory variables:

$$Wealth\_ind_i = \varphi_0 + \varphi_1 X_{1i} + \boldsymbol{\lambda_2 \widehat{X_{2i}}} + \cdots + \varphi_K X_{Ki} + \varepsilon_i \quad (7)$$

In equation (7), $\boldsymbol{\lambda_2}$ is known as the two-stage least squares estimator. In this case, as the estimator is now unbiased and consistent, it can capture the causal effect of X_2 on socioeconomic achievement.

6.4.Implementation Strategy and Definition of Main Variables

The central variables used for the current analysis were wealth of origin, achieved wealth and adult height. Adult height was treated as an endogenous variable. Therefore, a two-stage estimator was used to identify the causal effect of height on socioeconomic achievement. In the first stage, a robustness OLS model was estimated in order to obtain a predicted value for height. For the estimation, origin and predetermined conditions such as the wealth origin index and parents' education were used as explanatory variables. Controls such as birth cohort, ethnic condition, urban-rural origin and region were also included. Then, in the second stage of the analysis, an ordered probit model was estimated.[181] Here, the achieved wealth index could be explained by the predicted value of height from the previous OLS regression once the origin wealth index was controlled

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[181] An ordered probit is a model used to estimate the probability for some categorical variables with more than two ordinal categories. For more details on this type of model, see Train, *Discrete Choice Methods with Simulation*.

for, thus also controlling for endogeneity. Several other variables included in the OLS regression were, again, used as explanatory variables in the model.

Conventionally speaking, income (earnings/consumption) is the typical variable used to measure living standards. However, if the purpose is to obtain information in order to analyse and compare living standards between two generations without anonymity, as in the present chapter, data availability is more limited. Therefore, an alternative is to design cross-section surveys which include current and retrospective information. However, it can be difficult for respondents to remember the income level of their household of origin, which can result in different kinds of measurement error. For example, there exists a potential bias related to age, or mistakes of different range depending on differences in socioeconomic condition.

In the case of the ESRU-EMOVI 2011, as previously mentioned, the retrospective questions refer to the interviewee's living conditions when s/he was 14 years old. These types of studies contain certain requirements, a key one being not to ask questions about parents' earnings in the past in order to avoid measurement error and biases. Moreover, the main objective should be to collect information that is easier to remember correctly, e.g., the possession of certain assets or services in the household of origin.

This type of information then makes it possible to build asset/wealth indices. In fact, the one proposed by Filmer and Pritchett is one of the most commonly used in the literature. Due to a lack of income information, these authors estimate an index of household assets and services by using the principal components method (MCP). They argue that this kind of index is a good approximation of wealth.[182] Sahn and Stiffel also argue that the accumulation of assets is a good predictor of poverty reduction.[183] Moreover, Torche contends that this type of index captures the contribution of both occupational and non-occupational activities of all household members. In addition, she argues that the index composition enables the capture of information closely related to the condition of permanent wellbeing, i.e., it is not sensitive to short term fluctuations.[184] Torche and Spilerman identify both the current and future influence of a household's wealth. On one hand, they argue that such wealth could avoid the negative effects of adverse shocks. On the other, they contend that wealth becomes an asset with which to pay for their children's education, fund their investment projects, or simply as a transfer in the form of an inheritance.[185]

For the purposes of the current chapter, an index on assets and household services estimating wealth for two generations was taken from the aforementioned work by Vélez-Grajales, Stabridis and Minor.[186] The indices were calculated with categorical variables using the method of multiple correspondence analysis (MCA).[187] For both the ESRU-EMOVI

[182] Filmer and Pritchett, 'The Effect of Household Wealth on Educational Attainment: Evidence from 35 Countries"; Filmer and Pritchett, 'Estimating Wealth Effects without Expenditure Data – or Tears: An Application to Educational Enrollments in States of India'. For an application of this technique to several countries, see McKenzie, 'Measuring Inequality with Asset Indicators'. For an application of this technique to the EMOVI-2006, see Vélez-Grajales and Vélez-Grajales, 'Intergenerational Mobility and Income Effects for Entrepreneurial Activity in México'.
[183] Sahn and Stifel, 'Exploring Alternative Measures of Welfare in the Absence of Expenditure Data'.
[184] Torche, 'Sociological and Economic Approaches to the Intergenerational Transmission of Inequality in Latin America'.
[185] Torche and Spilerman, 'Influencias intergeneracionales de la riqueza en México" [Intergenerational differences in wealth in Mexico].
[186] Vélez Grajales, Stabridis Arana and Minor Campa, 'Still Looking for the Land of Opportunity'.
[187] Multiple correspondence analysis is a multivariate analysis technique originally developed by Jean Paul Benzécri, a French statistician. For further details, see Greenacre and Blasius. *Correspondence Analysis in the Social Sciences: Recent Developments and Applications.* Initially, this method was used in the study of contingency tables with two variables, and it was known just as correspondence analysis. However, when

2011 and the MXNHNS-2012, a contemporary index (adult interviewees) was calculated. On the other hand, a retrospective one (interviewees' parents) was estimated for the ESRU-EMOVI 2011. Following these calculations, the authors conducted a matching exercise in order to impute the retrospective index from the ESRU-EMOVI 2011to the MXNHNS-2012. Both origin and achieved wealth indices are presented in terciles: lower, middle and upper classes.

In the case of adult height, as previously mentioned, the predicted variable explained by wealth of origin was used as an explanatory variable for achieved wealth. The definition of height was discussed in chapter 2. For the purposes of the present chapter, the final sample obtained by Vélez-Grajales, Stabridis and Minor in the MXNHNS-2012 was reduced to one that included measures of height for individuals aged between 25 and 49 years. This age range was used, firstly, due to the fact that 25-year-olds were the youngest adults included in the ESRU-EMOVI 2011, and secondly, as already discussed in previous chapters, because those aged over 49 are in the age range for physical shrinking. The height sample was taken from the matched sample. It should be noted that the heights used were those of males and females measured for the MXNHNS-2012.[188]

6.5.Results

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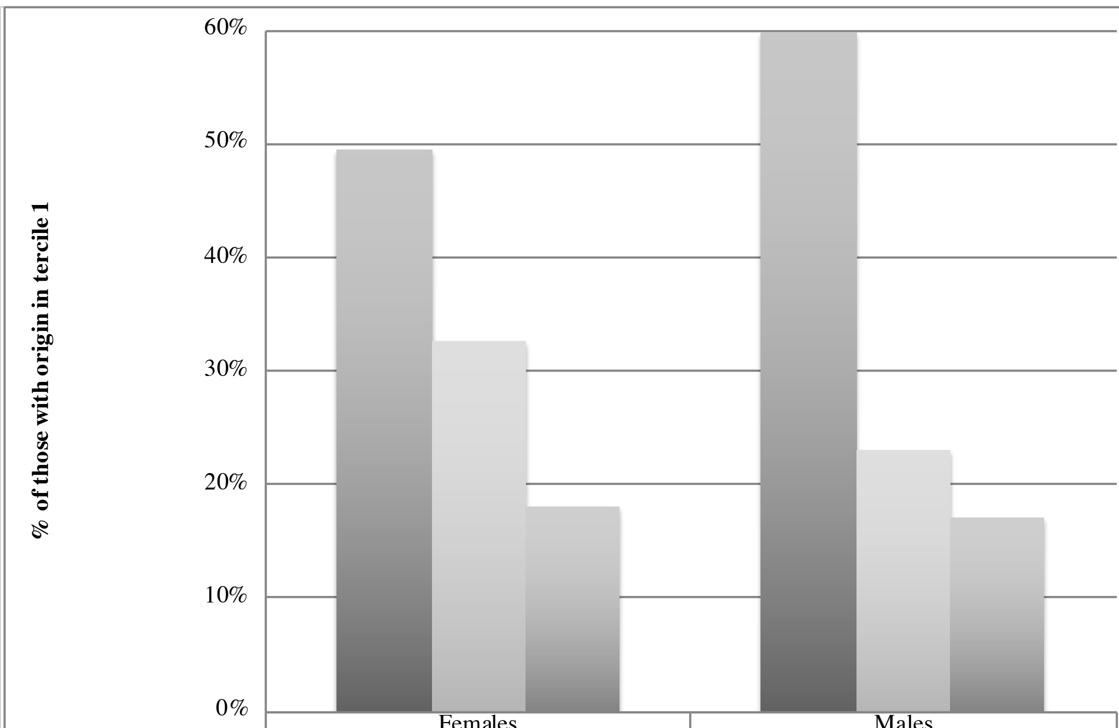
its use was extended to more than two variables, it came to be called multiple correspondence analysis (MCA). For further details, see Peña, *Análisis de Datos Multivariantes*.

[188] It should be noted that the ESRU-EMOVI 2011 includes the variable of individuals' self-declared height. However, the quality of this variable was not deemed to be good enough.

Once the two wealth index distributions – those of origin and that achieved – were divided by terciles, it was possible to construct transition matrices in order to measure relative intergenerational mobility. Figures 6.3 and 6.4 present the achieved terciles for those originating in the bottom and upper terciles by gender. At least half of those originating in the bottom tercile remained there (Figure 6.3); it should also be noted that less than a fifth of the latter moved up to the third tercile. On the other hand, intergenerational persistence in the upper tercile is even higher (Figure 6.4): two thirds of those originating in the third tercile stayed there. Moreover, downward mobility to the bottom tercile represents less than one tenth of those who originated in the third tercile.

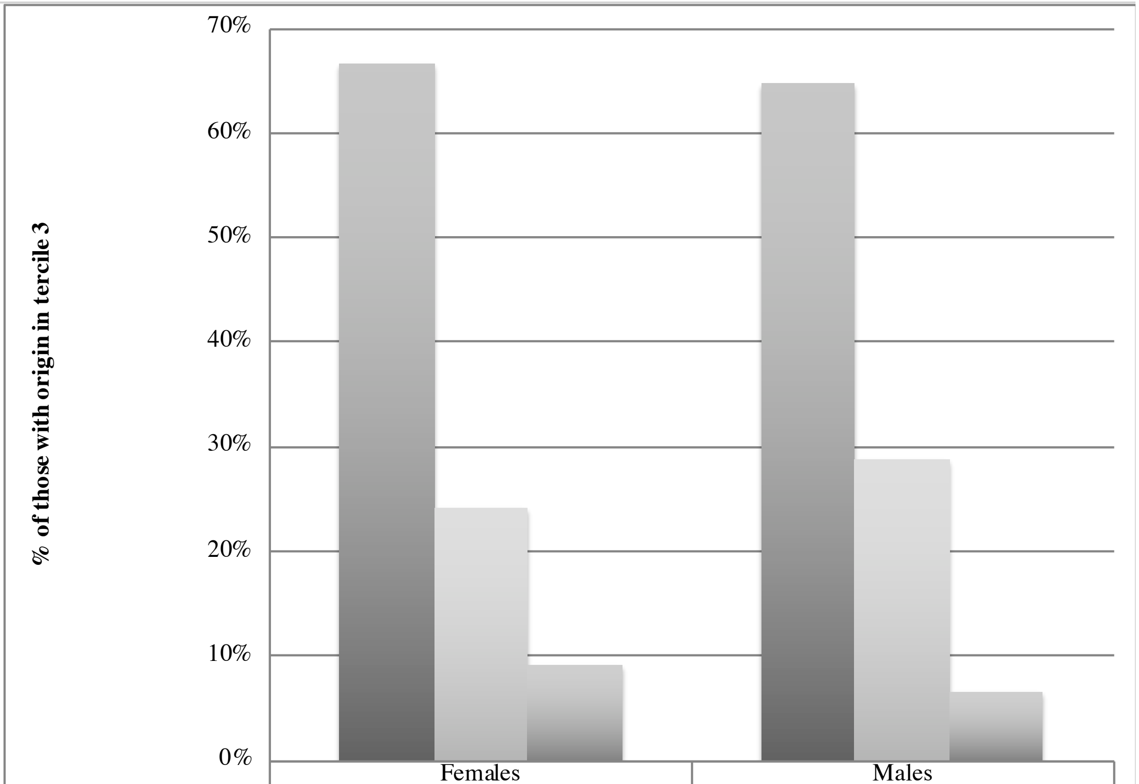
Figure 6-3. Intergenerational Wealth Mobility from the Bottom Tercile, Mexico, 1962-1986



	Females	Males
Lower-Lower (LL)	49%	60%
Lower-Middle (LM)	33%	23%
Lower-Upper (LH)	18%	17%

Source: Based on built database.

Figure 6-4. Intergenerational Wealth Mobility from the Upper Tercile, Mexico, 1962-1986



	Females	Males
Upper-Upper (HH)	67%	65%
Upper-Middle (HM)	24%	29%
Upper-Lower (HL)	9%	6%

Source: Based on built database.

The next step was to estimate average height for each subgroup based on the height OLS model described in the previous section. Five types of explanatory variables were included: birth cohorts (1962-1970, 1971-1978, 1979-1986), regions (Northwest, Northeast, West-Centre, Centre and Southeast), wealth origin (terciles 1 to 3), ethnic group (indigenous or non-indigenous), type of location (rural-urban) and origin education (father's and mother's). The results are presented in Table 6.1. Almost all of the included explanatory variables are statistically significant. For both males and females, it can be seen that wealth origin makes a difference in terms of height: those coming from the upper classes are taller. Another finding is that the father's education has a positive effect on females' height, and the mother's on males' height. Being from an indigenous group or living in rural areas negatively affects height. Finally, younger cohorts and northern regions can be seen to produce taller individuals.

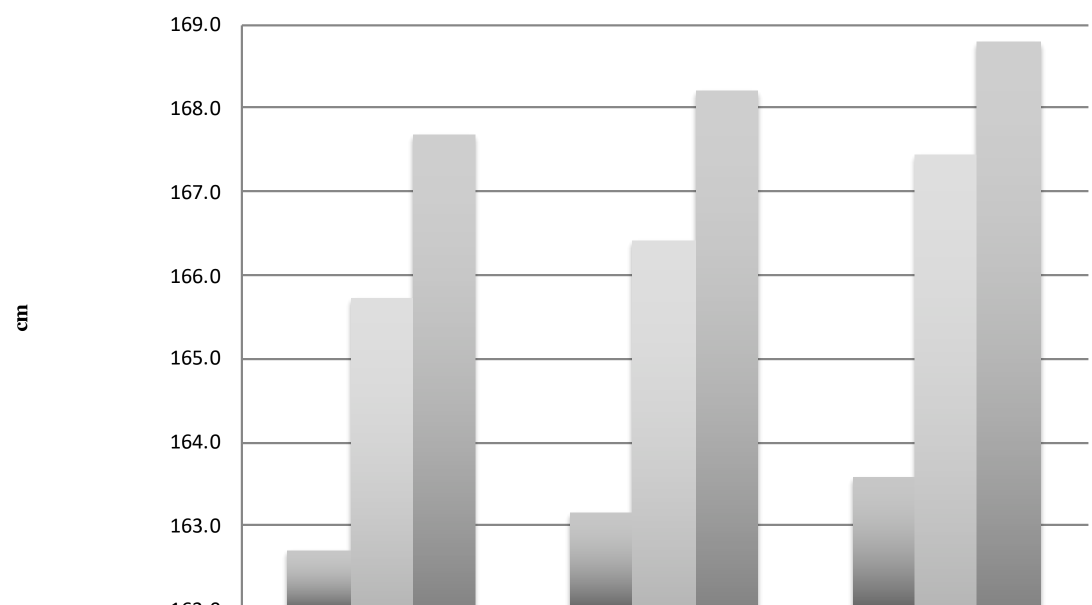
Table 6-1. Heights Model (OLS), Mexico, 1962-1986

VARIABLES	Males	Females
Birth Cohort		
1962 - 1970 (omitted)		
1971-1978	0.5201**	0.6878***
	(0.203)	(0.148)
1979-1986	1.1951***	1.3246***
	(0.207)	(0.156)
Regions		
South-Southeast (omitted)		
West-Centre	4.9916***	4.2246***
	(0.226)	(0.165)
Centre	2.1095***	1.5582***
	(0.233)	(0.182)
Northeast	5.1968***	4.2585***
	(0.257)	(0.209)
Northwest	5.9524***	5.6805***
	(0.300)	(0.226)
Wealth Origin		
Tercile 1: lower-class (omitted)		
Tercile 2: middle-class	0.8780***	0.6598***
	(0.210)	(0.160)
Tercile 3: upper-class	1.7250***	1.3876***
	(0.240)	(0.172)
Ethnic Group		
Self-declared as non-indigenous (omitted)		
Self-declared as indigenous	-1.7148***	-2.3605***
	(0.194)	(0.148)
Rural-Urban		
Lives in rural area (omitted)		
Lives in urban area	1.3847***	0.9979***
	(0.179)	(0.133)
Education		
Father's Schooling years	0.0565*	0.1018***
	(0.031)	(0.026)
Mother's Schooling years	0.0910***	0.0001
	(0.034)	(0.028)
Constant	160.3895***	148.8675***
	(0.253)	(0.191)
Observations	7850	10588
R-squared	0.180	0.179

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Based on the predicted height values, and as shown in Figures 6.5 and 6.6, both males and females who experienced persistence in tercile 3 are taller. Moreover, those who experienced persistence in tercile 1 are the shortest. By birth cohort, it is interesting to note that, in any case, the younger cohorts are taller. However, these dynamics do not result in a convergence process between the extremes of the distribution. Therefore, for example, the height difference between males at the extremes remained constant at around 5 cm (4 cm for females).

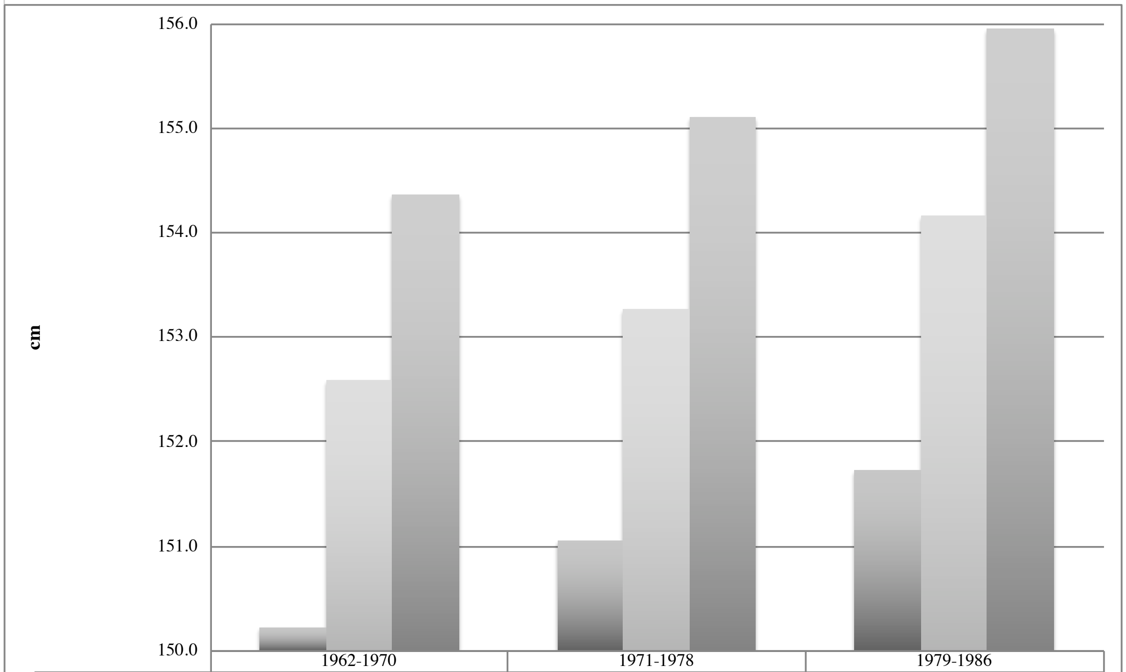
Figure 6-5. Predicted Male Average Height by Intergenerational Positional Persistence, Mexico, 1962-1986



	1962-1970	1971-1978	1979-1986
Lower-Lower (LL)	162.7	163.2	163.6
Middle-Middle (MM)	165.7	166.4	167.5
Upper-Upper (HH)	167.7	168.2	168.8

Source: Based on Table 6.1

Figure 6-6. Predicted Female Average Height by Intergenerational Positional Persistence, Mexico, 1962-1986



	1962-1970	1971-1978	1979-1986
Lower-Lower (LL)	150.2	151.1	151.7
Middle-Middle (MM)	152.6	153.3	154.2
Upper-Upper (HH)	154.4	155.1	156.0

Source: Based on Table 6.1

Once height was estimated, the endogenous ordered probit for three categories (three terciles) of relative wealth achievement could be estimated. In addition to predicted height based on the OLS, birth cohort, tercile of origin, ethnic group (indigenous or not) and rural-urban location were also included in the model. In the case of education, the respondent's one was used as an explanatory variable. Finally, an interaction between the dummies of rural-urban location and the indigenous/non-indigenous condition was also included. The results were statistically significant, and the direction of the effect of each explanatory variable result as expected. Table 6.2 presents the model's results and marginal effects (base probability) for both males and females. The exogenous model, i.e., containing the raw height data (not predicted), was also estimated; a comparison with the endogenous one is presented in the Annex to the present chapter.

Table 6-2. Mobility Probability (oprobit): Endogenous Model

VARIABLES	(1) Model	(2) Marginal Effect: to be in Tercile 1	(3) Marginal Effect: to be in Tercile 2	(4) Marginal Effect: to be in Tercile 3	(1) Model	(2) Marginal Effect: to be in Tercile 1	(3) Marginal Effect: to be in Tercile 2	(4) Marginal Effect: to be in Tercile 3
	Males				Females			
Height								
Predicted Value (from OLS)	0.0857***	-0.0293***	0.0006	0.0288***	0.1113***	-0.0361***	-0.0010*	0.0371***
	(0.007)	(0.002)	(0.000)	(0.002)	(0.006)	(0.002)	(0.001)	(0.002)
Birth Cohort								
1962-1970 (omitted)								
1971-1978	-0.3096***	0.1088***	-0.0087***	-0.1001***	-0.3524***	0.1172***	-0.0034**	-0.1138***
	(0.033)	(0.012)	(0.002)	(0.010)	(0.032)	(0.011)	(0.002)	(0.010)
1979-1986	-0.6823***	0.2400***	-0.0248***	-0.2151***	-0.8312***	0.2891***	-0.0441***	-0.2450***
	(0.042)	(0.015)	(0.004)	(0.012)	(0.034)	(0.012)	(0.004)	(0.009)
Tercile of Origin								
Tercile 1: lower-class (omitted)								
Tercile 2: middle class	0.4579***	-0.1488***	-0.0107***	0.1595***	0.1684***	-0.0536***	-0.0035**	0.0570***
	(0.035)	(0.011)	(0.002)	(0.012)	(0.031)	(0.010)	(0.001)	(0.011)
Tercile 3: upper-class	1.0345***	-0.3227***	-0.0333***	0.3561***	0.8492***	-0.2522***	-0.0413***	0.2935***
	(0.040)	(0.011)	(0.005)	(0.013)	(0.028)	(0.008)	(0.004)	(0.010)
Ethnic Group								
Self-declared as non-indigenous (omitted)								
Self-declared as indigenous	-0.2805***	0.0994***	-0.0095***	-0.0899***	-0.1596***	0.0530***	-0.0011	-0.0519***
	(0.032)	(0.019)	(0.004)	(0.016)	(0.051)	(0.017)	(0.002)	(0.016)
Rural-Urban								
Lives in rural area (omitted)								
Lives in urban area	0.5480***	-0.1935***	0.0196***	0.1738***	0.4688***	-0.1580***	0.0095***	0.1484***
	(0.100)	(0.011)	(0.003)	(0.009)	(0.034)	(0.012)	(0.002)	(0.010)
Other								
Urban-Indigenous interaction	0.2064***	-0.0674***	-0.0047	0.0722***	0.2072***	-0.0637***	-0.0083**	0.0720***
	(0.059)	(0.018)	(0.003)	(0.021)	(0.056)	(0.017)	(0.004)	(0.020)
Schooling years	0.1015***	-0.0347***	0.0007	0.0341***	0.1110***	-0.0360***	-0.0010**	0.0370***
	(0.005)	(0.002)	(0.001)	(0.002)	(0.004)	(0.001)	(0.001)	(0.001)
Constant Cut1	15.1145***				17.6777***			
	(1.078)				(0.869)			
Constant Cut2	16.2558***				18.9204***			
	(1.079)				(0.875)			
Observations	7831	7831	7831	7831	10574	10574	10574	10574

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As shown in the table, taller height for both males and females increases the probability of reaching the upper tercile and reduces the probability of descending to the bottom tercile. It should be noted, firstly, that such effects stay in place even after the wealth tercile of origin is controlled for and, secondly, that even the magnitude of the height effect is not the biggest one among all explanatory variables; rather, it is similar for both males and females in relation to the schooling years variable. Moreover, being from an indigenous ethnic group and rural location reduce the probability of upper tercile achievement, and the interaction between them reinforces their negative effect. In the case of the probability of ending up in tercile two, further empirical analysis is needed to identify the main determinants.

These results are consistent with the findings presented in the literature review. With respect to height determinants it can be seen that, firstly, height is positively correlated with socioeconomic origin (wealth origin): those coming from the upper classes are taller. Secondly, while average height increases, regional differences can be observed. Thirdly, even though there exists this positive trend in average height, no convergence can be found among the terciles.

With respect to socioeconomic achievement, the results are also consistent with evidence in the literature. Once endogeneity is controlled for, each additional centimetre increases the probability of males being in the upper tercile by around three percentage points, and reduces the probability of their being in the bottom tercile also by three percentage points. In the case of females, the effect is even bigger: each additional centimetre increases their probability of being in the upper tercile by 3.6 percentage points, and reduces the probability of being in the bottom tercile by almost the same percentage.

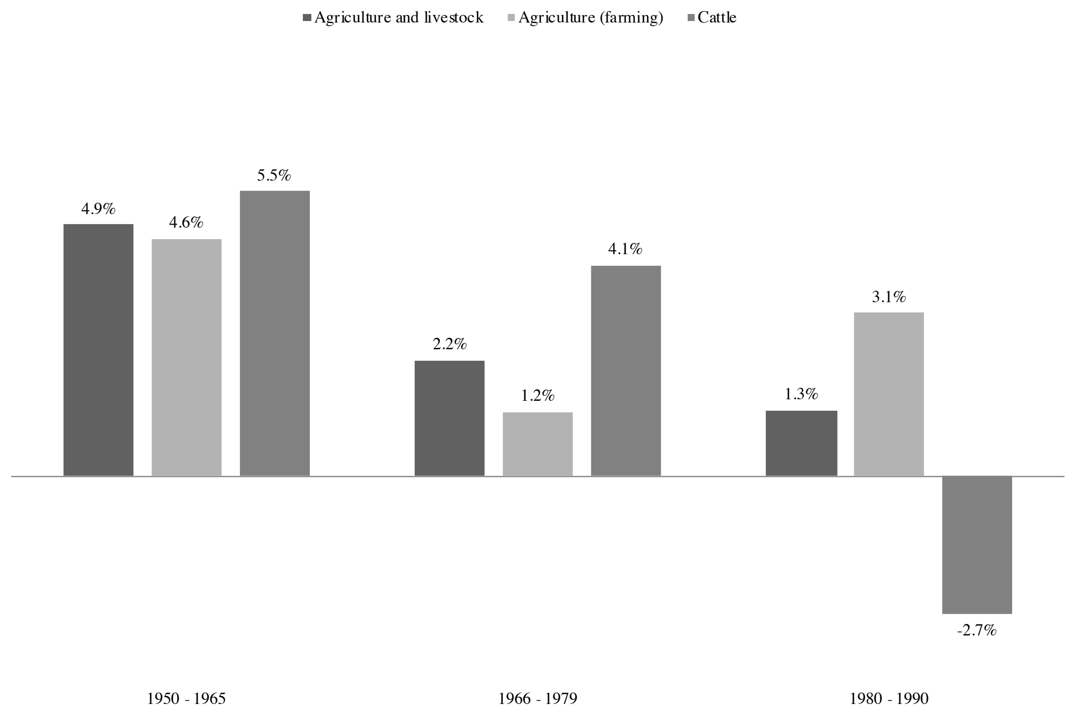
Finally, with respect to intergenerational mobility, the results are consistent with the aforementioned literature review, in the sense that additional centimetres increase the probability of achieving upper class status (and reduce the one of ending up in the lower classes), even when the socioeconomic status of origin is controlled for.

6.6. Results and Discussion

Height is mainly determined during early childhood; therefore, the selected period for the current analysis was determined by the available birth cohorts: 1962-1986. As mentioned in previous chapters, this period was one in which both economic growth and average height trends grew constantly. As also mentioned in chapter 4, however, these height increases were not sufficient to converge Mexico to at least the levels of other Latin American countries such as Colombia or Brazil.

It was also possible to analyse sectors of economic activity that are closely related to nutritional status. As shown in Figure 6.7, annual average growth rates for agriculture and livestock production were positive, but decreased over time. In the early 1960s, the annual growth rate was around 5%, but decreased to less than half that during the period 1966-1979. Moreover, for the period covering the youngest analysed cohort (1979-1986), the annual growth rate was just over 1%.

Figure 6-7. Agriculture-Livestock GDP: Average Annual Growth Rates, Mexico, 1950-1990

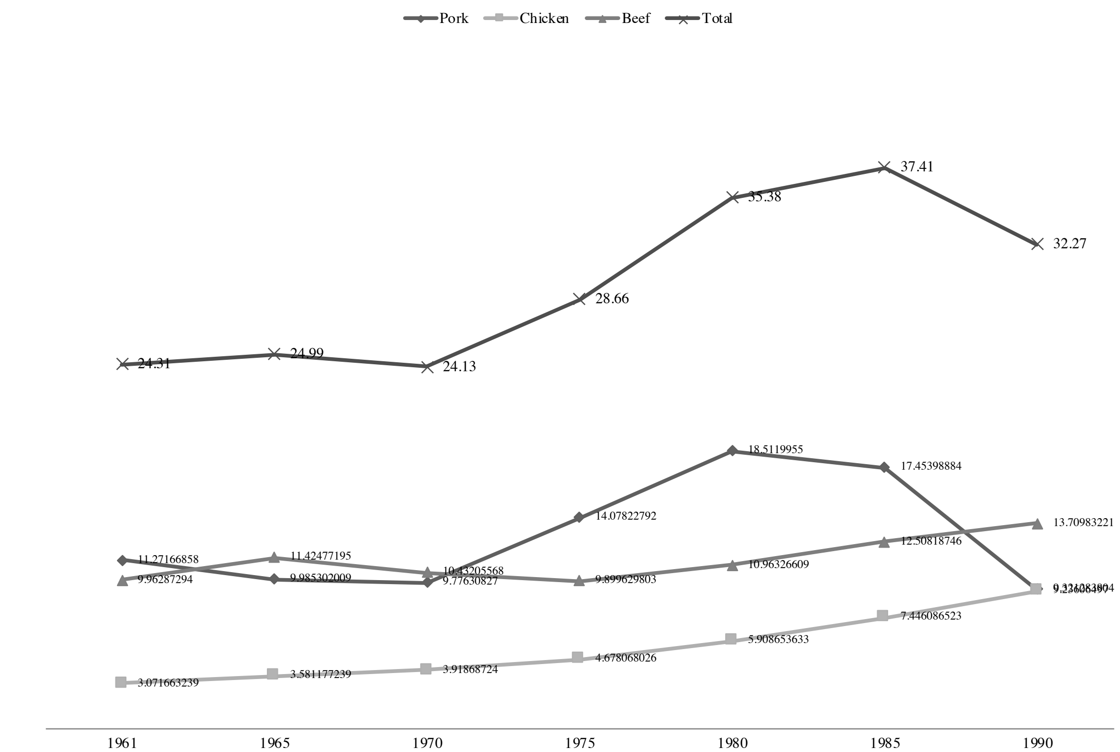


Source: Antonio Yunez Naude, "La transformación del campo y el papel de las políticas públicas: 1929-2008". In Sandra Kuntz Ficker (coord.), *Historia económica general de México. De la colonia a nuestros días*. El Colegio de México/Secretaría de Economía, 2010.

Meat production per capita, on the other hand, stayed constant during the 1960s (see Figure 6.8), but grew constantly during the remaining years under analysis. Per capita production was around 24 kilograms in 1961 and reached a peak of 37 kilograms by 1985. It should, however, be noted that this level had decreased in a major way by 1990, when the per capita production was 32 kilograms. This decline presumably happened due to one of the effects of the 1980s Mexican crisis.

Both agriculture-livestock activity and meat production dynamics are positively correlated with height increases. Furthermore, the observed dynamics suggest that these decreasing improvements can, at least in part, explain why the increased heights were not sufficient for Mexico to converge to the previously mentioned international height experiences. With regard to this, it is also important to analyse socioeconomic distributional dynamics.

Figure 6-8. Meat per capita Production (kilograms), Mexico, 1961-1990



Source: Antonio Yunez Naude, "La transformación del campo y el papel de las políticas públicas: 1929-2008". In Sandra Kuntz Ficker (coord.), *Historia económica general de México*. *De la colonia a nuestros días*. El Colegio de México/Secretaría de Economía, 2010.

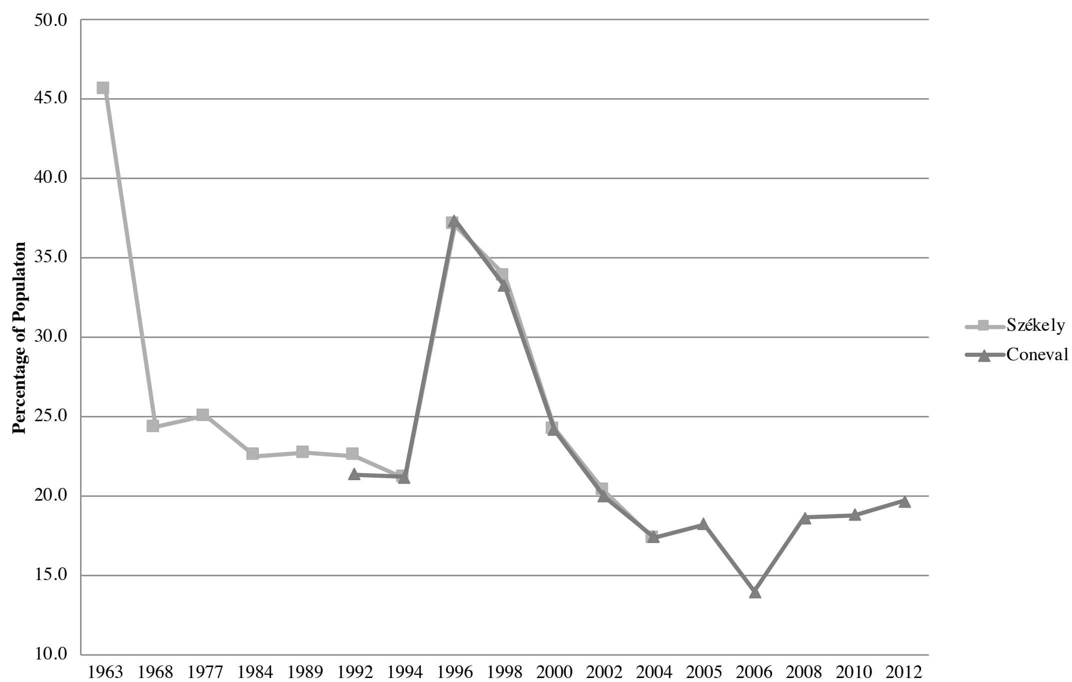
One way to do so in a descriptive way is by analysing the trend of food poverty. In chapter 4, food poverty as reported by Székely was presented for the period 1950-1992. In Figure 6.9, the analysed time period is 1963-2012, including Székely's series for the sub-period 1963-2004.[189] For the sub-period 1992-2012, the series plotted are the ones published by the Mexican National Council for the Evaluation of Social Development Policy

[189] Székely, 'Medición de la pobreza y la desigualdad'.

(CONEVAL, *Consejo Nacional de Evaluación de la Política de Desarrollo Social*).[190] The trends can be analysed for two different time periods – one for the period of origin (1962-1986) and another for the period of achievement (1987-2012). During the origin period, there occurred an important reduction in the percentage of population in food poverty. Overall, this reduction is consistent with Mexico's increasing food production and the positive trend of economic growth. For the achievement period, however, the opposite happened during two sub-periods: 1994-1996 and 2006-2012. In the first case, the effect of the 1995 Mexican crisis was rapidly reversed. However, in the second case, an increase in poverty occurred even before the 2008-2009 financial crisis, which trend did not stop until the end of the observed years. These trends are reflected in height in two different, observed ways. In the first case, in the origin period, constant food poverty is positively correlated with the observed general positive trend in mean height. On the other hand, however, the lack of height convergence among individuals displaying intergenerational socioeconomic persistence can be explained by the negative distributional effects of all Mexican contemporary crises. In particular, such effects are reflected in food poverty: after two decades (1994-2012), the percentage of population in food poverty almost remained the same.

[190] CONEVAL, http://www.coneval.gob.mx (Accessed 28/07/2015).

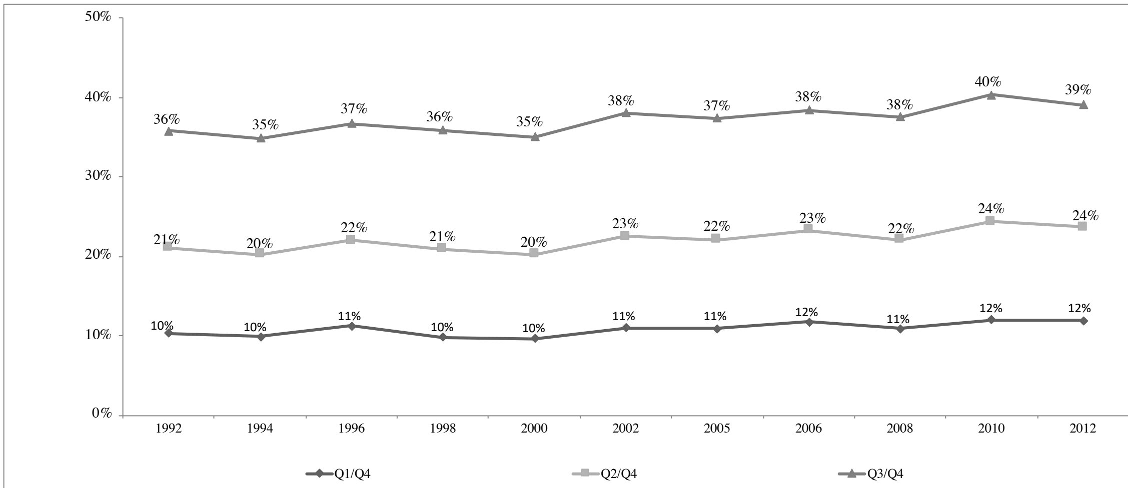
Figure 6-9. Food Poverty, Mexico, 1963-2012



Source: Miguel Székely "Medición de la pobreza y la desigualdad" and *Consejo Nacional de Evaluación de la Política de Desarrollo Social*.

Finally, the persistence in mean height differences among the intergenerational immobile groups is also consistent with the observed dynamics of household income. As shown in Figure 6.10, where household income quartiles 1 to 3 are presented as proportions of the fourth quartile's income for the period 1992-2012, differences in household income also persisted.

Figure 6-10. Household Income. Quartiles 1-3 as Proportion of Quartile 4, Mexico, 1992-2012



Note: Income quartiles were calculated based on total household current income. Income was calculated in 2013 (June) constant Mexican pesos.

Source: Author's own estimations based on Enigh 1992-Enigh 2012.

To sum up, the historical context suggests that Mexico's distributional dynamics have disabled higher rates of average height growth. Also, as both a cause and an effect of the previous result, no convergence in height among terciles can be observed. These results are consistent with the distributional income dynamics during the period of socioeconomic achievement for the analysed birth cohorts: the origin gap between socioeconomic groups is reflected in the one pertaining to net nutritional status (i.e., height). It can be seen that nutritional inequality translates into high and constant levels of inequality in terms of socioeconomic achievement and that, therefore, Mexico has become a society in which the socioeconomic status quo persists from one generation to the next.

6.7.Conclusions

Based on the 2011 ESRU Social Mobility Survey in Mexico (*Encuesta ESRU de movilidad social en México 2011*, ESRU-EMOVI 2011) and the 2012 Mexican National Survey on

Health and Nutrition (*Encuesta nacional de salud y nutrición 2012*, MXNHNS-2012), this chapter analysed the relationship between socioeconomic origin/achievement and adult height, focusing on the case of Mexico for the period 1962-1986. This period was determined by the birth cohorts of measured Mexican adults who were between 25 and 49 years old in 2012.

ESRU-EMOVI 2012

In particular, the analytical interest here lay in observing how socioeconomic origin influenced attained height, and how such attained height impacted socioeconomic achievement. In this way, it was possible to draw inferences relating to the issue that Cliquet has analysed: the relationship between biological variation (in the current case, adult height) and intergenerational social mobility.[191] In the present chapter, and contrary to analyses from the social biology literature previously mentioned, the proposed methodology engaged with an important task: endogeneity. For this purpose, a two-stage analysis was estimated: (1) an OLS height model in which socioeconomic origin was included as a determinant variable; and (2) an ordered probit model for socioeconomic achievement in which predicted height (from the OLS model) was included as a determinant variable.

The results show that socioeconomic origin is a positive and important determinant of final adult height but, once endogeneity is controlled for, this attained height determines socioeconomic achievement. As these findings were obtained for the contemporary case

[191] Cliquet, *Biosocial Interactions in Modernisation.*

of Mexico, the results thus had to be analysed in the context of the Mexican economic and socioeconomic distributional dynamics.

The results further demonstrate that Mexico is a country in which the options of upward-downward mobility are reduced. Therefore, even though economic growth, food production and poverty reduction show a positive performance during almost the whole period under study, the results on nutritional status suggest that such improvements have not been good enough for Mexico to converge to similar international experiences. Given the country's observed economic performance, it was expected that there would be, at least, a reduction in the height differences between socioeconomic terciles. However, these differences persisted. On the other hand, this result is consistent with the dynamics observed for income distribution during and after the period under study. As mentioned in the introduction to the present chapter, a vicious, intergenerational circle pertaining to the socioeconomic, status-adult height relationship can be observed, maintaining the persistence of the status quo.

Further research is needed for the mobility analysis. In the present chapter, the results focus more on persistence (non-mobile groups). However, as in the case of the previously cited social biology literature, it is also necessary to analyse the dynamics between height and socioeconomic status for those who have experienced upward or downward mobility. By doing so, the opportunities for policy intervention can be identified. Moreover, once the relevant data become available, it will be necessary to perform an analysis of more than two generations in order to confirm the intergenerational relationships found in the present chapter.

6.8. Annex

Table 6-3. Oprobit: Endogeneous versus Exogeneous Models

VARIABLES	(1) Endogenous	(2) Exogenous	(1) Endogenous	(2) Exogenous
	Males		Females	
Height				
Height (raw)		0.0338***		0.0401***
		(0.002)		(0.002)
Predicted Value (from OLS)	0.0857***		0.1113***	
	(0.007)		(0.006)	
Birth Cohort				
1962-1970 (omitted)				
1971-1978	-0.3096***	-0.2855***	-0.3524***	-0.3235***
	(0.033)	(0.036)	(0.032)	(0.029)
1979-1986	-0.6823***	-0.5996***	-0.8312***	-0.6806***
	(0.042)	(0.036)	(0.034)	(0.025)
Tercile of Origin				
Tercile 1: lower-class (omitted)				
Tercile 2: middle class	0.4579***	0.5718***	0.1684***	0.1632***
	(0.035)	(0.034)	(0.031)	(0.029)
Tercile 3: upper-class	1.0345***	1.1497***	0.8492***	0.9852***
	(0.040)	(0.045)	(0.028)	(0.037)
Ethnic Group				
Self-declared as non-indigenous (omitted)				
Self-declared as indigenous	-0.2805***	-0.4013***	-0.1596***	-0.3818***
	(0.032)	(0.048)	(0.051)	(0.044)
Rural-Urban				
Lives in rural area (omitted)				
Lives in urban area	0.5480***	0.6668***	0.4688***	0.5856***
	(0.100)	(0.027)	(0.034)	(0.021)
Other				
Urban-Indigenous interaction	0.2064***	0.1647**	0.2072***	0.1646***
	(0.059)	(0.070)	(0.056)	(0.052)
Schooling years	0.1015***	0.0922***	0.1110***	0.1158***
	(0.005)	(0.004)	(0.004)	(0.003)
Constant Cut1	15.1145***	6.5490***	17.6777***	6.8903***
	(1.078)	(0.366)	(0.869)	(0.338)
Constant Cut2	16.2558***	7.7222***	18.9204***	8.1113***
	(1.079)	(0.365)	(0.875)	(0.337)
Observations	7831	9082	10574	12697

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

7. General Summary

The original objective of this dissertation was to fill the gap in the anthropometric history literature on the case of Mexico. For that purpose, I analysed the long-run dynamics of adult average height in Mexico and the influence of the country's environmental/socioeconomic context on this average height. Three main questions guided the course of this study: How did inequality evolve during the period 1951-1992 in Mexico? Did the processes of industrialisation and urbanisation affect the evolution of average height in Mexico? If so, can it be asserted that for such period in Mexico physical stature is determined more by environmental factors rather than biological ones?

Despite the fact that many of the answers to these questions will remain controversial, this study offers some key insights leading to the conclusion that even though Mexico has undergone improvements in education, life expectancy and poverty reduction during the period of study, these have not been sufficient to close the potential gap in the country's height growth. From that perspective, one of the main motivations of the present study was to analyse if the origin gap between socioeconomic groups translates into height inequality that is, ultimately, reflected in high levels of inequality in socioeconomic achievement.

The work starts, firstly, offering a general introduction to the importance of the study of anthropometrics as an approach towards understanding standard of living, given that adult height reflects life quality during childhood. And secondly, I propose the case of Mexico as one of particular interest for four main reasons: i) the post-revolutionary period has not been studied, ii) the country's economy exhibited its longest period of growth during 1930-1980, despite the fact that inequality remained at high levels, iii) the industrialisation that took place after the 1930s, and iv) in terms of the human biology approach, this case study presented an opportunity to analyse a period just after the epidemiological transition took place.

From that perspective, one of the main contributions of this study is the span of time it covers. While previous analyses have focused on the eighteenth, nineteenth and first half of the twentieth century, little research exists to date on Mexico's biological standard of living in the post-revolutionary period.

In chapter two, some of the literature on anthropometric history and the determinants of height are discussed. In chapter three, the methodological steps used to check the data quality of height databases were specified. In particular, in such chapter, the step by step quality analysis is shown by using a specific data set obtained from a Mexican historical archive.

In chapter four, I analyse how inequality has changed in Mexico over 1951-1992 by doing an analysis on adult height trends. Here, the dynamics of average male height in Mexico provides an intuitive understanding of the differences between groups, comparing by age, region and occupation. It also allows for a multivariate estimation of the average height by region. A moderate increase in average height has taken place, but not to do better than other similar economies such as Brazil or Colombia. Moreover, the Mexican height average increase per decade is much lower than the one observed in more developed countries such as the European ones. One plausible explanation for this relatively poor performance can be related to inequality. This hypothesis was explored from different perspectives. As mentioned, even though income inequality decreased during the period 1950-1992, this trend was inverted during the 1980s and, by 1992, its level was still very high. The Gini index accounted for up to 0.475. At a regional level, inequalities remained high, so that from 1950-1990 the improvement in regional disparities was meager.

Regarding socioeconomic differences, approximated by education and location variables, the inequality was also reflected in heights. The estimation shows that both rural females and rural males were shorter than their urban counterparts. Overall, educational disparities were found to exert a significant difference and, while absolute differences emerged as larger among females, in relative terms this gap widened. This result suggests that the socioeconomic inequality captured by school attainment differences is even more pronounced for females.

Concerning school coverage, the analysis shows that despite the widening of educational coverage over the past few decades of the period of study, socioeconomic origin does affect achievement in upper secondary school and even more so in tertiary education.[192] Moreover, the probability of educational achievement as conditional on the father's education level was found to be lower for females than for males. These results suggest that the status quo, including gender inequality, has persisted in Mexico.[193]

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[192] Vélez Grajales, Campos Vázquez, and Huerta Wong. *Informe Movilidad Social en México 2013. Imagina tu futuro*, pp. 32-4.
[193] Ibid.

Another dimension of inequality is explored when analysing the industrialisation that took place after the1930s. The effect of urbanisation on both male and female average height for the period 1953-1982 is analysed in chapter five. While the industrialisation process led to a constant economic growth and to an improvement in several dimensions of living standards during 1940-1980, those improvements were not widespread. After testing the hypothesis of positive but decreasing marginal returns on average height in Mexico and controlling for factors like education attainment and individuals' fathers' first employment, it was found that the size of the place of origin was positively correlated with both women's and men's heights.

Overall, urbanisation was positively correlated, but a decreasing rate, with both women's and men's heights. This result suggests that urbanisation had a positive effect on heights but that, at the same time, there were costs that reduced the net effect of these benefits. This also suggests that part of the economic and social benefits of the high concentration of economic activity around metropolitan areas were overcompensated for by the negative effects of overcrowding.

To test the hypothesis that the high-levels of inequality might have had a negative effect on the potential height in Mexico, the data in the last part of the study show that for both males and females, one's wealth background makes a difference in terms of height: those coming from the upper classes were seen to be taller. Another key finding was that the father's education had a positive effect on females' height, and the mother's on males' height. Moreover, being from an indigenous group or living in rural areas negatively impacted height. Finally, younger cohorts and northern regions were seen to have taller individuals.

In chapter six, containing the analysis of social mobility, the study shows that a taller height among both males and females increases the probability of reaching the upper tercile and reduces the probability of descending to the bottom tercile. It should be noted, firstly, that such effects stay in place even after the wealth tercile of origin is controlled for and, secondly, that even the magnitude of the height effect is not the biggest one among all explanatory variables; rather, it is similar for both males and females in relation to the schooling years variable. And, again, being from an indigenous ethnic group and rural location reduces the probability of upper tercile achievement, and the interaction between them reinforces their negative effect. In the case of the probability of ending up in tercile two, further empirical analysis is needed to identify the main determinants.

In relation to socioeconomic achievement, these results are also consistent with evidence in the literature. Once endogeneity is controlled for, each additional centimetre increases the probability of males being in the upper tercile by around three percentage points, and reduces the probability of being in the bottom tercile also by three percentage points. In the case of females, the effect is even bigger: each additional centimetre increases their probability of being in the upper tercile by 3.6 percentage points, and reduces the probability of being in the bottom tercile by almost the same percentage.

Finally, regarding intergenerational mobility, the results are consistent with the literature review: additional centimetres increase the probability of achieving upper class status (and reduce that of ending up in the lower classes), even when the socioeconomic status of origin is controlled for. In conclusion, the historical context suggests that Mexico's distributional dynamics have disabled higher rates of average height growth. Moreover, as both a cause and an effect of the previous result, no convergence in height among terciles can be observed.

These results are consistent with the distributional income dynamics during the period of socioeconomic achievement for the analysed birth cohorts: the origin gap between socioeconomic groups is reflected in the one pertaining to net nutritional status (i.e., height). It can be seen that nutritional inequality translates into high and constant levels of inequality in terms of socioeconomic achievement and that, therefore, Mexico has become a society in which the socioeconomic status quo persists generation after generation.

These results reveal Mexico to be a country in which the options of upward-downward mobility are reduced. Therefore, even though economic growth, food production and poverty reduction showed a positive performance during almost the whole period under study, the results on nutritional status suggest that such improvements have not been sufficient enough for Mexico to converge to similar international experiences. It was expected that, given the country's observed economic performance there would be, at least, a reduction in the height differences between socioeconomic terciles. However, a vicious, intergenerational circle pertaining to the socioeconomic, status-adult height relationship can be observed, maintaining the persistence of the status quo. It thus follows that physical stature in Mexico seems to be more determined by environmental than biological alone factors.

These results provide key insights for public policies that intend to tackle inequality and promote social mobility. First of all, the historical experiences that took place in the period of study show that economic growth is not the only dimension to take into account when measuring differences in living standards among the population. Secondly, the costs of concentration of economic activity derived from industrialisation ultimately had a negative impact on citizens' biological wellbeing, since the agglomeration strategy did not ensure the reduction of inequalities within regions, even if there was migration from rural-urban areas. In fact, according to the obtained results, migration seems to be the key factor explaining overcrowded areas. In third place, regarding gender gap, it is clear that relative differences by school level are greater for women than for men. These socioeconomic differences are still reflected in height, and it is also plausible that such differences have not been eliminated through improvements in public services. In addition, the size of the women's differences suggests that such improvements are not accessible to all.

Finally, some questions remain open for further research. For instance, even though migration seems to be a key variable explaining the height penalty for more overcrowded areas, in a context of low inter-generational social mobility it is possible that migration to those areas is negatively selected. Another aspect was that of limitations due to missing data. Since for such analysis a period of 30 years was studied, it was not possible to capture inter-generational changes. In any case, it should be noted that social patterns should not differ entirely between two immediate generations, even after considering migration; if that is the case then not all changes in the local environment will impact adult children's height.

In the present dissertation, the results focused on persistence (non-mobile groups). However, as in the case of the social biology literature, it is also necessary to analyse the dynamics between height and socioeconomic status for those who have experienced upward or downward mobility. By doing so, the opportunities for policy intervention can be identified more effectively. Moreover, once the relevant data become available, it will be necessary to perform an analysis of more than two generations in order to confirm the intergenerational relationships found in the present study. Further research is also needed to evaluate the extent to which there exists an optimal urbanisation/overcrowding degree, where the difference between the total benefits and total costs reaches its maximum.

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