



Department of Economics Discussion Paper Series

Monetary Capacity

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Number 926
November, 2020

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November 12, 2020

Abstract

Monetary capacity refers to a state's capacity to circulate money that is accepted by the public, while fiscal capacity refers to its capacity to tax. We argue that monetary and fiscal capacity, and by extension, markets and states are complements. The long-run European evidence since antiquity shows money stocks and tax revenues moving in close synchrony. History also offers a natural experiment to estimate the causal effect of monetary capacity on fiscal capacity. The discovery of silver in the New World increased money stocks followed by tax revenues, a finding that is robust to controlling for economic growth.

JEL Codes: E50, E60, H21, N10, O11

Keywords: monetary capacity, fiscal capacity, monetization, inflation, taxation, quantity theory of money, monetary non-neutrality.

*We thank Tim Besley, Eric Chaney, David van Dijke, İlkay Kiriscioglu, Patrick O'Brien, Sevket Pamuk, Rick van der Ploeg, Itzhak Rasooly, Felix Ward, Nikolaus Wolf, and seminar participants at Humboldt-University Berlin, the University of Manchester and the University of Oxford for valuable feedback. K. Kıvanç Karaman was supported by Bogazici University Research Fund, project number 16141. Nuno Palma acknowledges financial support from Fundação para a Ciência e a Tecnologia (CEECIND/04197/2017).

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1 Introduction

Even a cursory review of long-run evidence hints at a close relationship between monetization and taxation. Breakdowns of monetary systems tend to bring about falling tax revenues and the collapse of government authority, while fiscally troubled states fail to issue and circulate their own money. Understanding this two-way relationship is central to both the study of economics and politics, since markets cannot function without money, and states without taxes. Beyond the anecdotal evidence, however, there is a lack of studies that formally model how monetization and taxation interact, empirically identify the causal effects, and put this relationship in historical perspective.

In this study, we address each of these three points in turn. First, building on long-run evidence, we lay out a theoretical model that explains why monetization and taxation are co-determined. Second, relying on a natural experiment associated with the massive inflow of silver and gold from the New World, we estimate the causal effect of monetization on taxation for early modern England, France and Spain. Finally, we put the model and the empirical results in historical perspective, relying on monetary and fiscal data for Europe since antiquity. The results indicate that economic and political development are interdependent, and money is not neutral in the long run.

In broad terms, our paper investigates the relationship between monetary and fiscal capacity. We define monetary capacity as a state's capacity to provision and circulate money that is accepted by the public, which in turn determines the monetization level of the economy. This capacity depends on demand-side factors, such as the public's willingness to accept state-issued money.¹ It also depends on supply-side factors, which, in the commodity money era, included the availability of silver and gold. Fiscal capacity, on the other hand, is defined as a state's administrative and political capacity to raise taxes, and determines the level of taxation (Besley and Persson, 2011, 2009). This capacity depends on the physical infrastructure, bureaucratic know-how and coercive capabilities of the state.

¹We focus on state-issued money, because historically, private forms of money rarely circulated at the national level, did not last long without government backing, and complemented state-issued money rather than displacing it.

Our theoretical model builds on two insights. The first insight is that the public demand for money decreases with the expected inflation rate. The second is that a higher monetization level eases the collection and administration of taxes. It eases the collection, because it expands the role of markets, and markets are easier to monitor and tax than nonmarket activities. Monetization also eases the administration of taxes, because once collected, money taxes can be conveniently transported and governed in a centralized way, whereas taxes in kind cannot.

In a two-period model, we show that these insights together imply a dynamically reinforcing relationship between monetary and fiscal capacity. On the one hand, greater monetary capacity induces a government to invest in building fiscal capacity, because it is more convenient to tax a monetized economy. On the other, greater fiscal capacity induces the public to hold more money, because expected inflation is lower. In the long-run, monetary and fiscal capacity depend on each other. Furthermore, any exogenous increase or disruption in monetary capacity spills over to fiscal capacity, and vice versa.

On the empirical front, we estimate the causal impact of monetary capacity on fiscal capacity. We focus on the impact of monetary on fiscal capacity, because it has received less attention in the empirical literature than the converse impact of fiscal on monetary capacity.² For estimation, we rely on a Local Projection Instrumental Variable (LP-IV) approach, which yields consistent estimates even at long horizons. For identification, we rely on the unique historical experiment offered by the discovery of precious metals in the New World, and the exogenous variation it generated in European money stocks (Palma, 2019). For the sample period, we restrict attention to the period after 1550, when American silver began to arrive in large quantities, and before 1790, when paper monies increasingly replaced commodity money and weakened the link between precious metals and money stocks. For the sample countries, we restrict attention to England, France and Spain, as these countries were heavily impacted by the New World shock, and have detailed historical data for both monetization and taxation

The empirical results identify a significant and substantial causal impact of monetary capacity on fiscal capacity. In the first stage, an increase in the production of precious metals in the

²For the latter impact, see, among others, Catao and Terrones (2005), Karaman et al. (2020) and Sargent (1982).

Americas increased monetary capacity, as proxied by the per capita real money stock. In the second stage, a 1% increase in monetary capacity increased fiscal capacity by 0.5%- 1% within a decade, and this impact did not diminish over the course of subsequent decades. These findings are robust after controlling for income, wars and political regime. Likewise, the findings remain robust after accounting for potential violations of the exclusion restriction, relying on the adjusted impulse responses methodology of Jordà et al. (2020a).

Lastly, we put these empirical results into broader historical context by collecting the fragmentary data available for earlier periods and other parts of Europe. The resulting patterns support the notion of a close relationship between precious metals, monetization and taxation. Before 1500, we find large swings in monetary and fiscal capacity, with peaks at the 5th century BC Athens, the first two centuries AD Rome, and early 14th century, and with troughs in between. We also find that each of these three peaks was associated with surges in silver production, respectively at Laurion, Iberian and central European mines.

For the period between 1500 and 1800, we collect the fragmentary monetary and fiscal estimates available for the Dutch Republic, Portugal, the Ottomans, Poland-Lithuania and Russia, and put them in a comparative perspective with the English, French and Spanish data analyzed in the empirical section. Figure 1 summarizes the resulting patterns. The top panel plots the relationship between money stock per capita and tax revenue per capita, in grams of silver, for eight states over three centuries. The middle panel plots the money stock per capita and tax revenue per capita, after dividing them both by the cost of a standard consumption basket, in order to account for the changes in price levels. Finally, the bottom panel plots the two variables after dividing them by the nominal wages, in order to account for changes in incomes.

The review of the comparative evidence identifies several patterns. For one, the evidence corroborates the notion that the New World shock resulted in an unprecedented increase in monetization levels, breaking the cycles of monetization and demonetization that had characterized European history until then. Secondly, the impact of the shock on the monetization levels was real, in the sense that money stocks increased more than prices and incomes. Third, the impact of the shock was asymmetric, in the sense that it primarily affected Western Europe, and diffused to the East only in limited amounts, leading to a divergence in monetization

levels. Taken together, the continent-wide evidence corroborates the close relationship between monetary and fiscal capacity, as consistent with the theoretical model and the earlier empirical results.

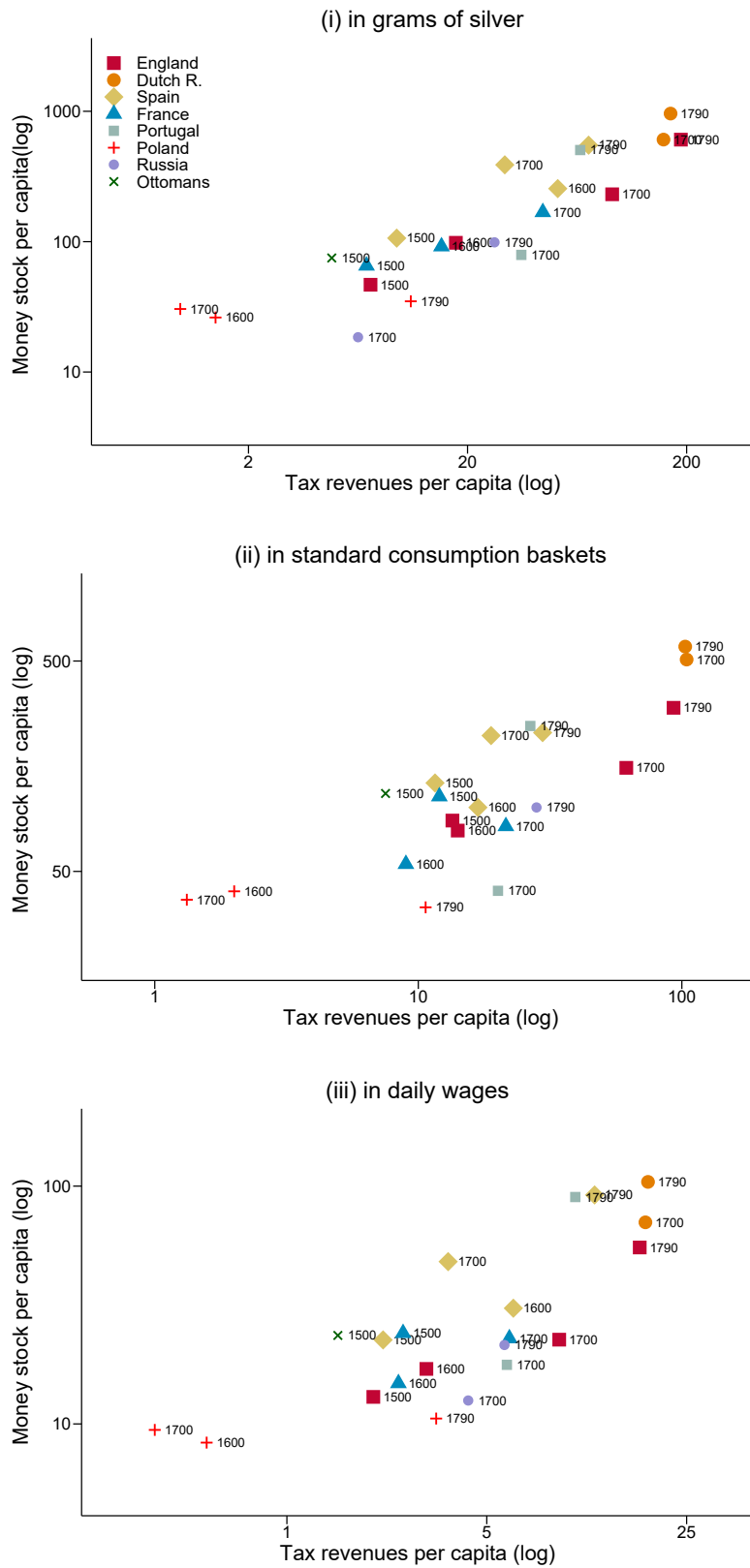
The main contribution of the paper is to establish theoretically and empirically that monetary and fiscal capacity, and in more general terms, markets and states are interdependent. Markets and states are often conceptualized as alternative methods of allocating resources and governing social interactions. This characterization is incomplete, however, as they also depend on each other to function. Markets, and by extension, a monetized and commercialized economy facilitates state-building, while a strong state fosters monetization. We also document that this interdependence is not merely a theoretical possibility. Rather, the co-movement of monetary and fiscal capacity has been a defining and robust characteristic of the European political economy since antiquity.

The co-evolution of monetary and fiscal capacity matters because they shape economic performance. Fiscal capacity allows states to integrate domestic markets, provide public goods, and solve externality problems. It also promotes growth by financing legal capacity and the protection of property rights (Besley and Persson, 2011, 2009; Besley et al., 2013). Monetary capacity, on the other hand, is itself a public good that pervades all sectors of the economy. It lowers transaction costs and facilitates trade and investment (Irigoin, 2009a,b, 2013; Palma, 2018a, 2019b). Hence, understanding the evolution of monetary and fiscal capacity helps understand the patterns of long-run economic growth.

The findings also offer new insights on one of the central ideas in macroeconomics, the long-run neutrality of money. The common wisdom in the literature is that money is neutral in the long run: an increase in money supply has no real effects and only leads to a proportional increase in the price level.³ In contrast, we find that it did have a real long-run effect, in the form of an increase in fiscal capacity. The reason for this positive effect is that historically large segments of economies were not sufficiently monetized. Following a positive monetary shock, money penetrated into these under-monetized segments. Prices increased, but less than proportionally, because now a greater share of the economic activity relied on money. The

³See, however, Brzezinski et al. (2019); Jordà et al. (2020b); Palma (2018a, 2019a).

Figure 1: Per Capita Money Stocks and Tax Revenues



growing monetization in turn facilitated market transactions and increased tax revenues. Hence, the effects of the increase in money supply were real and had economic as well as political implications.

In the same vein, our findings relate to the literature on the trade-off between monetary expansion and taxation (Mankiw, 1987; Sargent and Wallace, 1981; Sims, 1994). The common wisdom in the literature is that states can raise revenue by either increasing taxes or increasing money supply, the latter of which in turn increases the price level. Hence, in the short run, increasing taxes and increasing money supply are substitutes. We find in this study that, over the long run, the relationship is more complex. In under-monetized economies, if the money supply expands in a way that provides liquidity to new regions or sectors, it also improves the tax collection, triggering a virtuous cycle of monetary and fiscal capacity-building. Hence, in the long run, monetization and taxation are in fact complements.

The remainder of the paper is structured as follows. Section 2 describes our model. Section 3 discusses the new dataset and empirical results. Section 4 puts the evolution of monetary and fiscal capacity in historical context. Section 5 concludes.

2 Model

In this section, we construct a simple model that investigates the relationship between monetary and fiscal capacity. In a two-period, perfect information setup, we establish that a positive shock to fiscal capacity increases monetary capacity, because economic agents expect a lower future inflation tax. In a symmetric fashion, a positive shock to monetary capacity spills over to fiscal capacity, because it induces the state to invest in building the capacity to tax the money economy. Below, we introduce the model, solve for the equilibrium and the comparative statistics, and interpret the results.

2.1 Setup

Consider an economy inhabited by a multitude of private agents, which lasts for two periods. Aggregate income is equal to 1 in both periods. Preferences are linear in consumption, and

in a public good g_s provided by the government. While consumption receives weight one in preferences, the public good receives weight α_s , a random variable which takes value $\alpha > 0$ with probability π , and value zero with probability $1 - \pi$. The public good can be interpreted as expenditure in defence, and the case $\alpha_s = \alpha$ as one in which the country must fight an external war in period s .

Income can be seen as the sum of the value added generated in a multitude of transactions taking place in each period. A share m_s of these transactions is conducted using money, as opposed to barter. As explained below, the share for period one is exogenously given, while the share for period two is determined by agents at the end of period one. We will refer to m_s as to the economy's degree of monetization.

The public good is produced using a decreasing returns to scale technology. To keep things simple, we assume a stark technology: up to γm_s units of the public good (where $0 < \gamma < 1$) can be produced at a one-to-one transformation ratio with the consumption good, while the marginal cost of producing additional units is prohibitively high. This implies that optimal production is zero if $\alpha_s = 0$, and γm_s if $\alpha_s = \alpha$. The assumption that maximum production is proportional to the monetary economy ensures that public expenditures are proportional to public revenues. It is a simplifying assumption which does not affect the results qualitatively.

In each period, the government can impose an inflation tax i_s , inflicting a loss $i_s m_s$ on private agents and yielding revenues $\delta i_s m_s$.⁴ We assume $1 > \delta > 1/\alpha$. By the first inequality, the inflation tax is inefficient, since it generates a higher cost on private agents than it generates revenues for the government. The second inequality ensures that, despite its inefficiency, the inflation tax is desirable as a last-resort source of revenues in case of war.

The government can also impose a tax on transactions. The key modelling assumption for taxation is that it was easier to tax money transactions than barter transactions and non-market economic activity. This assumption reflects the insight that monetized transactions were easier to monitor and assess (Bonney, 1995; Tilly, 1990). Furthermore, once collected, money taxes could be transported to the central treasury and redistributed back across the country, making

⁴With fiat money, the government imposed the tax by printing more of it. With commodity silver or gold money, states reminted old coins that were delivered to the mint with less silver or gold, paid the agents that delivered the coins with these new depreciated coins, and appropriated the difference.

fiscal centralization feasible. In contrast, in-kind taxes were primarily spent locally, often leaving the central government little effective say on their use (Vries, 2015, p. 124).

To capture the insight that a monetized economy is more convenient to tax, it is assumed that the government can impose the tax, t_s , only on money transactions. This strong assumption is made to simplify the model and can be relaxed to allow for taxation of barter, as long as it is more difficult than taxing the money transactions. The tax inflicts a loss $t_s m_s$ on private agents, generating an equal amount of revenues for the government. To keep the model simple, we assume that the inflation and transaction taxes are additive: they inflict a total cost $(t_s + i_s) m_s$ on private agents.

We have assumed that the transaction tax is more efficient than the inflation tax: while the former yields one unit of revenues per each unit paid by agents, the latter only yields δ units. This assumption is a crucial. As further clarified below, it implies that the government strictly prefers to raise revenues through the transaction tax, which in turn implies that greater fiscal capacity creates the expectation of a lower inflation tax.⁵

Central to the model is the notion of monetary capacity. It refers to a state's capacity to issue and circulate money that is accepted by the public and it determines the monetization level of the economy. Monetary capacity depends on both the demand and the supply for money. On the demand side, to the extent that a government can commit to not imposing an inflation tax, agents will choose to conduct transactions in money rather than in kind, and monetary capacity will increase. In our model, money demand is endogenous, as private agents optimally choose the degree to which they rely on money for transactions (m_s). On the supply side, to the extent that a government has access to precious metals and can organize the production and circulation of money, monetary capacity will increase. In our model, the supply-side determinants of monetary capacity are exogenous, and captured by the parameter ϕ_μ .⁶

⁵This assumption could be micro-founded in a model in which the two taxable bases were made endogenous. To the extent that agents can choose not to conduct transactions in money in order to avoid the inflation tax (or to conduct them using a foreign currency), but they cannot choose not to conduct transactions at all in order to avoid the transaction tax, the taxable base of the inflation tax would be more elastic than that of the transaction tax, making the former less efficient than the latter. The argument relies on all type of transactions being subject to the transaction tax to some extent, including transactions in kind. While we have ruled this out in the model, it is of course true in reality.

⁶We model these supply-side determinants as exogenous for simplicity, and to be consistent with the empirical part of the paper. There, the identification comes from an exogenous increase in the European states' capacity

Agents choose monetization one period in advance, in accordance with their expectations about monetary capacity. Since the supply-side determinants of monetary capacity are exogenous, the key determinant of these expectations is the government's capacity to commit to a low future inflation tax. When this capacity is high, agents expect a low future inflation tax, or, in other words, they expect the monetary capacity to be high. They thus choose a high future level of monetization. In equilibrium, the government is able to commit to a low future inflation tax by investing in fiscal capacity, since it is against the government's interest to raise revenues through the inflation tax when it can do so through the more efficient transaction tax. Given this lag in decisions, monetization in period one (m_1) is exogenously given. In contrast, monetization in period two (m_2) is determined at the end of period one, based on the expectations about the monetary capacity.

More formally, agents set monetization in period two as

$$m_2 = \mu_2 \left(\begin{array}{c} i_2^e + t_2^e \\ - \\ \phi_\mu \\ + \end{array} \right),$$

where the function μ_2 denotes monetary capacity.⁷ This monetary capacity function is increasing in ϕ_μ , the parameter capturing exogenous supply factors. In addition, the function is decreasing in the expected value of taxes on the monetary economy, $i_2^e + t_2^e$. These variables capture the demand factors described above: when the government can commit to a low future tax on the monetary economy, expectations will reflect this, resulting in a high expected monetary capacity and the choice of a high degree of monetization in period one. Note that, by assumption, monetary transactions are hit by the transaction tax as well as by the inflation tax. However, because the former tax is more efficient, in equilibrium, higher fiscal capacity in period two will result not only in a lower i_2 , but also in a lower $i_2 + t_2$, thus increasing monetary capacity.

to supply money, due to an increasing availability of precious metals from the New World. In reality, a state's capacity to supply money was not shaped solely by the availability of precious metals, but also depended on the state's capacity to organize the production of money, which itself was endogenous to fiscal capacity. If included in the model, such feedback from fiscal to monetary capacity would strengthen the mutual dependence between the two that the model identifies.

⁷We use a greek letter to denote monetary capacity, to be consistent with the literature on fiscal capacity. This uses a greek letter, τ_t , to denote fiscal capacity, even though this is an endogenous variable. In the rest of our notation, we stick to the more general convention of using greek letters to denote parameters.

The function μ_2 is assumed to take a value between zero and one, to be twice continuously differentiable, and to satisfy the condition: $\partial^2 \mu_2 / [\partial(i_2^e + t_2^e) \partial \phi_\mu] \leq 0$.⁸ In words, if monetization increases due to exogenous shocks, it remains at least as responsive to changes in tax rates as it was before. Intuitively, the higher the share of transactions conducted using money, the more responsive the share should be to changes in the cost of holding money.⁹

In each period, the transaction tax cannot exceed the government's current fiscal capacity. Fiscal capacity in period one is exogenously given. We represent it by the function $\tau_1 \left(\begin{smallmatrix} \phi_\tau \\ + \end{smallmatrix} \right) \in (0, 1)$, where the parameter ϕ_τ captures all the exogenous supply factors that may increase the government's fiscal capacity. Increasing fiscal capacity to $\tau_2 > \tau_1(\phi_1)$ costs $F[\tau_2 - \tau_1(\phi_1)]$, where F is a continuously differentiable, increasing and convex function. There is a maximum attainable level of fiscal capacity, $\bar{\tau} \in [\tau_1(\phi_1), 1]$. To ensure that the government's problem has an interior solution, we also assume $F'(0) = 0$ and $F'[\bar{\tau} - \tau_1(\phi_1)] = \infty$.

Finally, we assume $\delta[1 - \tau_1(\phi_1)] + \tau_1(\phi_1) - F[\bar{\tau} - \tau_1(\phi_1)]/m_1 > \gamma > \bar{\tau}$. The first inequality ensures that the government can always generate enough revenues (net of investment in fiscal capacity) to provide the optimal amount of the public good. The second inequality ensures that in the "war scenario", the government must resort to the inflation tax. This assumption narrows down the analysis to the case of interest.

2.2 Timing and government objectives

The timing of the game is as follows:

- Period one:
 - Nature sets α_1 .
 - The government sets i_1 , t_1 and τ_2 .
 - Private agents set m_2 . The public good is produced, payoffs realise.
- Period two:

⁸The function μ_2 could be micro-founded using a standard shopping-time model.

⁹This assumption could be relaxed, since it is only sufficient (but not necessary) for our results. That the assumption is only sufficient for the results can be appreciated by inspecting condition (9) below.

- Nature sets α_2 .
- The government sets i_2 and t_2 .
- The public good is produced, payoffs realise.

Instantaneous indirect utility in period s is equal to

$$v_s = 1 - (i_s + t_s) m_s + \alpha_s g_s,$$

while V_s denotes inter-temporal utility. The government maximises $V_2 = v_2$ with respect to i_2 and t_2 in period two, and $V_1 = v_1 + v_2^e$ with respect to i_1 , t_1 and τ_2 in period one.

2.3 Equilibrium

We now derive the equilibrium of the model. We begin by stating the key relationship between endogenous variables:

Result 1. *Greater investment in future fiscal capacity (a higher τ_2) leads to a higher monetary capacity and future monetization (higher μ_2 and m_2).*

Proof. We solve for the equilibrium using backward induction. The government's problem in period two is

$$\begin{aligned} \max_{i_2, t_2} \quad & 1 - (i_2 + t_2) m_2 + \alpha_2 g_2 \quad \text{s.t.} \\ & g_2 \leq (\delta i_2 + t_2) m_2 \\ & t_2 \leq \tau_2. \end{aligned}$$

If $\alpha_2 = 0$, then the optimal expenditure is zero, and the solution to the government's problem is $i_2 = t_2 = 0$. If $\alpha_2 = \alpha$, then the optimal expenditure is γm_2 . Given that the inflation tax is less efficient a source of revenues than the transaction tax, the government first sets the transaction tax to its highest possible level, and then finances the remaining expenditure through the inflation

tax.¹⁰

$$t_2^* = \tau_2 \quad (1)$$

$$i_2^* = \frac{\gamma - \tau_2}{\delta}. \quad (2)$$

At the end of period one, forward-looking agents set $i_2^e = \pi i_2^*$ and $t_2^e = \pi t_2^*$. They then set

$$\begin{aligned} m_2^* &= \mu_2 \left(\pi \frac{\gamma - \tau_2 (1 - \delta)}{\delta}, \phi_\tau \right) \\ &= \mu_2 \left(\begin{matrix} \tau_2 & \phi_\mu \\ + & + \end{matrix} \right). \end{aligned} \quad (3)$$

The function $\mu(\tau_2, \phi_\mu)$ is increasing in τ_2 , proving the result. \square

Investment in future fiscal capacity guarantees that the government will finance a greater portion of future expenditure through the transaction tax, rather than the inflation tax. Since the former is less distortionary, this amounts to a lower future taxation of the monetary economy, or greater monetary capacity. The greater monetary capacity induces agents to increase future monetization. Thus, Result 1 implies that investment in fiscal capacity serves two purposes: It increases public revenues and is a commitment device that paves the way for an increase in monetary capacity.

Consider now the government's problem in period one. Once future choices (1)-(3) are taken into account, the expected period two instantaneous utility, v_2^e , is only a function of τ_2 . Then, the government's problem is

$$\begin{aligned} \max_{i_1, t_1, \tau_2} \quad & 1 - (i_1 + t_1) m_1 + \alpha_1 g_1 + v_2^e(\tau_2) \quad \text{s.t.} \\ & g_1 + F[\tau_2 - \tau_1(\phi_\tau)] \leq (\delta i_1 + t_1) m_1 \\ & t_1 \leq \tau_1(\phi_\tau). \end{aligned}$$

By an earlier assumption, the government can always raise enough revenues to pay for both

¹⁰Note that the constraint $t_2^* + i_2^* < 1$ is always satisfied. To see this, recall assumption $\delta(1 - \tau_1) + \tau_1 - F[\tau_2 - \tau_1(\phi_\tau)]/m_1 > \gamma$. Since $\tau_2 \geq \tau_1$ and $F \geq 0$, this assumption implies $\delta(1 - \tau_2) + \tau_2 > \gamma$, which can be re-arranged as $\tau_2 + (\gamma - \tau_2)/\delta < 1$, or $t_2^* + i_2^* < 1$.

the optimal expenditure on the public good and for the optimal investment in fiscal capacity. It follows that the optimal investment problem can be solved as the stand-alone problem,

$$\begin{aligned}\max_{\tau_2} V_1(\tau_2) &= k - \lambda F[\tau_2 - \tau_1(\phi_\tau)] + \pi \left[\alpha\gamma - \left(\frac{\gamma - \tau_2}{\delta} + \tau_2 \right) \right] \mu_2(\tau_2, \phi_\mu) \\ &= k - \lambda F[\tau_2 - \tau_1(\phi_\tau)] + \pi \frac{(\delta\alpha - 1)\gamma + (1 - \delta)\tau_2}{\delta} \mu_2(\tau_2, \phi_\mu),\end{aligned}$$

where k is an expression which does not depend on τ_2 , and $\lambda \in \{1, 1/\delta\}$ is the opportunity cost of public revenues in period one.

The solution to this problem satisfies the first-order condition

$$\frac{\partial V_1(\tau_2)}{\partial \tau_2} = 0, \quad (4)$$

which can also be written as

$$\lambda F'[\tau_2 - \tau_1(\phi_\tau)] = \overbrace{\pi \frac{1 - \delta}{\delta} \mu_2(\tau_2, \phi_\mu)}^I + \overbrace{\pi \frac{(\delta\alpha - 1)\gamma + (1 - \delta)\tau_2}{\delta} \left(\frac{\partial \mu_2(\tau_2, \phi_\mu)}{\partial \tau_2} \right)}^{II}. \quad (5)$$

The second-order condition is

$$\frac{\partial^2 V_1(\tau_2)}{\partial (\tau_2)^2} < 0. \quad (6)$$

Equation (5) clearly illustrates the trade-off faced by the government. It equalises the marginal cost of investment in fiscal capacity, $\lambda F'[\tau_2 - \tau_1(\phi_\tau)]$ to its marginal return. As anticipated, the latter can be decomposed into two parts. First, investment in fiscal capacity increases future revenues (term *I*). This term is increasing in monetary capacity, which increases the future taxable base. Second, it allows the government to commit to a low future inflation tax, thus increasing monetary capacity (term *II*).

Exploring (5), one finds that there is always an internal solution to (4) and (6). However, the solution is not necessarily unique.¹¹ Thus, the solution to the optimal investment problem,

¹¹To see that the solution might not be unique, note that the marginal cost on the left-hand side of (5) is a standard marginal cost curve, which continuously increases from zero to infinity as τ_2 increases from τ_1 to $\bar{\tau}$.

τ_2^* , may have to be chosen between alternative solutions to (4) and (6). These complications are of no consequence for our purposes, since we are not interested in the solution per se. We are instead interested in the comparative statics of the solution, which, as will be clear momentarily, is the same for all solutions.

For completeness, we conclude by solving the rest of the government problem. If $\alpha_1 = 0$, then optimal expenditure on the public good is zero, implying that taxes are set to the minimum required to pay for investment in fiscal capacity. If $\alpha_1 = \alpha$, then

$$t_1^* = \tau_1(\phi_\tau) \tag{7}$$

$$i_2^* = \frac{\gamma + F[\tau_2^* - \tau_1(\phi_\tau)]/m_1 - \tau_1(\phi_\tau)}{\delta}. \tag{8}$$

After solving for the equilibrium (t_1^* , i_1^* , τ_2^* , m_2^* , t_2^* and i_2^*), we next turn to the comparative statics.

2.4 Comparative statics

In the short run, that is, taking monetary and fiscal capacity as given, monetary expansion (higher inflation) and higher taxes are clearly substitutes since they are alternative tools to generate revenues (see equations 1-2 and 7-8).¹²

In the long run, however, monetary and fiscal capacity are endogenous. The central result of the paper establishes that, in this long-run setup, monetary and fiscal capacity, and thus, monetary expansion and higher taxes, are complements.

Proposition 1. *An exogenous positive shock to monetary capacity (ϕ_μ) increases both monetary capacity (μ_2^*) and fiscal capacity (τ_2^*) in period two. Likewise, an exogenous positive shock to fiscal capacity (ϕ_τ) increases both monetary capacity and fiscal capacity in period two.*

However, the marginal benefit on the right-hand side might also be increasing in τ_2 , because term I is increasing, and the shape of term II depends on the sign of the second derivative of $\mu_2(\tau_2, \phi_\tau)$, which we have not made any assumption on. To see that an internal solution exists, note that the curve on the right-hand side of (5) is a continuous function, and it is positive and finite for both $\tau_2 = \tau_1$ and $\tau_2 = \bar{\tau}$. Given the properties of the curve on the left-hand side, the latter must cross the former at least once from below. At that point, both (4) and (6) are satisfied.

¹²For example, suppose there was a temporary shock which increased fiscal capacity from τ_s to $\tau_s + \epsilon$. In response, the government would increase t_s by ϵ , and reduce i_s (by ϵ/δ).

Proof. Note first that

$$\begin{aligned}\frac{\partial^2 V_1(\tau_2)}{\partial \tau_2 \partial \phi_\mu} &= \pi \frac{1 - \delta}{\delta} \frac{\partial \mu_2(\tau_2, \phi_\mu)}{\partial \phi_\mu} + \pi \frac{(\delta \alpha - 1) \gamma + (1 - \delta) \tau_2}{\delta} \left(\frac{\partial^2 \mu_2(\tau_2, \phi_\mu)}{\partial \tau_2 \partial \phi_\mu} \right) > 0 \\ \frac{\partial^2 V_1(\tau_2)}{\partial \tau_2 \partial \phi_\tau} &= \lambda F'' [\tau_2 - \tau_1(\phi_\tau)] \frac{\partial \tau_1(\phi_\tau)}{\partial \phi_\tau} > 0,\end{aligned}\quad (9)$$

where the first inequality follows from the fact that, by assumption, $\partial^2 \mu_2 / (\partial \tau_2 \partial \phi_\mu) = -\partial^2 \mu_2 / (\partial i_2^e \partial \phi_\mu) \geq 0$.

Consider any solution τ_2^* to (4) and (6). The total differential of $\partial V_1(\tau_2^*) / \partial \tau_2^* = 0$ with respect to ϕ_μ is

$$\begin{aligned}\frac{\partial^2 V_1(\tau_2^*)}{\partial \tau_2^* \partial \phi_\mu} d\phi_\mu + \frac{\partial^2 V_1(\tau_2^*)}{\partial (\tau_2^*)^2} d\tau_2^* &= 0 \\ \frac{d\tau_2^*}{d\phi_\mu} &= -\frac{\frac{\partial^2 V_1(\tau_2^*)}{\partial \tau_2^* \partial \phi_\mu}}{\frac{\partial^2 V_1(\tau_2^*)}{\partial (\tau_2^*)^2}} > 0.\end{aligned}\quad (10)$$

Given (10), since $\mu_2^* = \mu_2(\tau_2^*, \phi_\mu)$ is an increasing function of both its arguments, it immediately follows that $d\mu_2^*/d\phi_\mu > 0$. The total differential of $\partial V_1(\tau_2^*) / \partial \tau_2^* = 0$ with respect to ϕ_τ is

$$\begin{aligned}\frac{\partial^2 V_1(\tau_2^*)}{\partial \tau_2^* \partial \phi_\tau} d\phi_\tau + \frac{\partial^2 V_1(\tau_2^*)}{\partial (\tau_2^*)^2} d\tau_2^* &= 0 \\ \frac{d\tau_2^*}{d\phi_\tau} &= -\frac{\frac{\partial^2 V_1(\tau_2^*)}{\partial \tau_2^* \partial \phi_\tau}}{\frac{\partial^2 V_1(\tau_2^*)}{\partial (\tau_2^*)^2}} > 0.\end{aligned}\quad (11)$$

Given (11), it again follows from the properties of $\mu_2^* = \mu_2(\tau_2^*, \phi_\mu)$ that $d\mu_2^*/d\phi_\tau > 0$. \square

To interpret this result, note first that an exogenous positive shock to monetary capacity (ϕ_μ) not only increases monetary capacity (μ_2^*) and actual monetization levels in the second period (m_2^*), but also the second-period fiscal capacity (τ_2^*) and actual tax collection (t_2^*). This impact works by easing tax collection and hence incentivizing the government to invest in future fiscal capacity. In the empirical section, we test this prediction, relying on the exogenous positive shock to monetary capacity due to the discovery of silver and gold in the New World.

Secondly, in a symmetric fashion, the model predicts that an exogenous positive shock to fiscal capacity increases not only the second-period fiscal capacity and actual tax collection, but also monetary capacity and actual monetization levels in the second period. This impact works by lowering the inflation expectations of the private agents, and making them hold more money.¹³

Lastly, these two effects do not work independently, but rather reinforce and magnify each other. This mutual dependence does not necessarily imply a virtuous cycle of monetary and fiscal capacity building, however. Just as a positive exogenous shock to one is predicted to spill over to the other, so does a negative exogenous shock. Hence, the model predicts that monetary and fiscal capacity move together, but depending on the particulars of the sequence of exogenous shocks to the system, the trajectory of their co-movement might change course.

In the long run, since monetary and fiscal capacity are complements, so are monetary expansion and higher taxes. To see this, it is sufficient to note that an increase in monetary capacity implies a monetary expansion: It implies greater monetization, which will typically require a greater nominal money supply.¹⁴

3 Empirical analysis

The theoretical model in the previous section predicts that an exogenous positive shock to monetary capacity increases fiscal capacity, and a positive shock to fiscal capacity increases monetary capacity. This section tests the first of these predictions, the causal impact of monetary capacity on fiscal capacity. The reason we focus on the impact of monetary capacity is that it is less well-understood and has received less attention in the empirical literature than the impact of fiscal capacity.¹⁵ Moreover, the natural experiment associated with the discovery of massive amounts

¹³In this setup, the impact of fiscal capacity on monetary capacity works through the money demand channel. We do not formally model the potential impact through the money supply channel. If, as historical evidence suggests, a higher fiscal capacity affords states greater ability to produce and circulate money (Depeyrot, 2020; Karaman et al., 2020), this impact would complement the money demand channel, and result in a greater aggregate impact on monetization.

¹⁴In principle, an increase in the real money supply could also be obtained through a decrease in prices. In the early modern period, however, this was made difficult by a technological constraint: that it was difficult to put too little silver in coins.

¹⁵For the early modern period, empirical support for the argument that fiscal capacity had a positive impact on monetary capacity is provided by Karaman et al. (2020). For 11 European states between 1500 and 1900, the paper finds that a higher fiscal capacity stabilized monetary units, as states no longer depreciated their currencies

of silver in America allows for a unique opportunity to identify this impact.

The first subsection that follows discusses the construction of the data series for monetary and fiscal capacity for early modern European states. The second subsection discusses the empirical methodology. The causal effect of monetary capacity on fiscal capacity is estimated by a Local Projection Instrumental Variable (LP-IV) model, where monetary capacity is instrumented by the production of precious metals in the Americas. The third subsection discusses the results. For Spain, England and France, monetary capacity has a positive, significant and persistent effect on fiscal capacity. The last subsection discusses the robustness of the results.

3.1 Data

We test the impact of monetary capacity on fiscal capacity, instrumenting the former with the silver and gold output in the New World. Because we rely on a natural experiment for identification, we focus on the period in which this experiment was most relevant, between 1550 and 1790.¹⁶ We also restrict the sample to England, France and Spain, the only countries for which detailed monetary and fiscal data is available. Furthermore, these three countries were among the most affected by the inflow of metals from the New World.

The proxy for monetary capacity is the per capita real money stock.¹⁷ To calculate this proxy, we first collect the data on the money stocks of different countries.¹⁸ We then convert the money stock from local currency into silver, the universal measure of value for the early modern

for seigniorage. This impact breaks down only at very low levels of fiscal capacity, because weak states lacked the capacity to circulate currency, and could not generate seigniorage revenues in the first place. As for the modern period, among others, Sargent (1982) and Catao and Terrones (2005) provide empirical support for the impact of fiscal capacity on monetary capacity.

¹⁶1550 marks the beginning of the arrival of American precious metals in Europe in large quantities, whereas 1790 marks the growing importance of paper money and a weakening relationship between precious metals and money stocks.

¹⁷We focus on state-issued money because private forms of money rarely circulated at the national level, did not last long without government backing, and complemented, rather than displaced, state-issued money.

¹⁸Annual money stock estimates for England are based on Palma (2018b) and for Spain based on Brzezinski et al. (2019). For France, annual estimates for 1493-1680 are based on Glassman and Redish (1985). Between 1680-1788, the series are interpolated based on the six benchmark estimates by Riley and McCusker (1983). The money stock estimates include silver and gold commodity money, but not other types of fiat and paper monies, which were insignificant until the 19th century.

period.¹⁹ We next divide the money stock by the population²⁰ to get the per capita money stock in grams of silver. Finally, we divide the per capita money stock by the daily cost of a standard consumption basket in grams of silver²¹ to arrive at the per capita real money stock.²²

Note that monetary capacity is defined as the capacity to monetize the economy, but we proxy for it with the actual monetization level. In order for this proxy to be valid, states should choose to monetize their economies at the highest level they can. This is indeed the case in the equilibrium of the model. It is also empirically plausible, because early modern economies were chronically starved of money, and states sought to remedy undermonetization by all policy means available.

The proxy for fiscal capacity is per capita real tax revenues. It is calculated by dividing the central government revenues²³ by the population and price level of each country. Consequently, fiscal capacity is measured in terms of standard consumption baskets, the same unit as monetary capacity.

Figure 2 shows the per capita real money stock and real tax revenue series for the three countries in our sample. The two series appear to be closely related, and both increased significantly through the early modern period. This close relationship, however, does not by itself imply a causal relationship between the two, since monetary and fiscal capacity may both be determined by other variables.

In the empirical model, the production of precious metals in the Americas serves as the

¹⁹The value of monetary units in terms of silver are based on Karaman et al. (2020) and the sources cited therein.

²⁰Population data is based on Broadberry et al. (2015), who in turn rely from 1541 on Wrigley et al. (1997), for England, McEvedy and Jones (1978) for France, and Santiago Caballero et al. (2020) for Spain.

²¹Price level data is based on Allen (2001b). The price series tracks the daily cost of a standard consumption basket that includes food items totaling 1941 calories per day, fuel and clothing, and reflects the consumption patterns of an adult male for the early modern period.

²²Money stocks (which for premodern Europe were predominantly composed of coin stocks) have been reconstructed using a combination of assumptions. These rely on the annual observation of mint output flows combined with the occasionally observed stock (usually at the moment of total or partial recoinages) and other supporting information, which varies from study to study. For more details on the reconstruction method of money stocks, see Palma (2018b).

²³For Portugal, the revenue series are interpolated based on Costa et al. (2020). The other three states are based on Karaman and Pamuk (2010) and the sources therein. English revenue data is available annually with few gaps. There are gaps for French revenue data in the 16th and Spanish revenue data in the 17th century, which are interpolated. These revenues are converted to silver, once again based on the rates in Karaman et al. (2020).

instrument for monetary capacity. The precious metal production is the sum of silver and gold production in metric tons, with the latter translated to silver units. The production series is based on Palma (2019a), which in turn largely relies on TePaske (2010).

3.2 Empirical strategy

The empirical specification follows the LP-IV methodology. This methodology uses an excluded instrument to estimate the causal effects for different time horizons. The methodology is well-suited for our aim of estimating long-run effects, as it yields consistent estimates even at long horizons.²⁴

Following the LP-IV methodology, we estimate the model in two stages. In the first stage, we use the production of precious metals in the Americas as an instrument for monetary capacity. In the second stage, we estimate the causal effect of monetary capacity on fiscal capacity, using only the exogenous variation in the former variable that was generated by the production of precious metals.

The first-stage equation, estimated separately for each country i , is of the following form:

$$\ln(\text{monetary}_{i,t}) = \alpha_i + \gamma_i \ln(\text{metals}_{t-1}) + \phi_i \mathbf{x}_{i,t} + e_{i,t}, \quad (12)$$

where metals_t is the production of precious metals in the American mines, expressed in grams of silver.²⁵

The second-stage relationship is estimated separately for each country i for each time horizon h :

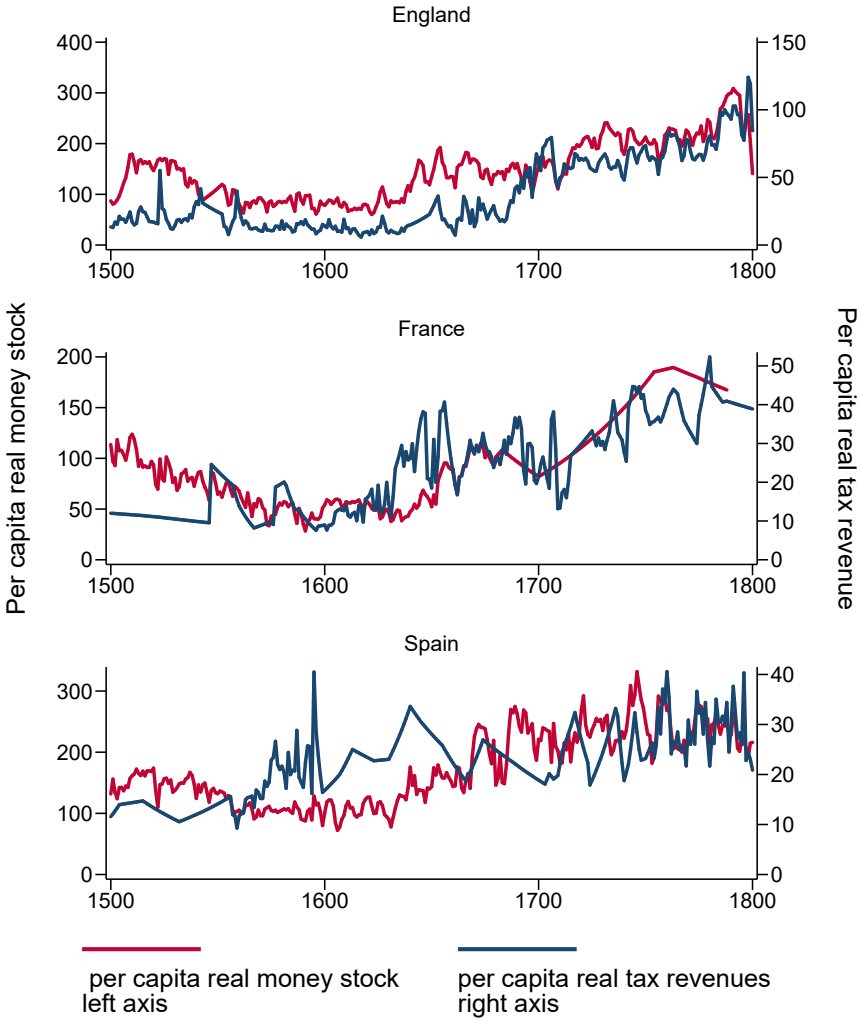
$$\ln(\widehat{\text{fiscal}}_{i,t+h}) - \ln(\widehat{\text{fiscal}}_{i,t-1}) = \alpha_{i,h} + \beta_{i,h} \ln(\widehat{\text{monetary}}_{i,t}) + \psi_{i,h} \mathbf{x}_{i,t} + u_{i,t+h}. \quad (13)$$

The outcome variable on the left-hand side is the cumulative growth of real per capita fiscal capacity between period $t + h$ and $t - 1$ in country i . The main explanatory variable on the right-hand side, $\ln(\widehat{\text{monetary}}_{i,t})$, is the log of real per capita monetary capacity, instrumented

²⁴See Jordà et al. (2020b) for a general discussion of the methodology and the consistency of the estimates.

²⁵Note that the excluded instrument has no i -subscript, since it captures the production of precious metals in the Americas and hence is the same across the European countries in the analysis.

Figure 2: Money Stock and Tax Revenues Per Capita (in standard consumption baskets)



by the production of precious metals in the first stage. $\mathbf{x}_{i,t}$ is a vector of control variables whose components are described below for each local projection result. $u_{i,t+h}$ is a horizon-specific error term. To address the potential serial correlation in the error term (Jordà, 2005), we use HAC-robust standard errors based on Newey and West (1987) throughout.²⁶

The main coefficient of interest is $\beta_{i,h}$, estimated for each time horizon h in the second stage of the empirical model. This coefficient captures the impact of exogenous changes in monetary capacity on the cumulative growth of fiscal capacity up to period h in country i . For example, $\beta_{i,0}$ measures the impact of monetary capacity on fiscal capacity between periods t and $t - 1$; $\beta_{i,1}$ measures the impact between periods $t + 1$ and $t - 1$; and so on.

There is a close relationship correspondence between the theoretical model discussed in the previous section and the empirical model discussed in this section. In the theoretical model, an exogenous positive shock to the money supply (ϕ_μ) increases monetary capacity (μ_2) and the equilibrium level of monetization (m_2^*). The first stage of the empirical model tests this impact, with American precious metal output as the exogenous shock, and money stock per capita as the monetization level. The theoretical model also establishes that the higher monetization level in turn increases fiscal capacity ($\tau_2 - \tau_1$) and equilibrium tax level (t_2^*). This impact is tested in the second stage of the empirical model, which estimates the impact of real money stock per capita on real tax revenue per capita.

One concern with the empirical strategy is whether the proposed instrument, American precious metal production, satisfies the two requirements of the LP-IV methodology.²⁷ The first requirement is relevance: the instrument, precious metal production, should be sufficiently correlated with the European money stocks, after controlling for other variables. The existence of a strong correlation between the two is confirmed by both historical and statistical evidence. In the early modern period, the bulk of the European money stock was coins made of silver and gold, and America was by far the most important producer of these two metals (Barrett, 1990). As for the statistical evidence, the first-stage estimation results presented in the next section

²⁶Olea and Plagborg-Møller (2020) note that the inclusion of lagged variables in the estimation can eliminate the need to use HAC-robust standard errors. In our specification, we include lagged variables and additionally allow for autocorrelation in the error term.

²⁷For a formal discussion, see (Stock and Watson, 2018)

corroborate the close relationship between American precious metal production and European money stocks.

The second requirement is the exclusion restriction: after controlling for other covariates, the American precious metal production should affect fiscal capacity only through monetary capacity. There are several ways that this condition can be violated. One potential violation would occur if the conditions in Europe, such as the state of the economy, affected both the precious metal production and fiscal capacity simultaneously. The historical evidence suggests, however, that the variations in American precious metal production were independent of European conditions. In particular, Palma (2019a) shows that both the discovery of the mines and the mining intensity were driven by local conditions and accidents, with a high degree of randomness. A second potential violation is that American metal production might have affected fiscal capacity through covariates other than monetary capacity. To address this concern, we include the main political and economic characteristics of European states as covariates in the regressions: GDP, warfare and political regime. A final issue, mainly relevant for Spain, is that the precious metal production was itself a source of tax revenue and thereby increased fiscal capacity directly. To address this specific issue, and as a general robustness exercise, we estimate a modified version of the LP-IV method based on the methodology outlined by Jordà et al. (2020a). The modified method assumes that the exclusion restriction does get violated, and adjusts the estimates for this violation. The results of these exercises, reported in the following sections, support the robustness of the empirical findings.

3.3 Results

Table 1 reports the first-stage results. The F-statistic is above the rule-of-thumb value of ten for all three countries in the sample. Likewise, the elasticity of the money stock with respect to metal production is positive and significant for all three, with a higher point estimate for Spain. In particular, a one percent increase in the production of precious metals in the Americas is estimated to have increased Spanish real per capita money supply by 0.4 percent after one year. This greater impact on Spanish money supply is expected, since the American metals first

arrived in Spain, and diffused to England and France only indirectly through capture or trade.²⁸

Table 1: First-stage results

Dependent variable:	England	France	Spain
real money p. c.	(1550-1790)	(1550-1788)	(1550-1790)
lagged metals production	0.189*** (0.058)	0.261*** (0.054)	0.431*** (0.053)
Observations	241	239	241
First-stage F	10.39	23.36	65.89

Note: The table shows the first-stage results, where the endogenous variable is the log real per capita money stock. Regressions control for two lags of log real tax per capita, and contemporaneous and lagged real GDP. The LP-IV approach uses Newey-West standard errors throughout. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

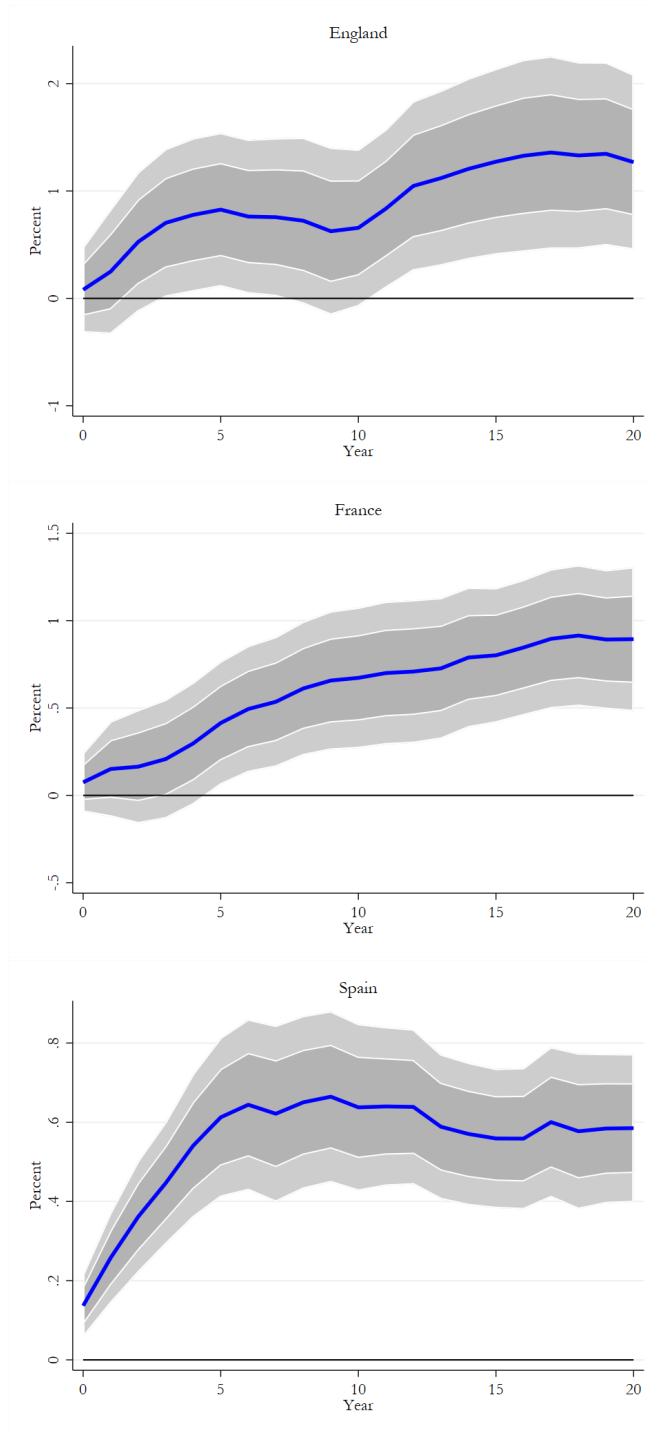
Figure 3 presents the second-stage results. For each horizon h and each country i , the vertical axis reports the point estimate of the coefficient $\beta_{i,h}$, together with the confidence intervals. For all three countries in our sample, an exogenous increase in monetary capacity increased fiscal capacity. For the timing of impact, it was instantaneous in Spain, but worked with a lag for France and England. For its magnitude, it was the strongest for England, where a one percent increase in real money stock per capita increased real tax revenues per capita by 0.8 percent in five years and more than one percent in twelve years. As for its persistence, in all three countries, the impact did not diminish over time.

3.4 Robustness

We next evaluate the robustness of the results. For this purpose, we estimate the impulse responses with different sets of control variables and different time horizons. We also estimate adjusted impulse response functions that take into account potential violations of the exclusion restriction, following the methodology of Jordà et al. (2020a).

²⁸Note that, in principle, the higher elasticity could also be explained by differing initial money stock levels: if England and France had higher monetary stocks per capita, then an equal increase in precious metals would mechanically lead to a less strong response in these two countries. However, for our period of consideration, the opposite was the case, as Spain had a higher per capita monetary stock (see Figure 1).

Figure 3: % change in per capita real tax revenues due to a 1% exogenous increase in per capita real monetary stock



Note: LP-IV impulse responses showing the cumulative response of real tax per capita to a 1% increase in real money stock per capita, instrumented by the production of precious metals. 90% (light gray) and 1 standard deviation (dark gray) Confidence Intervals shown, based on Newey-West standard errors. The regressions control for two lags of log of real tax revenues per capita and contemporaneous GDP and lagged real GDP. Source: see text.

Robustness to control variables

Table 2 presents the estimation results for different sets of control variables. For each specification, the size of the impact and standard errors are reported for horizons $h = 10$ and $h = 20$. The full set of impulse responses are reported in Appendix A.

Column 1 is the baseline specification, presented earlier in Figure 3. Columns 2 and 3 report the results when the money stock is instrumented with the contemporaneous or the second lag of metals production instead of the first lag. Across both specifications, the estimated coefficients are very similar in size and statistical significance to the baseline results.

Column 4 modifies the baseline specification by dropping GDP from the set of control variables. The estimated coefficients increase across all time horizons, except for Spain, where they remain similar. Note that in the baseline specification, the estimated coefficient for monetary capacity captures only its direct positive impact on fiscal capacity. When GDP is omitted from the set of control variables, the estimated coefficient also captures any indirect positive impact that may be transmitted through a higher GDP, which is consistent with a higher estimate.

Column 5 controls for the impact of warfare. Bellicist theories of state formation argue that wars in early modern Europe set in motion innovations in military and fiscal administration that resulted in ever higher tax revenues and the birth of the modern state (Hoffman and Norberg, 2002; Karaman and Pamuk, 2013; Levi, 1988; North, 1981; O’Brien and Palma, 2020). To account for any bias that the impact of warfare might introduce to the estimation results, we include a proxy for it in the regression equations. To construct the war proxy, we first calculate the total number of wars each state participated in each year, based on (Brecke, 1999). We then calculate a 3-year moving average of this variable, since the impact of war built up over time. When the proxy for warfare is included in the regressions, the estimates remain close to those in the baseline specification.

Column 6 controls for the level of parliamentary activity. The contract theory of the state argues that parliaments increased tax revenues, by making it easier for the executive and economic elites to settle on a tax-for-public-services deal, solving associated collective action problems, and lending legitimacy to taxation (Hoffman and Norberg, 2002; Levi, 1988; North, 1981). To account for the potential impact of the parliaments, we include in the regressions an indicator

variable for parliamentary meetings for each year and state, based on Henriques and Palma (2019). For England and France, the estimation results remain similar to the baseline, while for Spain the estimates double. This result is consistent with the argument that the New World silver made Spanish kings less dependent on local elites and undermined the representative government (Abad and Palma, 2020; Drelichman and Voth, 2008). If precious metals had two separate effects on tax revenues, a positive effect through monetization and a negative effect through the collapse of parliaments, controlling for the latter would only leave the former to be estimated and result in a higher coefficient. Column 7 controls for the impacts of warfare and parliamentary activity simultaneously. The estimates remain very similar.

Table 2: Robustness checks

	Baseline	No Lag Instrument	Second Lag Instrument	No GDP Control	War	Parliaments	War and Parliaments
England							
$h = 10$	0.656 (0.444)	0.636 (0.448)	0.739* (0.435)	1.325*** (0.478)	0.557 (0.511)	0.708 (0.463)	0.612 (0.541)
$h = 20$	1.268** (0.496)	1.181** (0.515)	1.210*** (0.458)	1.842*** (0.500)	1.336** (0.606)	1.345*** (0.507)	1.427** (0.627)
France							
$h = 10$	0.673*** (0.245)	0.637*** (0.224)	0.744*** (0.274)	1.160*** (0.271)	0.718** (0.326)	0.686*** (0.249)	0.753** (0.341)
$h = 20$	0.894*** (0.251)	0.834*** (0.225)	0.983*** (0.285)	1.299*** (0.259)	1.095*** (0.354)	0.898*** (0.255)	1.111*** (0.369)
Spain							
$h = 10$	0.638*** (0.128)	0.630*** (0.122)	0.652*** (0.130)	0.627*** (0.129)	0.736*** (0.169)	1.370*** (0.353)	1.491*** (0.431)
$h = 20$	0.585*** (0.114)	0.571*** (0.111)	0.615*** (0.119)	0.607*** (0.121)	0.572*** (0.140)	1.133*** (0.310)	1.083*** (0.342)

This table shows second-stage results for horizons $h = 10$ and $h = 20$ for alternative specifications, with Newey-West standard errors in parentheses. The first column shows the baseline specification. The second and third column show alternative specifications where the contemporaneous value or the second lag of the metals production variable are used in the first stage, respectively. The fourth column shows the baseline specification without any GDP controls. The fifth, sixth and seventh column show results when adding war controls, parliament controls, and both of these controls to the baseline, respectively.

Finally, we consider the validity of our results for longer time horizons. Note that, the further we extend our horizon, the smaller the sample becomes, and thus the less reliable and precisely estimated the results are. Nevertheless, Appendix Figure A7 clearly shows that the estimated effects remain strong and significant for the subsequent decade, at horizons of 20-30 years.

Robustness to violations of the exclusion restriction

One concern with the LP-IV approach and Instrumental Variables models in general is potential violations of the exclusion restriction. In our case, such a violation would occur if the production of precious metals increased fiscal capacity through a channel other than monetary capacity. This concern is particularly relevant for Spain, where American precious metal production also generated tax revenues for the treasury. In this section, we investigate the robustness of our findings under such a violation.

To construct impulse responses that are robust to violations of the exclusion restriction, we adopt the procedure proposed by Jordà et al. (2020a). To see how this approach works, suppose that the excluded instrument has a direct effect on fiscal capacity that does not operate through monetary capacity and other control variables. In that case, the true two-stage relationship for each country i changes to the following system of equations:

$$y_{i,t+h} = \tilde{\alpha}_{i,h} + \tilde{\beta}_{i,h} \ln(\widehat{\text{monetary}}_{i,t}) + \tilde{\delta}_{i,h} \ln(\text{metals}_{t-1}) + \tilde{\psi}_{i,h} \mathbf{x}_{i,t} + \tilde{u}_{i,t+h} \quad (14)$$

$$\ln(\text{monetary}_{i,t}) = \tilde{\alpha}_i + \tilde{\gamma}_i \ln(\text{metals}_{t-1}) + \tilde{\phi}_i \mathbf{x}_{i,t} + \tilde{e}_{i,t}, \quad (15)$$

where $y_{i,t+h} \equiv \ln(\text{fiscal}_{i,t+h}) - \ln(\text{fiscal}_{i,t-1})$. The only difference with equations 13-12 is that the term $\ln(\text{metals}_{t-1})$ now enters the second-stage equation 14 directly, violating the exclusion restriction.

Jordà et al. (2020a) offer a potential way to test the robustness of the results to such violations of the exclusion restriction. In particular, suppose that $\tilde{\beta}_{i,h} = \lambda_{i,h} * \tilde{\delta}_{i,h}$. In our setup, $\tilde{\beta}_{i,h}$ is the impact of monetary capacity on fiscal capacity, whereas $\tilde{\delta}_{i,h}$ is the direct impact of American precious metal production that does not work through monetary capacity and any other control variable. Hence, a higher $\lambda_{i,h}$ corresponds to a greater relative impact for monetary capacity.

With $\lambda_{i,h}$ in hand, one can adjust the left-hand-side variable such that the exclusion restriction is satisfied (Jordà et al., 2020a, Appendix B). In particular, define $y_{i,t+h}^{adj}$ as:

$$y_{i,t+h}^{adj} = y_{i,t+h} - \ln(metals_{t-1}) * \frac{\widehat{\delta}_{i,h} + \widehat{\gamma} \times \widehat{\beta}_{i,h}}{1 + \lambda_{i,h} \times \widehat{\gamma}} \quad (16)$$

where the “ $\widehat{}$ ”-symbol stands for OLS estimates from equations 14-15. After replacing the left-hand-side variable with the adjusted variable from equation 16, the LP-IV procedure will yield valid results.

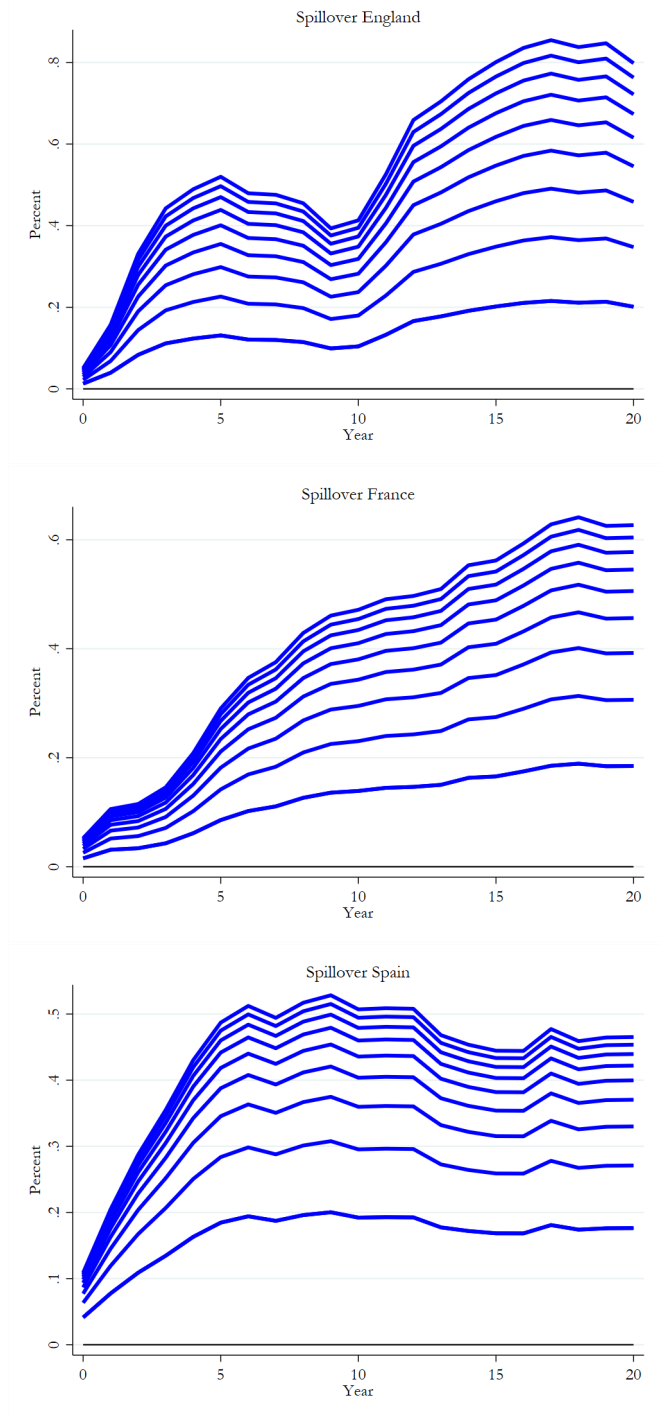
The difficulty in implementing this procedure is that the true value of $\lambda_{i,h}$ is not known and cannot be determined from the data. Hence, Jordà et al. (2020a) advocate performing the adjustments for various reasonable levels of $\lambda_{i,h}$. These levels can be viewed as the bounds on the true impulse responses that would have arisen if the exclusion restriction did not hold.

In our case, we estimate the model for $\lambda_{i,h}$ values between 1 and 10. A $\lambda_{i,h}$ value less than 1 is unlikely, as it would imply that, after accounting for the impacts of GDP and the remaining control variables, the direct impact of precious metals on tax revenues outweighed the impact of the economy’s monetary stock. For Spain, the main beneficiary of the American Silver, the revenues from taxation of the domestic economy greatly outweighed the revenues associated with the colonies and silver (Comín and Yun-Casalilla, 2012). As for England and France, if American silver did have any direct impact, it must have been much less important. A $\lambda_{i,h}$ value greater than 10 is plausible, but as $\lambda_{i,h}$ increases, the estimation results converge to the baseline estimates, and so does not have much value as a robustness exercise.

Figure 4 presents the estimation results for $\lambda_{i,h} = 1, 2, \dots, 10$. For each country in our analysis, the spillover-adjusted responses are very similar in shape to the baseline results. As before, the effect does not fade away at longer horizons. For the more realistic larger values of $\lambda_{i,h}$, the effect sizes are within the confidence bounds of the baseline results presented in Figure 3.

Taken together, the results in this section confirm that the increase in monetary capacity caused by the massive inflow of precious metals from the Americas had a positive impact on fiscal capacity. This empirical support for this impact is robust to taking into account the effects of other relevant variables, and potential violations of the exclusion restriction.

Figure 4: Spillover-adjusted Impulse Responses



Note: Spillover-adjusted impulse responses (Jordà et al., 2020a). Spillover terms are $\lambda_{i,h} = 1, 2, \dots, 10$. Lower lines correspond to lower values of $\lambda_{i,h}$. Specifications follow the baseline LP-IV approach. Sources: see text.

4 Long-Run Patterns

This section puts the theoretical model and empirical analysis in the preceding sections into a broader historical context by reviewing the European evidence since antiquity. The long-run evidence supports the notion that precious metal production, monetary capacity and fiscal capacity had a mutually reinforcing relationship and moved together through several cycles of ups and downs from antiquity to the Middle Ages. It also indicates that the New World shock ended these cycles and had a real, substantial, asymmetric and transformative impact on the European economy and politics.

The first well-documented historical peak in monetization and taxation was in the mid-5th century BC Athenian Empire. In this period, the estimated money stock per capita reached a level of around 200 grams of silver, and tax revenues per capita a level of around 10-15 grams. These levels were made possible, in part, by the Laurion silver mines located nearby the city of Athens, which had an estimated annual peak output of about 80 tons (Ober, 2015; Patterson, 1972).

After the decline of Athens, the second peak was reached during the Pax Romana. In the first two centuries AD, money stocks per capita rose to 50-100 grams of silver, and tax revenues per capita to 10-15 grams. Roman monetization was supported by the Iberian mines, which had an estimated annual output of 200 tons of silver (Duncan-Jones, 1998; Goldsmith, 1987; Hopkins et al., 2009; Patterson, 1972).

The Roman peak was followed by a collapse in the third century AD. The exact line of causation is difficult to unravel. In terms of precious metal availability, the exhaustion of the Iberian mines and the resulting decline in annual silver output to about 30 tons arguably played a role (Patterson, 1972). Fiscally, the growing spending on war triggered depreciation of silver coinage and inflation, which in turn induced demonetization of the economy (Bransbourg, 2015; Harris, 2008; Kohn, 2005).²⁹

The early Middle Ages marked the nadir of both monetary and fiscal capacity. On the

²⁹During the Late Roman Empire, gold increasingly replaced silver, and perhaps constituted more than half of the money stock in value, but whether it was a perfect substitute for silver is debatable. Gold had a much slower velocity, and was only convenient for very large transactions (Goldsmith, 1987). Gold production itself declined after the fourth century and largely disappeared by the 8th century (Spufford, 1988, p. 18-21).

monetary front, annual silver output in Europe is estimated to have decreased to a few tens of tons, and money stocks per capita to about 15 grams of silver (Patterson, 1972). On the fiscal front, centralized taxation collapsed, leaving little historical record of treasury revenues. These two processes were inherently related. Demonetization necessitated breaking up the armies into smaller units that could be supported by the local produce, and central governments ceded de facto control over the countryside (Kohn, 2005; Spufford, 1988). The collapse of central governments in turn undermined monetization, as mining and minting required large-scale investments and centralized coordination.

Another cycle of expansion and contraction of silver output occurred from the 11th to the 15th centuries. With the discovery of new mines in northern and central Europe, annual silver output gradually increased to about 50 tons by around 1300. However, as soon as what could be extracted from these mines with the technology of the day was exhausted, the output began to decline, and collapsed back to around 15 tons by 1450s (Velde and Weber, 2000).

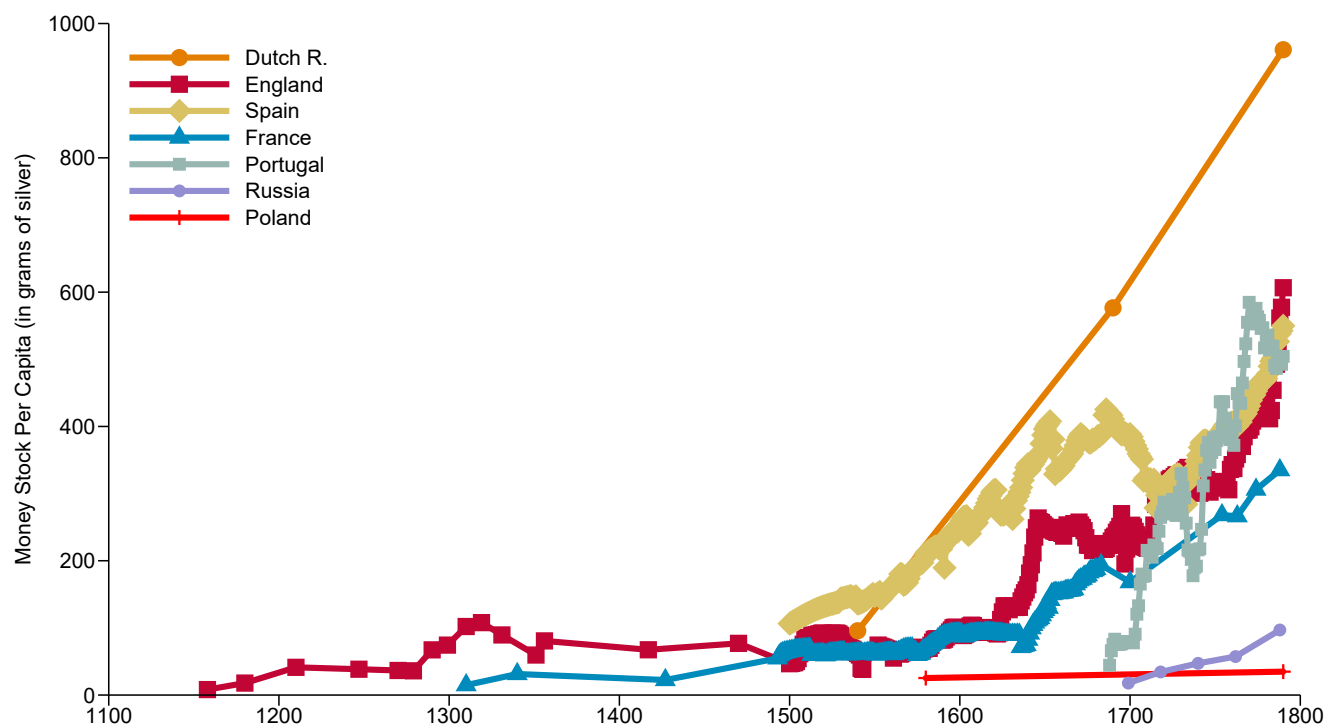
Estimates for English money stock are available for this period, allowing us to track how its trajectory mimicked that of the medieval silver production cycle. Figure 5 summarizes the available per capita money stock data. The English money stock per capita increased from 10 grams to 150 grams from 1150 to 1300, but fell back to around 70 grams by 1450, in line with the silver production estimates.³⁰

The 16th century marked a dramatic increase in the availability of precious metal. This increase was driven by the silver and gold discoveries in the New World. The total silver production in the Americas between the 16th and 18th centuries is estimated to be at around 100,000 tons, or, to compare with annual output estimates presented earlier, around 3,300 tons a year. The silver arrived in Europe in two waves, with Potosí silver peaking in the early 17th and Mexican silver in the late 18th century. The total gold production, mainly in Brazil, was about 2,500 tons, and peaked around the mid-18th century (Barrett, 1990).

This New World shock marked the end of the cycles of monetization and demonetization and the beginning of a dramatic upsurge in money stocks in Western Europe. Figure 5 plots the

³⁰The English money stock series for 1158-1247 is based on (Allen, 2001a) and for 1270-1470 on (Mayhew, 2013). The pre-1500 French money stock series is based on (Spufford, 1988).

Figure 5: Money Stock Per Capita (in grams of silver)



fragmentary evidence on the per capita money stocks of Portugal, the Dutch Republic, Russia, Poland-Lithuania, in addition to the more detailed estimates for England, Spain and France discussed earlier.³¹

Three patterns stand out. First, the money stocks in Western Europe surged following the New World shock. From 1500 to 1800, monetary stocks per capita of Western European states increased from 50-100 grams to 300-1000 grams of silver.

Second, the trajectory of money stocks once again mimicked that of precious metal production. For Spain, England and France, there were two local peaks, in the mid-17th and late 18th centuries, coinciding with the peaks in silver output. For Portugal and England, the main beneficiaries of the Brazilian gold, per capita money stocks increased rapidly over the 18th century.

³¹The money stock data is based on De Vries and Van der Woude (1997) and Weber (2000) for Dutch Republic, Wojtowicz et al. (2005) for Poland-Lithuania, Blanchard (1989) and Kahan and Hellie (1985) for Russia, (Sousa, 2006) for Portugal.

Finally, Figure 5 also makes it clear that the New World shock had an asymmetric impact across Western and Eastern Europe. The precious metals from the New World first arrived in Western Europe, diffused to the East through trade, but only to a limited extent, leading to a divergence in monetization levels. As the figure makes clear, monetization levels in Poland and Russia remained low.³²

One limitation of the per capita monetary stock series presented in Figure 5 is that they are in nominal terms and only prove a nominal impact. Establishing a real impact requires showing that the money stocks increased more than the prices and incomes, so that the real money stocks increased.

To investigate this question, the top panel in Figure 6 plots the ratio of per capita money stocks to the nominal wages of unskilled workers. The results are consistent with a real impact. For Western European states, money stocks per capita increased from 15 to 20 days worth of daily unskilled workers' wages in 1500 to around 45 to 100 days by 1800, while in Eastern Europe they remained stagnant.

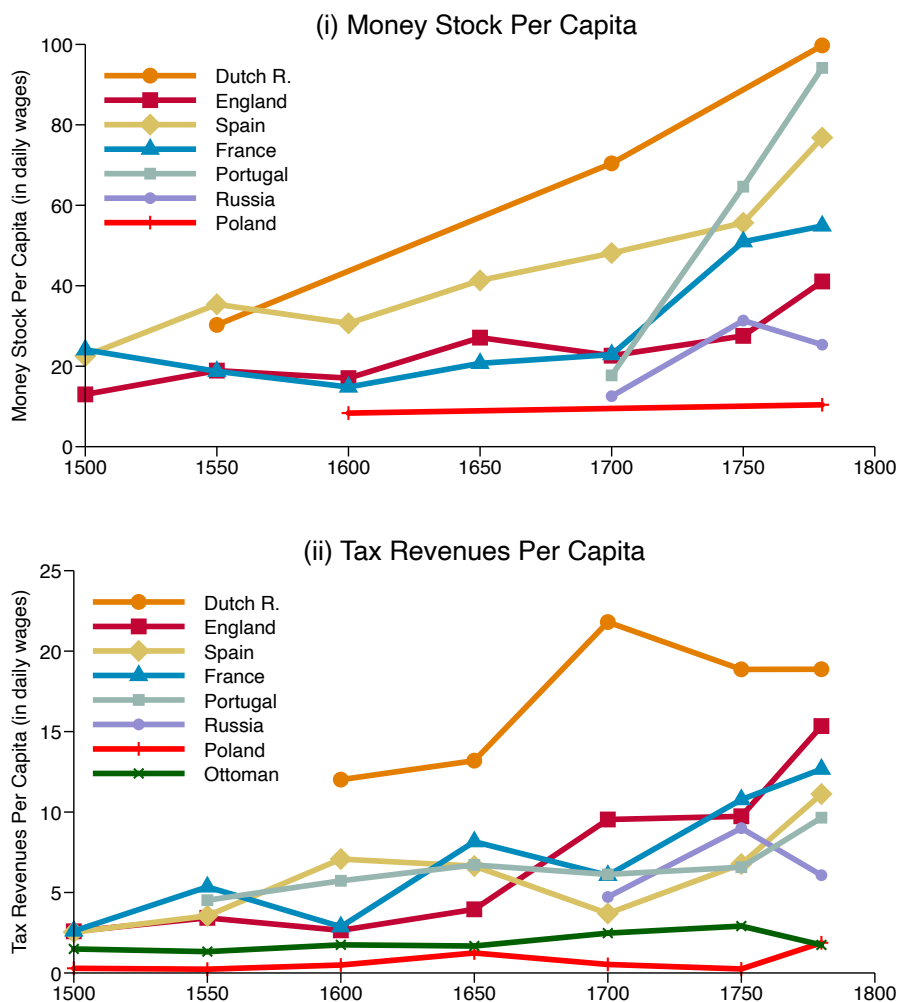
Finally, to explore the fiscal counterpart to this increase in monetary capacity, the bottom panel in Figure 6 plots the ratio of per capita tax revenues to nominal wages. The figure confirms a corresponding real increase in fiscal capacity. In Western Europe, per capita tax revenues increased from about 3 days of wages by 1500 to about 10-15 days by 1800, while they lingered at lower levels in the East.³³

The virtuous cycle of monetary and fiscal capacity building in early modern Western Europe ultimately altered the nature of money, but not the close relationship between the two. The money stock series presented in this section keep track of the levels of commodity silver and gold money over time. Increasingly, however, public banks began to experiment with paper money convertible to silver and gold, arguably made possible by the growing fiscal credibility of states. These experiments culminated in the successful paper note issue by the Bank of England in 1694, a model that spread across the continent. The growing adoption of convertible and later

³²Russia received limited American silver, and continued to rely on barter and furs in addition to foreign coins (Bonney, 1995; LeDonne, 1991; Seljak; Spasskii, 1970). Monetization levels only picked up in the 18th century, after opening of local silver mines (Danila, 2006; Kahan and Hellie, 1985; Kotilaine, 2005).

³³Revenue data is based on Costa et al. (2020), Karaman and Pamuk (2010), Karaman and Pamuk (2013) and the sources cited therein.

Figure 6: Money Stock and Tax Revenues Per Capita (in daily wages)



fiat paper money in turn weakened the historical dependence of the money supply on precious metals production. The value of paper money, however, still depended on the fiscal capacity of the state, perhaps even more so than commodity money. Hence, while the relationship between the precious metals and monetary capacity weakened, the relationship between monetary and fiscal capacity persisted.

All in all, the long-run historical evidence identifies large contemporaneous swings in monetary and fiscal capacity, which continued until the massive liquidity shock of the New World silver and gold. This shock transformed the European economy by increasing monetization levels in

Western Europe, and ultimately undermining the dependence on precious metals for the money supply itself. There is also overwhelming evidence that the shock triggered a virtuous cycle of monetary and fiscal capacity building, consistent with the theoretical and empirical analysis presented in earlier sections.

5 Conclusion

[E]ndless books have been written about the dangers of government printing too much money. But for centuries the opposite problem was just as common: governments often couldn't mint enough coins... to meet their subjects' needs (Pomeranz and Topik, 1999, p.14)

In this paper we have argued that monetary and fiscal capacity are jointly determined. This fact has implications for both macroeconomics and development.³⁴ In macroeconomics, higher taxes and monetary expansions are generally modeled as substitutes (Mankiw, 1987; Sargent and Wallace, 1981; Sims, 1994). In contrast, we argue that, in the long-run, they are complements: monetization is a precondition for the building of fiscal capacity, and, in turn, countries with high fiscal capacity are capable of building more efficient monetary systems. This co-dependence also suggests that, in the context of undermonetized economies, money is not neutral, even in the long run.

The theoretical insights of our paper are supported by causal estimates of the effects of monetary capacity on fiscal capacity. For this purpose, we rely on what was arguably the most significant exogenous shock to monetary capacity in history: the inflow of silver and gold from the New World. Our rich data for England, France and Spain allows us to pursue an instrumental variable approach, where we instrument money supply through the production of silver and gold in American mines. We find that a one percent increase in the real per capita money stock led to a 0.5-1 % increase in fiscal capacity over a decade. Importantly, this effect did not diminish over the course of subsequent decades. Thus, the level of monetization significantly affected the real

³⁴It was previously known that more advanced economies tend to have more advanced monetary and financial systems, but the direction of causality has been a matter of debate (Levine, 2005).

economy in the long run. Our historical discussion suggests that the cases of England, France and Spain are far from exceptional: complementarity between monetary and fiscal capacity has been the rule across the ancient, medieval and early modern world.

For economic development, our results relate to the growing emphasis on the role of state capacity, both as a force which historically allowed Western European countries to surge ahead, and as a constraint in developing countries today.³⁵ We highlight one neglected cost imposed on societies where the state is too weak: the inadequate provision of a liquid means of exchange, which hinders the collection of taxes, increases transaction costs, and undermines specialization and market participation. For the empirical evidence, we rely on the premodern period, as it allows identifying long-run trends, and provides a natural experiment for establishing the causal effects. The argument, however, is more general, and relevant for undermonetized economies both historical and modern.

³⁵For a sample of the literature which considers the links between state-building and economic growth, see Besley and Persson (2011), Brewer (1988), Dincecco (2009), O'Brien (2011), and Rosenthal (1990).

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Appendix
to “*Monetary Capacity*”

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¹University of Padua and University of Nottingham

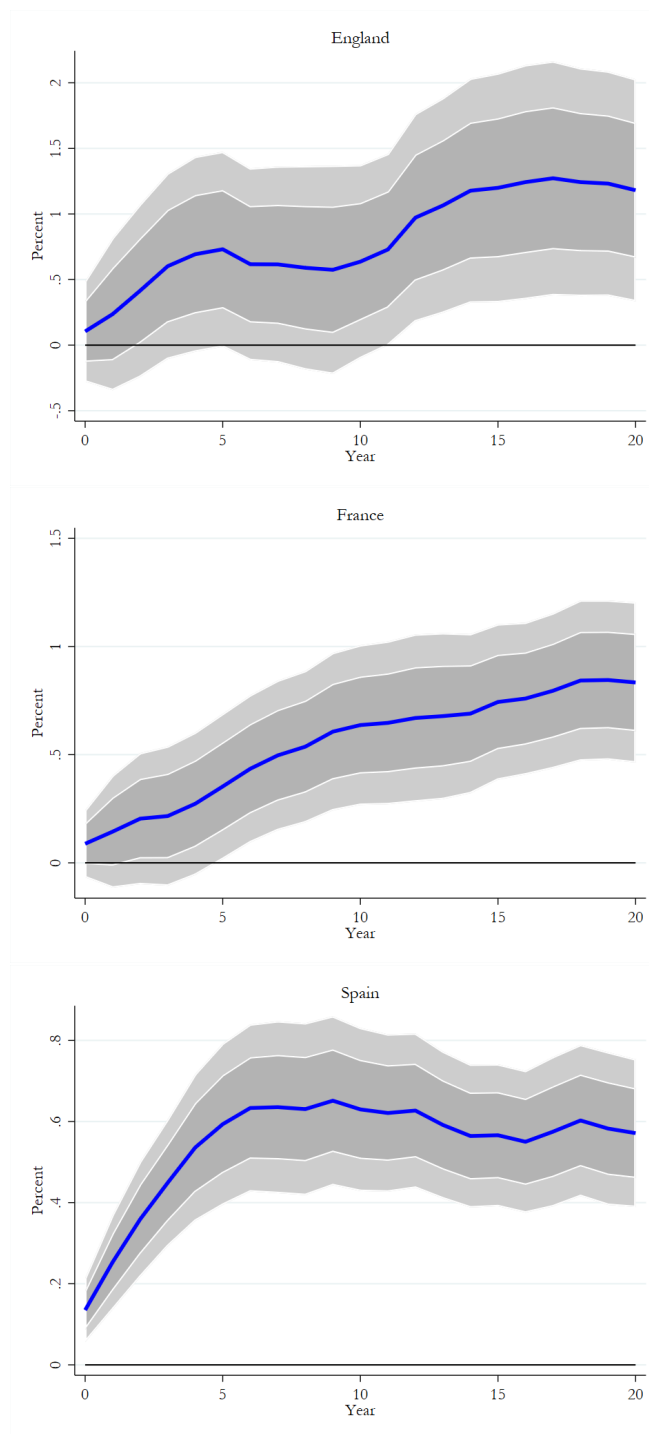
²University of Oxford

³Bogazici University

⁴University of Manchester; ICS, University of Lisbon; CEPR

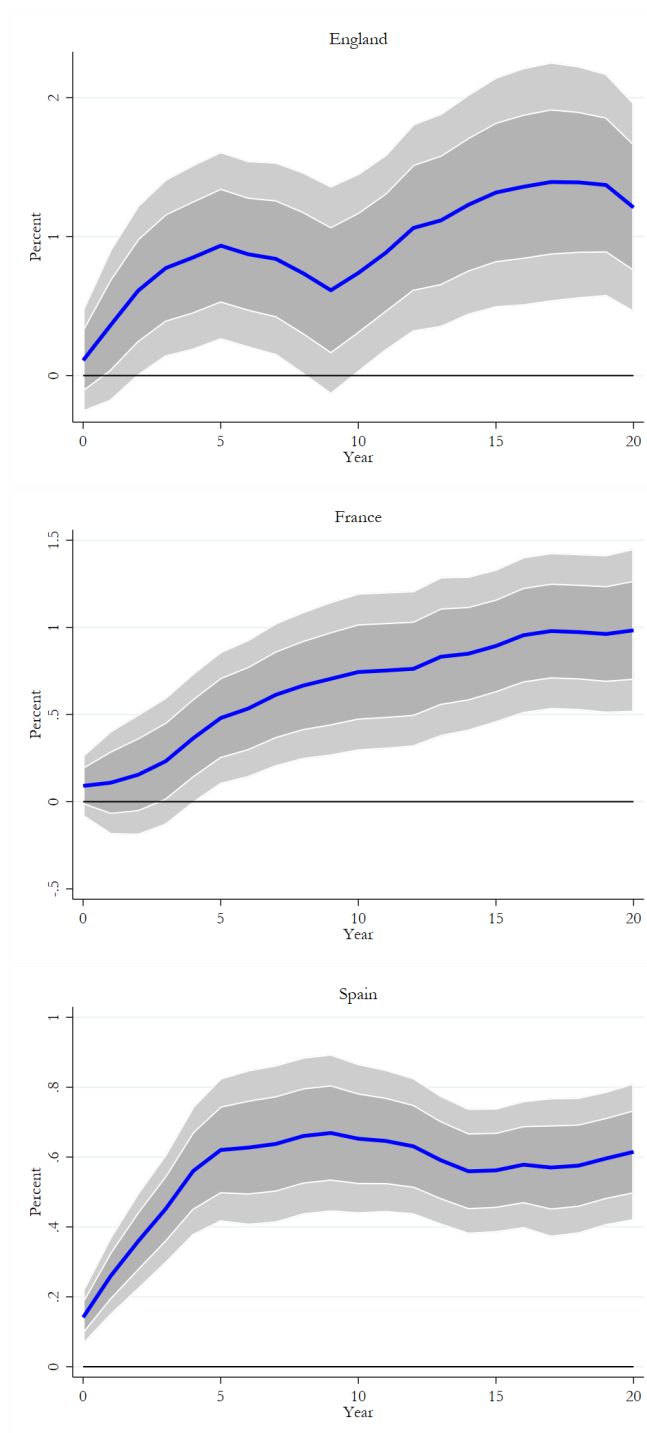
A Robustness

Figure A1: Robustness: contemporaneous lag of metals production



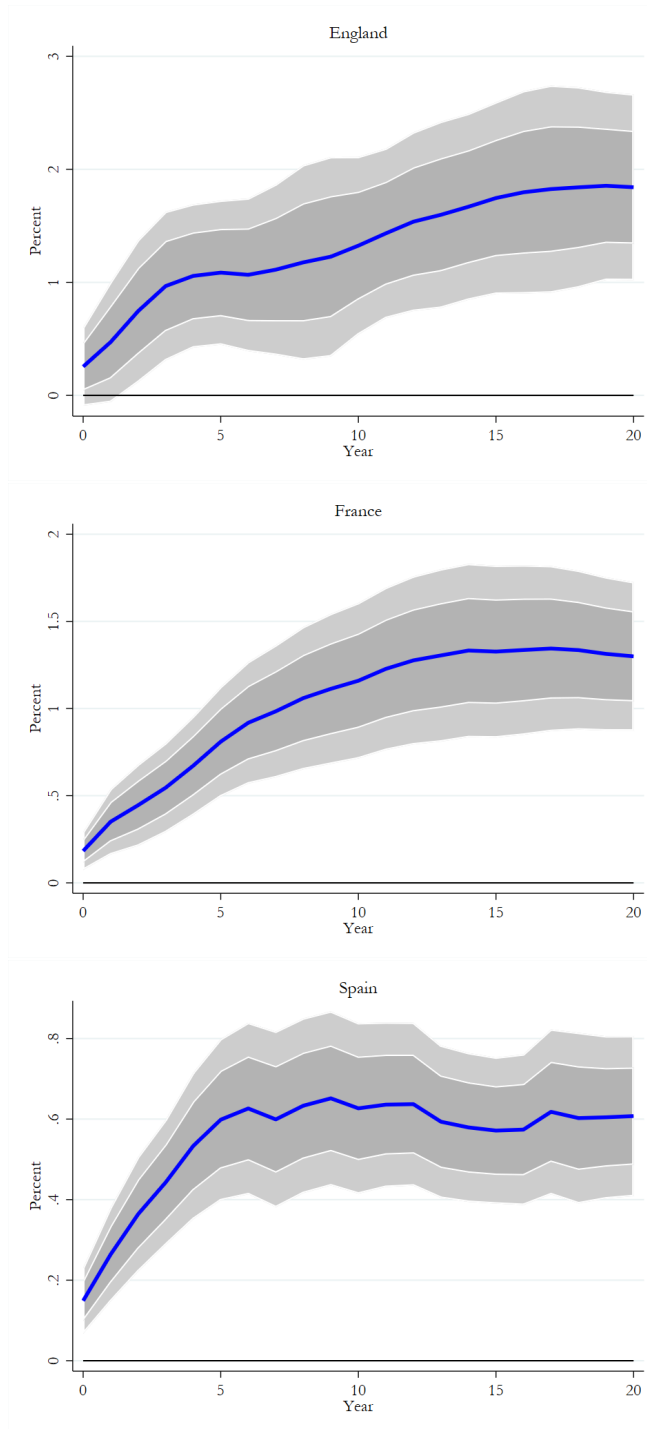
Note: LP-IV impulse responses, with contemporaneous metals production (Column 2 of table 2).

Figure A2: Robustness: second lag of metals production



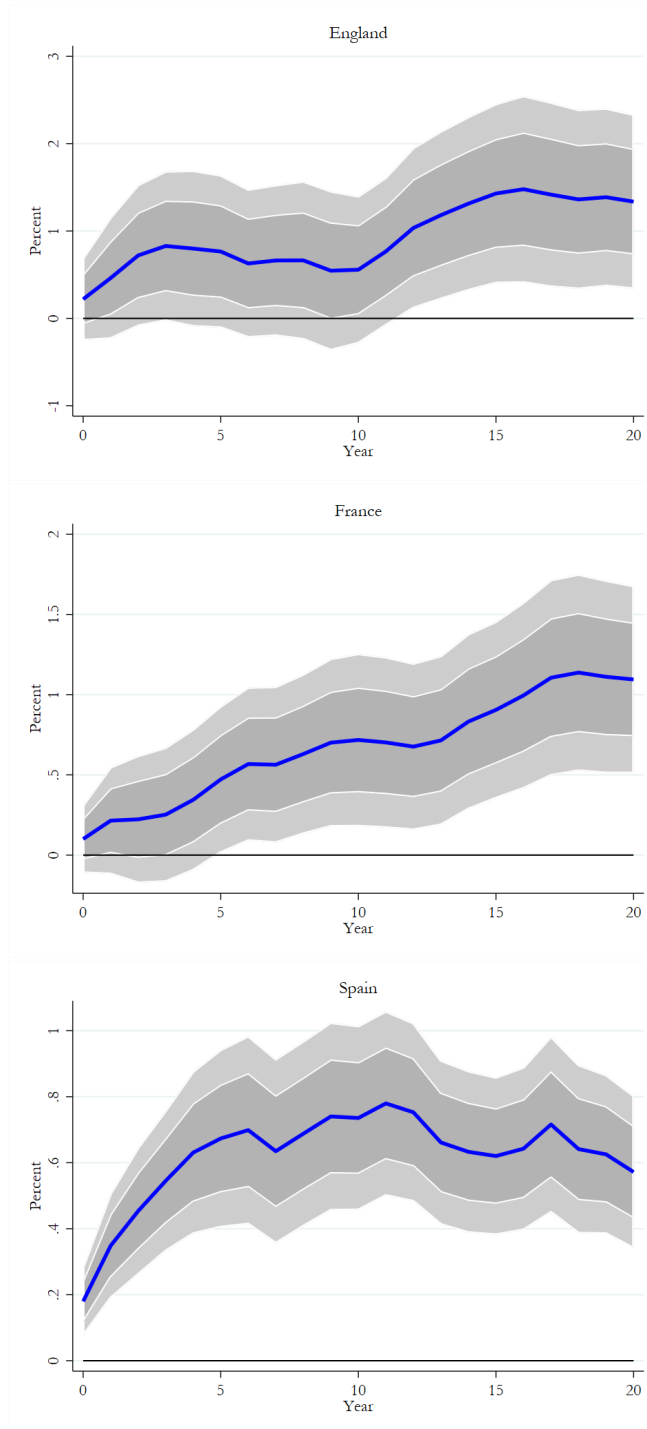
Note: LP-IV impulse responses, with second lag of metals production (Column 3 of table 2).

Figure A3: Robustness: no GDP control



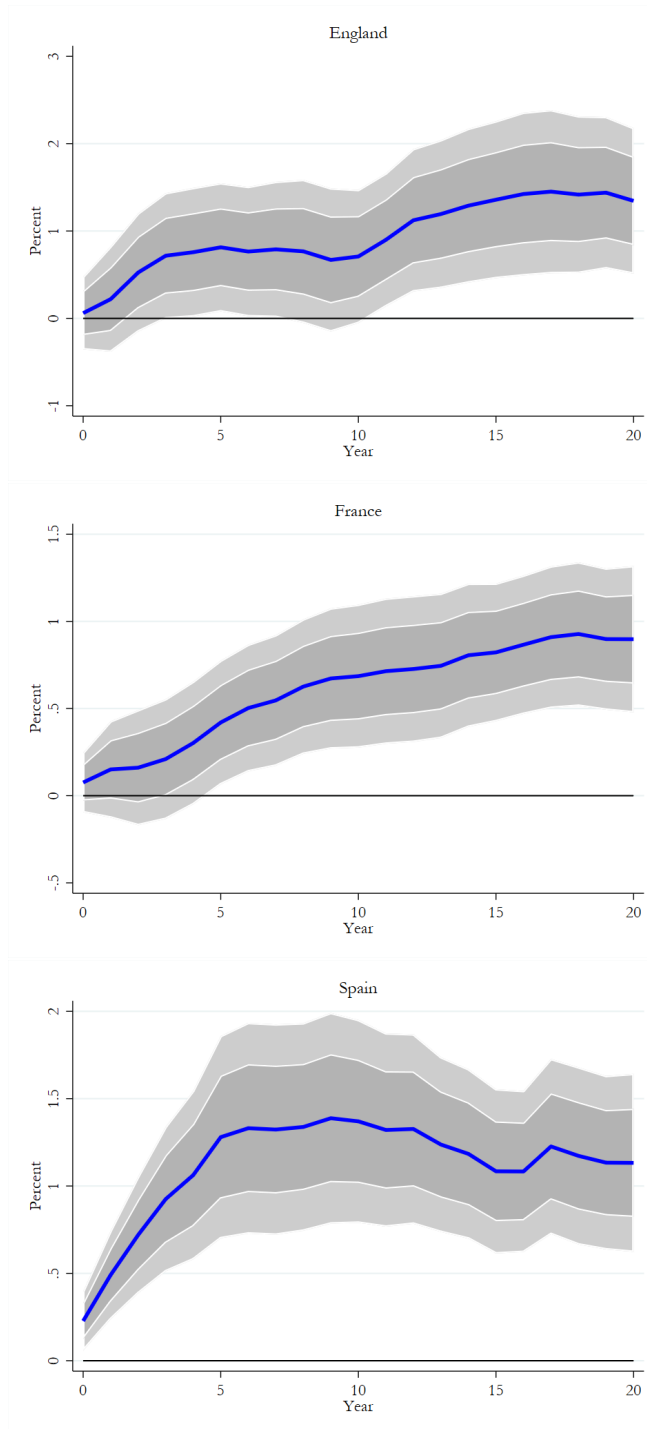
Note: LP-IV impulse responses, with no GDP control (Column 4 of table 2).

Figure A4: Robustness: war control



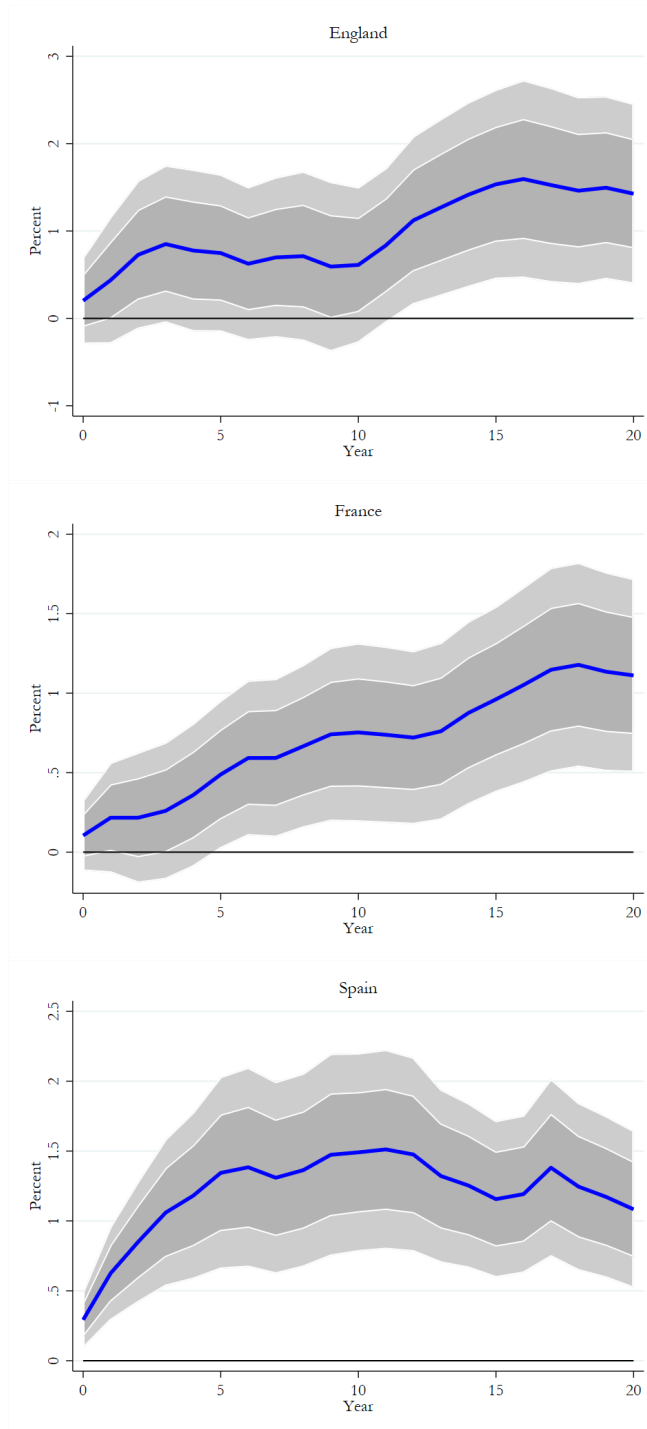
Note: LP-IV impulse responses, with additional war control (Column 5 of table 2).

Figure A5: Robustness: parliament control



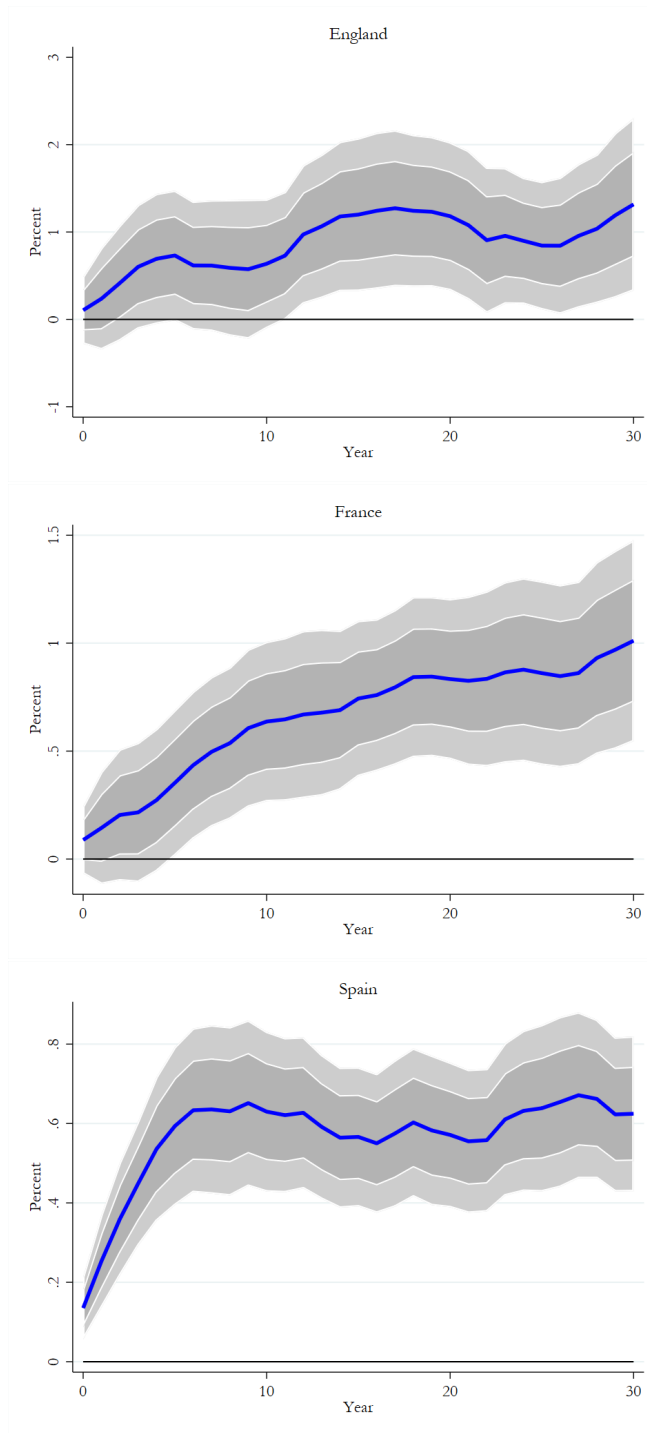
Note: LP-IV impulse responses, with additional parliament control (Column 6 of table 2).

Figure A6: Robustness: war and parliament control



Note: LP-IV impulse responses, with additional war and parliament controls (Column 7 of table 2).

Figure A7: Robustness: horizon up to 30



Note: Baseline LP-IV impulse responses, but with horizon up to $h = 30$.