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Goldilocks: American precious metals and the Rise of the West [⋆]

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Abstract

We estimate the contribution of the American precious metal windfall to West Europe's growth performance in the early modern period. The exogenous nature of American precious metal extraction allows for the identification of monetary effects. We find that American precious metals fostered West Europe's growth by stimulating trade and capital accumulation. Our findings place West Europe's second-stage receivers in a particularly fortunate goldilocks zone that enjoyed monetary stimulus, while being insulated against the transport-loss induced financial crises that caused persistent damage to first-stage receiver Spain.

Keywords: money non-neutrality, Great Divergence, Little Divergence, Smithian growth, market integration

JEL Codes: E51, F40, N10

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"*[S]ince the discovery of the mines in America, industry has increased in all the nations of Europe, except in the possessors of those mines; and this may justly be ascribed, amongst other reasons, to the increase of gold and silver*"

– Hume (1987 [1742], p.33)

1. Introduction

The early modern epoch lies at a crucial junction between the Malthusian stagnation of the pre-modern era and modern economic growth. In the 300 years preceding the Industrial Revolution, income levels in Europe had already pushed ahead of income levels in other parts of the world, giving rise to an early stage of what subsequently turned into the *Great Divergence* of global incomes (Pomeranz, 2000; Broadberry, 2021b,a). In many explanations for why the Industrial Revolution began in Europe its already elevated income level in the mid 18th century is a crucial initial condition that prompts the transition to modern economic growth by encouraging investments in labor-saving technologies and human capital (Galor and Weil, 2000; Allen, 2009; Galor, 2011). Understanding European growth exceptionalism in the early modern period is thus crucial to a comprehensive understanding of the *Rise of the West*.

This paper proposes that Europe's early modern growth exceptionalism has important monetary roots. In the three centuries following the Colombian voyage of 1492, Europe received vast quantities of American precious metals, with the average annual influx amounting to around 1% of West European GDP. American precious metals, however, have rarely been attributed a causal role in Europe's early modern growth exceptionalism. This is because, absent evidence to the contrary, the principle of long-run money neutrality discourages such an interpretation. Recent advances in the reconstruction of early modern GDP and monetary data, however, allow us for the first time to trace the real effects of American money arrivals.

The exogenous nature of American precious metal extraction and transportation losses allows for the identification of monetary effects. The arrival of American precious metals resembled a helicopter drop to the Spanish merchant community that directly altered the level of monetary assets held by the private sector.[1] We are particularly interested in

[1] Like a helicopter drop in a non-Ricardian environment, American precious metals also affected the overall wealth of merchants, rather than only the liquidity composition of the existing wealth stock. However, while the implied percentage change in the amount of liquid assets was sizeable, the overall wealth change was comparatively small. Considering the American money influx relative to West European GDP ($\frac{\Delta M}{Y}$) of around 1%, and a early modern wealth to GDP ratio ($\frac{W}{PY}$) in the 5 to 7 range (Piketty, 2014), the overall wealth change implied by the American precious metal influx ($\frac{\Delta M}{W} = \frac{\Delta M}{PY}\frac{Y}{W}$) ranged from 0.14% to 0.2%. By contrast, given a plausible early modern velocity of money ($V \equiv \frac{PY}{M}$) in the

the contribution of American precious metals to West European output growth between 1530 and 1780. Impulse response functions (IRF) indicate that the stimulating effect of American precious metals quickly dissipated along the geographic sequence from West to East, with Central European economies already exhibiting little responsiveness. Western Europe, however, saw its GDP increase by around 1% for every doubling in the inflow-to-stock ratio. Our estimates of the cumulative long-run effect suggest that by the end of the 18th century, the sustained nature of the monetary injections had swelled West European GDP by around one third.

Disaggregated data reveal that American precious metals promoted West European output growth in different ways. First, trade intensification afforded Western Europe an episode of Smithian growth. Second, the arrival of American money triggered investments in agriculture (land, livestock), transport (ships), and human capital (primary to tertiary education), thereby modestly increasing Europe's capital stock. These findings are indicative of American money arrivals easing liquidity constraints that previously had frustrated viable investment projects and trade connections. Finally, American money arrivals may also have exerted a demographic force by increasing female employment opportunities in pastoral agriculture and the service sector. The consequent delay in marriages is a prominent reason behind the low birth rates that contributed to increasing per capita incomes in early modern Europe (Hajnal, 1965; Wrigley, 1988).

The distribution of the American precious metal windfall is not just informative with respect to the early *Great Divergence* between Europe and other world regions, but also with respect to the *Little Divergence* in incomes between Europe's Northwest and South. As a first-stage receiver, Spain suffered from greater exposure to transport losses than second-stage receivers like England and Holland. This is because annual money inflows from America on average amounted to 10% of Spain's money stock. By contrast, the money flow's subsequent fourfold dispersion among England, Holland, France, and Italy provided these second-stage receivers with some insulation against the vagaries of Atlantic precious metal transports. Accordingly, second-stage receivers experienced only a temporary output setback in the aftermath of a big maritime disaster loss, whereas Spain suffered from a severe financial crisis that caused lasting damage. This damage is quantitatively similar to findings for modern financial crises, ranging from 5% to 10% of GDP (Cerra and Saxena, 2008; Jordà, Schularick, and Taylor, 2023). Over the early modern period as a whole, eleven big maritime disasters thus shaved a cumulative 50% to 80% off Spanish GDP growth, which can account for around one third of the *Little Divergence* between Northwestern Europe and Spain. Taken together, our findings suggest that Northwest Europe's early modern growth stars – England and Holland – were located in a

two to five range (Mayhew, 2013; Palma, 2018b; Chen et al., 2021), the percentage change in the money stock ($\frac{\Delta M}{M} = \frac{\Delta M}{PY}\frac{PY}{M}$) ranges from 2% to 5%.

monetary goldilocks zone which benefited from sustained monetary injections, while being sufficiently insulated from the effects of maritime disasters to avoid the repeated financial crises which contributed to Spain's comparatively disappointing growth performance.

Our paper contributes to the literature studying the origins of Europe's growth exceptionalism in the early modern period. Our findings are consistent with the long-standing conjecture that American precious metals promoted West European trade intensification by easing merchants' liquidity constraints (Hume, 1987 [1742]; Smith, 1776 [2007]; Keynes, 1936 [ch.23]; North and Thomas, 1970).[2] The ensuing specialization gains afforded Western Europe an episode of Smithian growth (Jacks, 2004) that was already recognized by namesake Adam Smith (1776 [2007], Book III, p.458). According to North and Thomas (1970, p.14), the trade intensification resulting from the arrival of American precious metals furthermore acted as a catalyst for institutional innovations, such as the joint stock corporation and limited liability.[3] Trade intensification and the institutional changes that typify Western Europe's *Commercial Revolution* (Neal, 1993, ch.1) are widely considered explanations for its early modern growth exceptionalism (Acemoglu et al., 2005). Other explanations highlight low birth rates and high death rates, which in a Malthusian environment gave rise to elevated income levels (Wrigley, 1988; Clark, 2007). Cultural changes that led households to increase their labor supply to purchase novel consumer goods (e.g. tea, silk, and porcelain), in what has been termed the *Industrious Revolution* (de Vries, 1994; Berg, 2005; de Vries, 2008), increased capital formation – physical (Frank, 2011, p.44) and human (van Zanden, 2009, ch.6) – and incremental technological improvements that exploited scale economies in Europe's newly integrated market environment (Nef, 1934; Mokyr, 1992). We propose that the high explanatory power of American precious metals suggests that, to a considerable extent, the multifaceted change that underpinned Western Europe's early modern growth exceptionalism was driven by a common geographic fundamental – American gold and silver.

The literature suggest a variety of potential channels through which American money arrivals could have affected long run outcomes in Western Europe by affecting capital and labor inputs, as well as technological, cultural, and even demographic developments.

[2]The notion that American precious metals promoted trade was also reflected in contemporary mercantilist thought (Rössner, 2018). Silver money was scarce in 15th century Europe (Spufford, 1989, pp.340,343). Day (1978) traces the origins of mercantilists' preoccupation with the supply of precious metals to this bullion scarcity in the late medieval period (Dyer, 2002, pp.266,384). While the French evidence for the monetary scarcity hypothesis has been qualified, other research has confirmed the late medieval bullion scarcity elsewhere (Nightingale, 1990, 1997, 2010; Desan, 2014; Le Goff, 2012, p.143).

[3]In addition, trade intensification was accompanied by the development of a multilateral payments system, first centered in Amsterdam and later in London (Neal and Quinn, 2001; Carlos and Neal, 2011), within which the bill of exchange emerged as Europe's dominant credit instrument (Schneider, 1986; Neal, 1993; Attman, 1996). American precious metals underpinned the smooth functioning of this system, because the market for bills was predicated on the expectation of final settlement in gold or silver coin; inside and outside money were complements rather than substitutes (Palma, 2018a).

First, to the extent that American precious metals promoted European market integration, they also rendered profitable the development of new technologies that exploited scale economies (Nef, 1934, pp.18–19). In this way, many industries that used to be dominated by household manufacturers were taken over by proto-industrial establishments.[4] The up-scaling of proto-industrial production was furthermore facilitated by increasing urban agglomeration, which itself hinged on employers' ability to reliably pay money wages – not a given in preceding centuries (Muldrew, 2007, pp.401,405,410). Second, and relatedly, low birth rates depended on womens' access to a vibrant labor market in which money incomes were available for prospective maids and agricultural servants (de Moor and van Zanden, 2010). Third, American precious metals were a necessary prerequisite for Europe's trade intensification with Asia, which brought tea, silk, and porcelain into European households and thus promoted the *Industrious Revolution* (Chaudhuri, 1986; Palma and Silva, 2024).[5] Finally, annual silver price inflation of around 0.5% – a consequence of the continued influx of American silver – encouraged wealthy households to divest their silver treasures and invest in other assets instead (de Vries and van der Woude, 1997; van Bavel, 2016, pp.167–196), thereby contributing to West European capital formation (Frank, 2011, p.44). Our analysis of disaggregated output series allows us to discern between these various transmission channels and thereby reveal how exactly American precious metals affected West European growth.

Our paper complements a recent literature that quantitatively explores the effect of American precious metal arrivals on the early modern European economy (Chen, Palma, and Ward, 2021; Palma, 2022; Brzezinski, Chen, Palma, and Ward, 2024). So far, this analysis was restricted to short- and medium-run outcomes within Europe. By contrast, in this paper we analyze long-run outcomes and we take a global perspective. In particular, we provide a quantitative analysis of the contribution of the American precious metal windfall to the incipient income divergence between Europe and Asia, and the intra-European income divergence between Europe's Northwest and first-stage receiver Spain.

We thus contributes a novel quantitative leg to the literature on the intra-European *Little Divergence*. Existing research highlights the resource curse brought about by first-stage receivers rich endowment with precious metals (Palma, 2020; Kedrosky and Palma, 2021; Charotti, Palma, and Pereira dos Santos, 2022). This resource curse exerted its detrimental effect on Iberian economic development in two ways. First, a real exchange

[4] At the eastern end of the Eurasian landmass, China moved in the opposite direction of less market integration in the late early modern period, as indicated by the regional correlation of wheat and rice prices (Bernhofen et al., 2020). By contrast, European wheat and rye prices reflect an increase in market integration during the early modern period (Jacks, 2004; Federico et al., 2021). European capital markets, likewise exhibited a high degree of integration already in the 18th century ().

[5] In particular Spanish pesos, minted in America, were accepted across East Asia for payment and even remained in circulation there (Palma and Silva, 2024).

rate appreciation reduced the price competitiveness of first-stage receivers' tradables sectors (Hamilton, 1934). Second, institutional progress halted as the reliance of the Spanish and Portuguese states on American precious metals for their expenditure needs rendered their rulers unresponsive to the demands of local taxpayers (Henriques and Palma, 2023). Our paper explores a third way in which the American precious metal windfall ended up hurting first-stage receivers – the monetary volatility entailed by first-stage receivers's heavy exposure to maritime disaster losses.

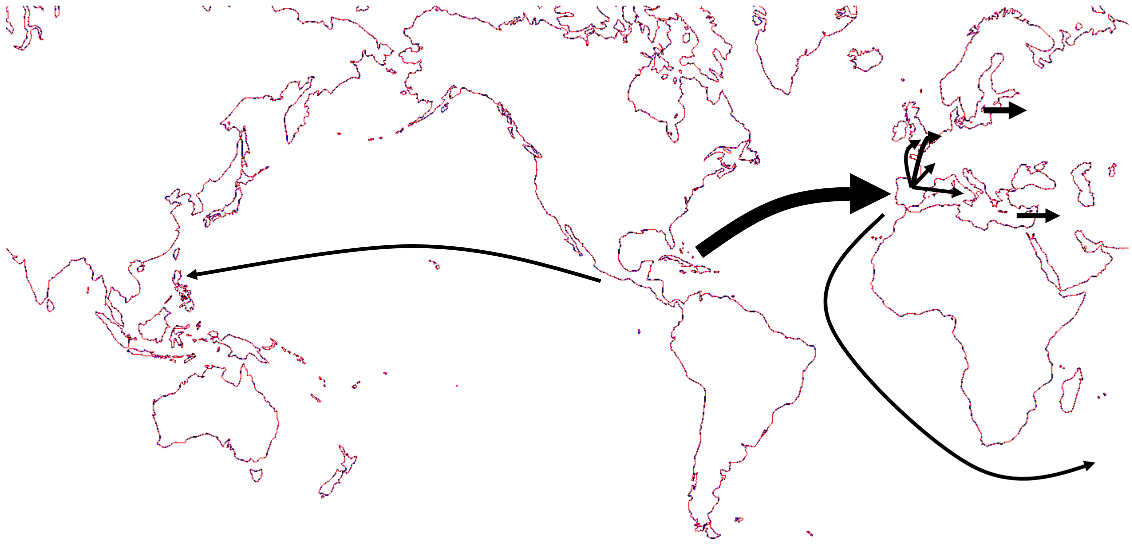
Next, our paper shines a novel light on the long-standing question to which extent the *Rise of the West* was grounded in colonialism (Williams, 1944 [1994]; Frank, 1979; Wallerstein, 1974-1980). Research has focused on the indirect role of colonial trade in fostering commerce-friendly institutions brought about by the enrichment and subsequent political empowerment of Atlantic merchants (Acemoglu, Johnson, and Robinson, 2005). Our analysis highlights an important monetary dimension of colonial history by focusing on the role played by the single most valuable commodity that America supplied to Europe up to the late 18th century – precious metals. Gold and silver accounted for more than 80% of the value of cross-Atlantic shipments arriving in Spain.[6] While the annual inflows were modest compared to the size of the European economy (Engerman, 1972; O'Brien, 1982; Inikori, 2002), our findings indicate that the sustained nature of American money injections over the course of three centuries in fact considerably promoted output growth – money was not neutral in the long-run.

Therefore our paper also contributes to the literature on long-run money non-neutrality (Blanchard and Summers, 1986; Benigno and Fornaro, 2018; Galí, 2022). Recent empirical evidence in favor of longer-run money non-neutrality comes from Jordà, Singh, and Taylor (2020). Our finding that American money arrivals contributed to West European growth by accelerating capital formation is particularly consistent with the operation of a Mundell-Tobin effect (Mundell, 1963; Tobin, 1965). With respect to the intra-European *Little Divergence* our account is closely related to recent research indicating that contractionary monetary shocks have the potency to trigger financial crises (Schularick, ter Steege, and Ward, 2021), which in turn can cause lasting damage to the economy (Teulings and Zubanov, 2014; Jordà, Schularick, and Taylor, 2023). Along the same lines, the large money losses associated with Spain's maritime disasters repeatedly triggered financial crises that exerted a negative long-run effect on Spain's economic development.[7]

[6]For much of the early modern period, America did not supply significant amounts of other commodities to Europe. Only late in the 18th century and in the 19th century did such imports become sufficiently large to significantly ease the land constraint under which the European economy was operating as suggested by Pomeranz (2000).

[7]A related strand of the literature analyzes the role of monetary volatility for macroeconomic outcomes (Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramirez, and Uribe, 2011; Mumtaz and Zanetti, 2013).

Figure 1: Global distribution of the American precious metal windfall



Notes: Arrow width reflects cumulated flow size between 1500 and 1800. The Atlantic flow equals 75 kilotonnes. Data sources: Chen et al. (2021), Attman (1986), and de Vries (2003).

2. The American precious metal windfall

This section describes the initial distribution of the American precious metal windfall and its subsequent global diffusion. Understanding the geographic diffusion of the American precious metal flow is key for understanding how the American precious metal windfall afforded Western Europe a powerful monetary stimulus that was unique among world regions.

2.1. Initial distribution and diffusion of the windfall

The arrows in Figure 1 present a true to scale depiction of American precious metal flows in the early modern period. By far the largest flow occurred across the Atlantic, towards the Iberian kingdoms which had recently colonized much of America. Over the early modern period, around 75,000 tonnes of silver thus arrived in Western Europe (Chen, Palma, and Ward, 2021).[8] By contrast, only around 13,000 tonnes went across the Pacific in the Manila Galleon trade between Acapulco (Mexico) and Manila (Philippines).[9] This initial distribution of the American precious metal windfall was particularly lopsided given the distribution of global economic activity at the time. In the early 1500s, Western Europe

[8]Throughout the text, we refer to metric tonnes. The values include gold flows translated into silver equivalent using contemporary gold-silver ratios.

[9]Throughout the text, we refer to countries as geographic entities in their modern borders even if they did not yet exist as politically unified entities during the early modern period.

accounted for less than one fifth of global GDP, whereas Asia accounted for around two thirds (Bolt and van Zanden, 2020).

Once American precious metals had arrived in Spain, they began to diffuse eastward, especially by means of trade.[10] The four most important second-stage receivers were England, Holland, France, and Italy, after which American silver began to diffuse more widely through Central and Eastern Europe. Propelled by silver's purchasing power differential between West and East, American precious metals continued to flow further East, with important European outflows occurring through the Baltics, the Levant, and through the Cape route.

2.2. The geography of American precious metal flows

2.2.1 Diffusion from West to East

The extent to which the American precious metal windfall had a differential impact on money stocks across the world depends on the speed with which initial arrivals began to diffuse across world regions.[11] Consider R regions that are aligned along a geographic sequence running from West to East. The region index $r = 1, ..., R$ reflects the regions' geographic sequencing, with $r = 1$ denoting the most Western first-stage receiver, and $r = R$ the most Eastern region. Each region receives inflows from its Western neighbor:

$$in_{r,t} = out_{r-1,t} \tag{1}$$

Region r retains a part $(1-\omega_r)$ of these inflows. The remainder is passed on to r's Eastern neigbhor, potentially with some lag:

$$out_{r,t} = \ \omega_r \theta(L) in_{r,t}, \tag{2}$$

where $\theta(L)$ denotes a lag polynomial. ω_r is implicitly defined by $\omega_r^Y = (1-\omega_r)\prod_{j=1}^{r-1}\omega_j$, where ω_r^Y denotes region r's steady state weight in the global money distribution.[12] Equations 1 and 2 allow for an expression of region r's money outflow as a function of the primary money influx $in_{1,t}$

$$out_{r,t} = \prod_{j=1}^{r} \omega_j \theta(L)^r in_{1,t}$$

[10] By contrast, the initial Atlantic flow between American colonies and Spain had little to do with trade, but predominantly constituted current transfers, such as remittances and repatriated profits (Brzezinski et al., 2024).

[11] American precious metal primarily fulfilled a monetary function. Until the late 18th century only around 20% of gold and silver found a non-monetary use in utensils and ornaments (Jacob, 1831). In fact, precious metals arriving from America were required to be minted upon arrival by regulation (Hamilton, 1934, pp.25,29) and over time the majority of American precious metals arrived in Europe already in coined form (Céspedes del Castillo, 1996; Palma, 2020).

[12] For example, in an environment with no cross-region differences in money velocity V and with the law of one price equalizing price levels P across countries, the equation of exchange $MV = PY$ implies that ω_r corresponds to region r's global GDP share.

Region r's money stock changes according to

$$\Delta M_{r,t} = in_{r,t} - out_{r,t} = [1 - \omega_r \theta(L)] \prod_{j=1}^{r-1} \omega_j \theta(L)^{r-1} in_{1,t} \tag{3}$$

This equation reveals that as the money flow progresses from one region to another, the primary money influx $in_{1,t}$ is modulated by a region-specific lag structure that generates a wavelike undulation in money stocks across the geographic sequence from West to East. The magnitude of the temporary swelling of regional money stocks $M_{r,t}$ that the primary influx $in_{1,t}$ brings about fades along the geographic sequence, as each region retains part $(1 - \omega_r)$ of the primary influx. This fading effect is amplified when the economic weight of regions increases along the geographic sequence: $\omega_r^Y < \omega_{r+1}^Y$. This was the case for the geographic sequence along which American precious metals progressed from Western Europe to East Asia. Thus, the initial distribution of the American precious metal windfall implied a disproportionate swelling of West European money stocks.

The left panel of Figure 2 shows the sequential swelling of money stocks from West to East after a 1 unit windfall of American precious metals arrives in Western Europe. For this example, we considered three regions (Western Europe, Central Eurasia, East Asia) and a mixture of instantaneous and lagged diffusion, $\theta(L) = 0.2 + 0.4L + 0.4L^2$.[13] We set region weights in line with population levels: $\omega_1^Y = 10\%$, $\omega_2^Y = 50\%$, $\omega_3^Y = 40\%$.[14] The resulting $\Delta M_{r,t}$, expressed relative to GDP, show how money stocks expanded along the geographic sequence from West to East. While West European money stocks exhibit a large expansion in the aftermath of an inflow of precious metals from America, East Asian money stocks exhibit a comparatively tame increase towards their new steady state level.

Note that, if the diffusion was instantaneous, i.e. $\theta(L) = 1$ and $out_{r,t} = \omega_r in_{r,t}$, each region would immediately receive its steady state share ω_r^Y of the primary money

[13]Some indication of the international diffusion speed of precious metals can be gleaned from the annual mint output data that exists for second-stage receivers England, France, Genoa, and Holland (Palma, 2022). A fixed effects regression of the log of second-stage receiver mint output on the log of American precious metal inflows and its lags yields the following result (with Driscroll-Kraay standard errors):

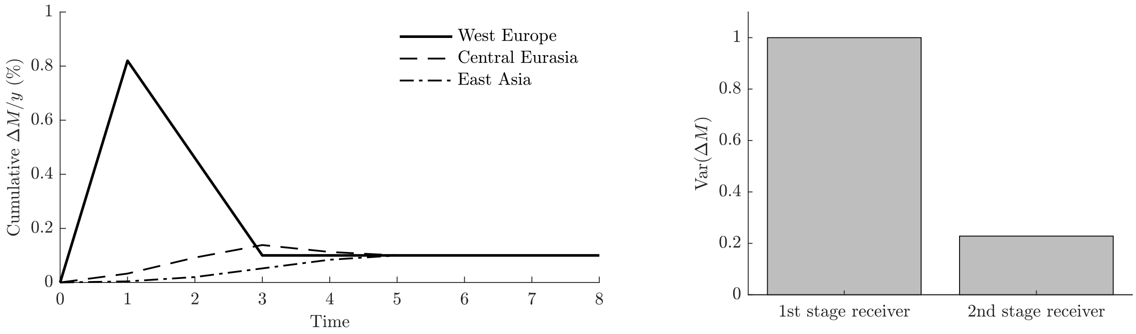
	in	l.in	l2.in	l3.in
mint out	0.21	0.16	0.33***	0.21
	(0.13)	(0.11)	(0.09)	(0.13)

* 0.10 ** 0.05 *** 0.01 (significance level)

This suggests that a 1 percent increase in American precious metal arrivals elicited a significant 0.33 percent increase in second-stage receiver mint output with a lag of two years. This indicates that precious metal diffusion was non-instantaneous at an annual frequency. Arguably, however, the mint output data underestimates the speed with which precious metals diffused internationally because silver bullion and Spanish coins could and did circulate beyond Spain without immediately having to enter a non-Spanish mint for re-minting in a non-Spanish denomination (Palma, 2018a; Palma and Silva, 2024).

[14]These shares correspond to the population numbers from Bolt and van Zanden (2020) for around 1600 (South Asia is included in the *Central Eurasia* group). The per capita money stock data by Bonfatti et al. (2020) suggest that actual eastward diffusion to Eastern Europe and Russia in practice fell short of these regions' global population shares.

Figure 2: Diffusion of the American precious metal windfall



(a) Monetary impact (b) Variance insulation

Notes: Panel (a) – results based on simulation of equation (3) for $\theta(L) = 0.2 + 0.4L + 0.4L^2$, and region weights $\omega_1^Y = 10\%$, $\omega_2^Y = 50\%$, $\omega_3^Y = 40\%$. The Figure shows the monetary stimulus enjoyed by different regions in response to a 1 unit increase in the primary influx $in_{1,t}$. Panel (b) – variance of money stock changes based on 1000 draws of $in_{1,t}$ from a normal distribution. first-stage receiver variance is normalized to 1. $\omega_1^Y = 2\%$, $\omega_2^Y = 8\%$, $\omega_3^Y = 90\%$

influx $in_{1,t}$. In this case the initial distribution of the precious metal windfall develops no differential impact on money stocks across the world – the geographic sequencing of money flows becomes irrelevant.

2.2.2 Volatility insulation and monetary goldilocks zone

Another implication of the geographic sequence described by equation (3) is that a large second-stage receiver's money supply is considerably better insulated from the year-to-year volatility of American precious metal arrivals than a small first-stage receiver's money supply. American precious metal inflows could be highly volatile, primarily due to maritime disasters in which large amounts of precious metals were lost (Brzezinski et al., 2024). For Spain, the loss of a large shipment of American precious metals could amount to 10% of its money stock. By contrast, the subsequent fourfold dispersion of the American precious metal flow to England, Holland, France, and Italy implied that their annual inflow of American precious metals only amounted to around 2.5% of the money stock. Thus, money stock turnover was significantly lower among second-stage receivers than in Spain. In addition, any diffusion delays contained in equation (3) imply that for second-stage receivers maritime disaster losses were smoothed out over time.

This insulation from the vagaries of American precious metal inflows mattered, especially because maritime disasters could trigger severe financial crises in Spain (Brzezinski et al., 2024). Merchant letters written in the aftermath of maritime disaster events bear witness to these financial crises. For example, merchants bemoaned a credit crunch at the exchange fairs in February 1568 (da Silva, 1959a, p.12) – the year after a maritime disaster had resulted in the loss of silver worth about 7% of the Spanish money supply. A merchant letter from August 25th 1568 indicates that money and credit market conditions remained tight throughout the summer of that year (da Silva, 1959b, p.22). Another merchant letter from 1592, one year after the maritime disaster of 1591, reveals one of the wealthiest merchants of his time (Simón Ruiz) instructing one of his employees to make parsimonious use of money and draw on credit instruments for payment where possible to bridge the money shortage (Martín, 1965, p.xiv).[15]

The financial turmoil in the aftermath of maritime disasters appears to have remained largely restricted to the Iberian peninsula, which is evidenced by the absence of systematic lending rate increases among financial exchanges located in Europe's second-stage receivers (Brzezinski et al., 2024, Appendix). This is consistent with the volatility insulation effect implied by equation (3). To the extent that maritime disaster-induced financial crises caused lasting damage (Cerra and Saxena, 2008; Jordà et al., 2023), the insulation afforded to second-stage receivers thus potentially safeguarded their economic development.[16]

A simulation of the inflow-outflow apparatus presented by equations 1 to 3 serves to illustrate the insulation that second-stage receivers enjoyed. For this simulation we consider Spain as the first-stage receiver and England, Holland, France, and Italy as the second-stage receiver region. We set region weights according to population shares of $\omega_1^Y = 2\%$, $\omega_2^Y = 8\%$, and $\omega_3^Y = 90\%$, with region $r = 3$ acting as a summary region for the rest of Eurasia. We apply the same lag polynomial as before. We then calculate the variance of money supply changes $\Delta M_{r,t}$ on the basis of 1000 random draws of the primary influx $in_{1,t}$ from a normal distribution. The right panel in Figure 2 displays the variance result, which illustrates that the first-stage receiver is exposed to a much higher money supply variance than a second-stage receiver.

In sum, the American precious metal windfall gave rise to a powerful monetary stimulus that was unique to Western Europe. Within Western Europe, second-stage receivers were situated in a particularly fortunate goldilocks zone, which enjoyed considerable monetary stimulus while being insulated against the high volatility of the primary precious metal influx.[17] The following analysis investigates the extent to which these insights find reflection in how the arrival of American precious metals affected economic outcomes

[15] The vulnerability of Spain's financial market to any disruption in American precious metal arrivals is further evidenced by the fact that mere delays in arrivals could trigger financial market turbulence (Pike, 1966, p.87). For example, in a letter dated November 25th 1553 – after a two month delay – a merchant laments the 60% annualized interest rate that had to be paid for the only credit still available (Lockhart et al., 1976, pp.91ff.).

[16] American precious metals were initially owned by a Spanish entity, as by the Spanish Empire's regulation transatlantic business with the American colonies was restricted to Spanish merchants (Nogues-Marco, 2011, p.6).

[17] To be sure, not all second-stage receivers experienced an exceptional output growth performance over the early modern period. Italy, for example, experienced a relative decline. Our analysis does not purport to fully explain the output development of each individual country, but rather focuses on assessing the monetary effect of the American precious metal windfall.

across Europe.

3. Data

Economic historians have recently reconstructed GDP series for the early modern period based on the data contained in probate inventories and the account books of long-lived institutions, such as monasteries, hospitals, and universities. Our dataset includes the GDP series for Spain, England, Holland, France, Italy, Germany, Poland, and Sweden.[18] These GDP series allow us to trace the effects of the American precious metal influx across Europe. In particular, our analysis distinguishes between first-stage receiver (Spain), second-stage receivers in Western Europe (England, Holland, France, Italy), and 3rd stage receivers further East (Germany, Poland, Sweden).[19]

Early modern GDP estimates come in two variants, demand-side estimates (Spain, France, Italy, Germany, Poland, Sweden) and supply-side estimates (England, Holland). The former draw on income data – wages and land rents – and price data to calculate real GDP from the demand side. The latter draw on a variety of disaggregated output series to calculate real GDP from the supply side (van Zanden and van Leeuwen, 2012; Broadberry et al., 2015). While the two approaches have been confirmed to produce broadly consistent results (Broadberry et al., 2015, pp.120–124), an advantage of the Dutch and English supply-side estimates is that the they come with a wealth of industry-level output series that allow for a more detailed analysis of how American precious metals affected the European economy. We make use of this data to gain insights into the channels through which American precious metals fostered economic growth in Northwestern Europe.[20]

To better understand the reaction of Spain's economy to big maritime disaster shocks, we draw on disaggregated output data compiled by Brzezinski et al. (2024). Compared to the disaggregated output data for England and Holland the Spanish data is more

[18]The GDP series come from Malanima (2011), van Zanden and van Leeuwen (2012), Álvarez-Nogal and Prados de la Escosura (2013), Broadberry et al. (2015), Krantz (2017), Malinowski and Van Zanden (2017), Ridolfi and Nuvolari (2021), and Pfister (2021). We do not use the series by Álvarez-Nogal et al. (2021), because its annual variation is exclusively informed by agricultural tithe data. Consequently, the annual ups and downs of this series are indicative of agriculture only. By contrast, the series by Álvarez-Nogal and Prados de la Escosura (2013) is based on a broader set of income indicators, such as wages (urban and rural) and land rents.

[19]The baseline analysis does not include Portugal, due to its ambiguous status as simultaneous first-stage receiver of Brazilian gold towards the end of our sample, and a second-stage receiver of American precious metals from Spain's colonies. The Appendix presents results based on a sample that includes Portugal as a first-stage receiver (data from Palma and Reis, 2019). The estimated monetary effects for West Europe are somewhat smaller in this case, but qualitatively the results are very similar (Figure A.15 and Table A.1).

[20]Demand-side GDP estimates often contain interpolated urbanization rate data which is uninformative with respect to short-term fluctuations in output. As a robustness check we therefore remove all interpolated urbanization data from the demand-side GDP estimates and re-run our analysis. While this slightly increases the size of the coefficient estimates of interest, the shape and statistical significance of the IRF estimates remains unaffected (Figures A.1 and A.2 in the Appendix).

fragmentary, covering shorter time periods and fewer regions, e.g. the revenues from a tax on cloths entering Toledo from 1540 to 1659.[21] Such time series nevertheless offer some insight into how transport-loss induced financial crises affected different industries in Spain.[22]

Data on the inflow of American precious metals into Europe comes from Palma (2022) and Brzezinski et al. (2024). Figure 3 depicts this inflow fluctuating between 1 and 2% of the European money stock.[23] Inflow variation springs from exogenous variation in American precious metal extraction and transport losses, neither of which were related to economic conditions in Europe.[24] American precious metal production primarily depended on the discovery of new mines, which was of an accidental nature (Bakewell, 1971; Boxer, 1962, pp.254–256). Once operational, American mines were too profitable for mining intensity to become a marginal decision influenced by the price of precious metals in Europe (Bacci, 2010). Instead, mining output was constrained by the availability of technology and location-specific costs, such as the supply of mercury for amalgamation and local administrative conditions.

The eleven marked downward spikes in the money inflow series depicted in Figure 3 reflect big maritime disaster losses from Brzezinski et al. (2024).[25] Whereas Brzezinski et al. (2024) describe more than 30 maritime disaster events, we here focus exclusively on

[21]We deflate nominal series with price indices constructed from corresponding goods prices from the same region or nearby regions as described in Brzezinski et al. (2024).

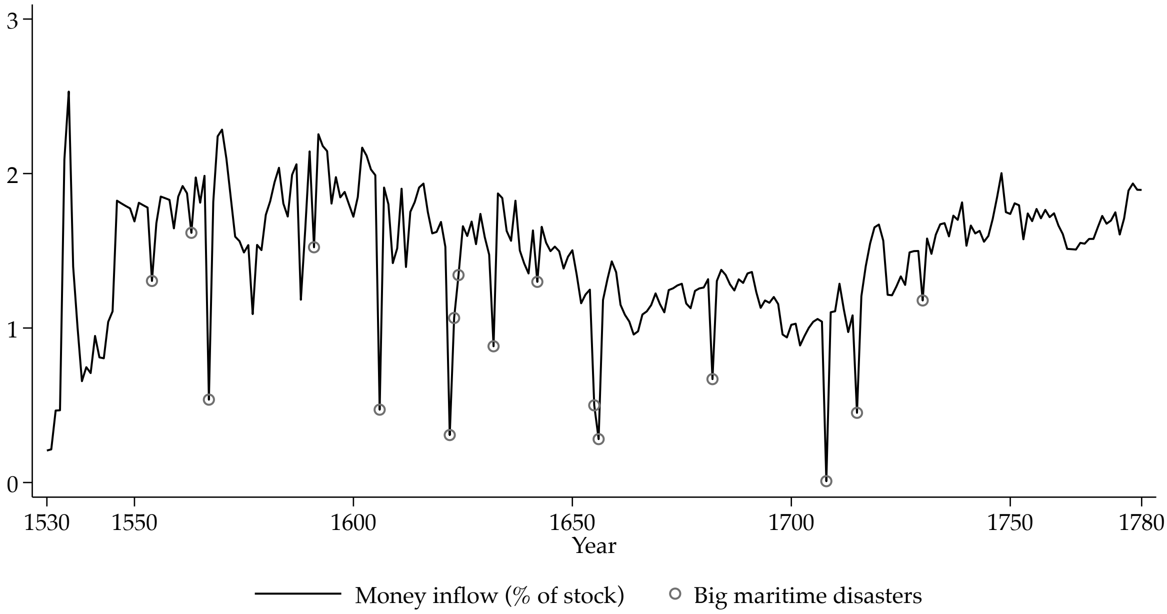
[22]We also draw on the agricultural output series provided by Alvarez-Nogal et al. (2021), which is based on annual variation in agricultural levies. This series covers our entire sample period.

[23]The vast majority of American precious metals was privately owned. The Spanish Crown typically received significantly less than one fifth of money arrivals (García-Baquero González, 2003; Palma, 2022). Brzezinski et al. (2024) show that variations in the inflow of American precious metals did not exert their influence on European economic outcomes through their effect on government finances. Although American precious metals could make up an important share of government revenues among first-stage receivers, public sector shares were too small for this to translate into aggregate economic effects.

[24]Although exogenous to the state of the European economy, American precious metal arrivals were partly anticipated by the public. The amount of annual inflows was highly persistent, and thus last year's inflows were a good predictor of this year's inflows. Each year the economic press reported how much gold and silver had arrived in Portugal and Spain (Morineau, 1985). In addition, small and fast dispatch boats carried information on the amount of precious metals that was about to arrive ahead of the treasure fleet (Martín, 1965, p.6). While published amounts and actual arrivals deviated from one another (Palma, 2022), generating an element of surprise, literate contemporaries were in a position to form broadly accurate expectations (on average) about the annual inflow of American precious metals into Europe (see Neal, 1988, on the early modern financial press). To the extent that this happened, the analysis of American precious metal inflows resembles the analysis of anticipated monetary policy changes (Mishkin, 1982; Cochrane, 1998; Hoover and Jordà, 2001; Milani and Treadwell, 2012). By contrast, maritime disaster losses constituted exogenous variation that was unanticipated.

[25]Individual silver shipments were partly insured (Baskes, 2013), but to the extent that insurance was provided within the Spanish merchant community large maritime disaster losses nevertheless constituted an aggregate shock to the Spanish economy. The existing information about foreign insurers' involvement at the time is anecdotal and does not allow for quantitative conclusions. However, the finding by Brzezinski et al. (2024, Appendix) that European lending rates beyond Spain's borders did not systematically increase in the aftermath of maritime disaster losses indicates that money losses were initially concentrated in Spain.

Figure 3: Atlantic money inflows into Europe (% of European money stock)



the biggest disasters events – those resulting in a money loss exceeding 0.5% of the European stock and followed by a financial crisis.[26] Like American mining output, maritime disaster losses were exogenous to the state of the European economy. Most maritime disasters were caused by bad weather, especially Caribbean hurricanes. Navigational errors – the second most common cause of maritime disaster losses – was similarly unrelated to economic conditions in Europe. Piracy and combat losses were the distant third and fourth causes of maritime disaster losses. Both were rooted in interstate conflicts, that potentially affected European economies in other ways than just through the loss of silver money. Conditional on that, however, piracy and combat losses arose as the consequence of random tactical opportunities, not the trajectory of economic variables in Europe.[27]

4. Method

We estimate cumulative impulse response functions (IRF) that describe the effect of American precious metals on European real output through local projections over a 15-year horizon $h = 1, ..., H$; $H = 15$ (Jordà, 2005):

$$ln(Y_{i,t+h}) - ln(Y_{i,t-1}) = \alpha_{i,h} + \beta_h \, in_t + \gamma_h X_{i,t} + u_{i,t+h}, \tag{4}$$

where $Y_{i,t}$ denotes the outcome variable of interest and in_t denotes variation in American precious metal arrivals in Europe – either the natural logarithm of the inflow-to-stock

[26] Indicative of their less disruptive nature, maritime disasters with a loss figure below 0.5% of the European stock are not systematically followed by rising lending rates.

[27] Brzezinski et al. (2024) document that the money value of the non-monetary losses entailed by maritime disasters (ships, non-money cargo) was negligible compared to the value of the monetary loss.

ratio or the disaster-loss-to-stock ratio, when we analyze the effect of maritime disaster shocks. When we distinguish between the different reaction of 1st, 2nd, and 3rd stage receivers we augment this specification with a term that interacts the money inflow measure with binary region indicators, D_i^r, that indicate to which region country i belongs: $\sum_{r=2}^{R} \beta_h^r \, in_t D_i^r$. The baseline specification contains country- and horizon-specific constants $\alpha_{i,h}$, a vector of controls $X_{i,t}$, and country- and horizon-specific error terms $u_{i,t+h}$.

The control vector includes two lags of the outcome variable's growth rate. It likewise includes two lags and leads up to the projection horizon h of the following exogenous control variables: the average growing season temperatures (Anderson et al., 2017) (an important control for early modern economies with large agricultural sector shares) and two war dummies indicating the involvement of country i in a war with another European country or a colonial war further abroad (Brecke, 1999) (regular occurrences that put demands on early modern European economies) (Stock and Watson, 2018).[28] In addition, $X_{i,t}$ includes a linear time trend and its square. We calculate confidence bands based on Driscoll-Kraay standard errors that account for cross-sectional and temporal dependencies among observations (Driscoll and Kraay, 1998).[29] The coefficient estimates $\{\hat{\beta}_h\}_{h=1}^{H}$ describe the trajectory of the outcome of interest in response to a change in the money inflow-to-stock-ratio. In the region-specific case, the coefficient sums $\{\hat{\beta}_h + \hat{\beta}_h^r\}_{h=1}^{H}$ $(r = 2, 3)$ present the regional responses for Central and Eastern Europe, whereas $\{\hat{\beta}_h\}_{h=1}^{H}$ presents the response of first-stage receiver Spain. [30]

Based on these coefficient estimates we can sum up the overlapping GDP change effects of past money inflows as

$$\Delta_{i,t}^{M \to GDP} = \sum_{h=0}^{\phi} \left(\hat{\beta}_h in_{t-h} Y_{i,t-1-h}^{M} \right), \tag{5}$$

where ϕ denotes the effect persistence. We equate ϕ with the projection horizon $H = 15$ beyond which we usually do not find significant coefficient estimates, i.e. we assume $\{\hat{\beta}_h\}_{h=16}^{\infty} = 0$.[31] $Y_{i,t}^{M}$, the gross GDP growth attributable to money inflows in region i at

[28]Including leads of the exogenous control variables serves to account for some of the outcome variable variance over the projection horizon, and thereby increase the precision of the estimates. However, the results are robust to dropping the control vector from the specification (Figures A.3 to A.4 in the Appendix).

[29]We set the lag order of autocorrelation equal to the projection's horizon h.

[30]In some cases, the fragmentary nature of the disaggregated Spanish output series does not allow us to work with the saturated control vector $X_{i,t}$. In this case, to prevent the number of coefficients from exceeding the number of observations, we drop the leads of exogenous control variables and the higher order time trend from $X_{i,t}$. This is the case for shipbuilding and the Toledean series on fishing, coarse cloth output, theater visits, and brothel visits (Montemayor, 1981).

[31]Only in the case of Spain's GDP reaction to maritime disasters, do we find evidence for a permanent output effect that lasts beyond 15 years (Section 5.3).

time t, is defined recursively as

$$Y_{i,t}^{M} = 1 + \Delta_{i,t}^{M \to GDP} \quad (6)$$

We initialize $Y_{i,t}^{M}$ to equal 1 in 1530 – the beginning of our dataset. We can then compare $Y_{i,t}^{M}$ with actual gross GDP growth to get an idea of the importance of American money inflows for Europe's early modern growth.[32]

5. Results

5.1. American precious metals and the *Rise of the West*

How did American precious metals affect European economies? Figure 4 traces the real GDP responses to a doubling in the precious metal inflow-to-stock ratio across the European continent. The left panel depicts the GDP response in Spain – the first-stage receiver. It displays a short-lived boom during which output increased by around 2%. After four years the boom has run its course. The output response remains somewhat elevated until year ten, but is statistically indistinguishable from zero.[33]

The middle panel depicts the GDP reaction of second-stage receivers – England, Holland, France, and Italy. Here, the real effect of a monetary injection persisted for longer. Real GDP increased by around 2% within one year. Output then remained elevated for around seven years, before returning to normal. While this suggests that Europe's second-stage receivers benefited more from American precious metals than Spain, (pointwise) Wald tests cannot reject the null of an equal effect size among first- and second-stage receivers (Table accompanying Figure 4, second row).[34]

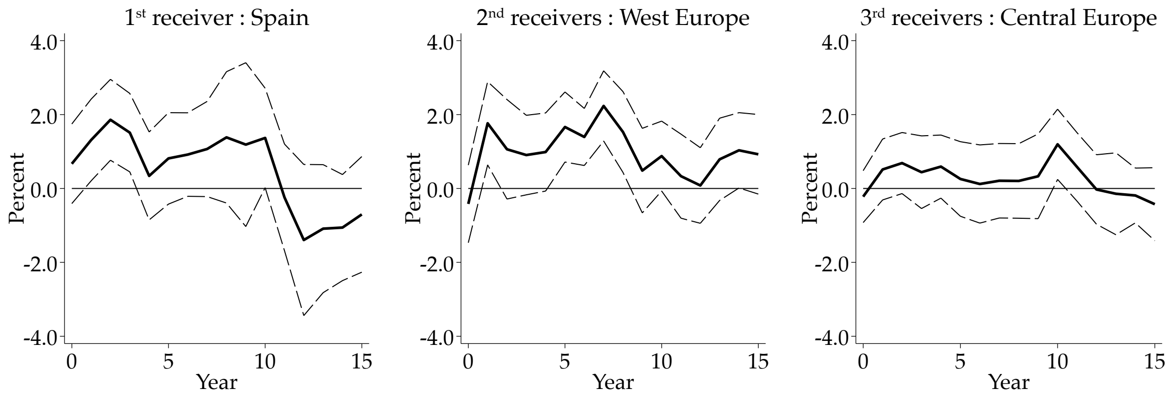
Finally, the right panel depicts the output response of 3$^{\text{rd}}$ stage receivers – Germany, Poland, and Sweden. The IRF estimate suggests that an increase in precious metal inflows failed to develop a stimulative effect in Central Europe. Although the mean IRF estimate tends to be slightly positive, most coefficient estimates are insignificant. These findings indicate that by the time an increase in American precious metals had worked its way into

[32] The Appendix displays results obtained from a mean group estimator that allows for dynamic heterogeneity (Pesaran and Smith, 1995). The results are very similar to the baseline results that either pool the West European data (Figures A.5 to A.7).

[33] The use of Driscoll-Kraay standard errors contributes to the wider confidence bands compared to those reported by Palma (2022). The difference in the mean estimates originates from the use of the updated series on the influx of American money into Europe by Chen et al. (2021). This series accounts for the non-monetary use of American precious metals, Pacific precious metal flows, non-registered production, and American precious metal retention.

[34] Spain's early modern *Dutch disease* problem presents a potential economic rationale for the smaller mean effect size estimates for Spain: Spanish manufacturers became too expensive compared to their competitors located in England, Holland, and France. As a consequence, Spain suffered a persistent trade deficit with these countries, which she settled with precious metals from America (Hamilton, 1934; Forsyth and Nicholas, 1983; Abad and Palma, 2021).

Figure 4: Real GDP response to doubling in money-inflow-to-stock ratio



	h=0	1	2	3	4	5	6	7	8	9	10
Difference (1^{st}-2^{nd})	1.1	-0.5	0.8	0.6	-0.6	-0.9	-0.5	-1.2	-0.1	0.7	0.5
1^{st}=2^{nd} (p-value)	0.14	0.61	0.36	0.50	0.48	0.25	0.52	0.26	0.90	0.56	0.68
Difference (2^{nd}-3^{rd})	-0.2	1.2	0.4	0.5	0.4	1.4	1.3	2.0	1.3	0.2	-0.3
2^{nd}=3^{rd} (p-value)	0.66	0.10	0.67	0.50	0.49	0.01	0.06	0.01	0.12	0.89	0.71

Notes: The graph analyzes the real GDP response in 1^{st}, 2^{nd}, and 3^{rd} stage receivers. Dashed lines delineate 90% confidence interval. The table displays the difference between 1^{st}, 2^{nd}, and 3^{rd} stage receiver-responses for horizons $h = 0, ..., 10$. The p-values correspond to pointwise Wald tests for response equality.

Central Europe, it no longer afforded any real stimulation. A Wald test confirms that the response differences between second- and third-stage receivers is statistically significant at the 10% level for horizons $4 < h < 8$ (Table accompanying Figure 4, fourth row).[35]

Which part of Western Europe's GDP growth over the early modern period can plausibly be attributed to American precious metals? To assess this according to the machinery laid out in equations 5 and 6, we first calculate the cumulative IRF for Europe's first- and second-stage receivers together. Expectedly, the resulting real GDP response is very similar to that of Western Europe's second-stage receivers (Figure A.16 in the Appendix). We then calculate the West European GDP growth that is attributable to injections of American money according to equation (6). The result amounts to 41% – around half of the actual West European GDP increase of 77% (Table 1). This lends empirical support to the notion that American precious metals were an important factor behind Western Europe's early modern growth.

The second column of Table 1 contrasts Western Europe's growth experience, with that of East Asia over the same time period. The East Asian economy grew by around

[35] Per capita real GDP responses look very similar (Figure A.8 in the Appendix). For most countries in our sample this is expected because the underlying population data is interpolated and thus cannot meaningfully contribute to the short- and medium-run response estimates we estimate. The available English demographic data, however, is annual from 1541 onwards, which allows us to estimate IRFs for the birth rate, the death rate, and the population level (see Section 5.2).

Table 1: Monetary origins of the early Great Divergence

	Western Europe	East Asia
Monetary effect	41%	*2%*
GDP change	77%	23%
% of early *Great Divergence*	**72%**	

Notes: % of early Great Divergence calculated as $(\Delta Y^M_{Europe,1780} - \Delta Y^M_{Asia,1780})/(\Delta Y_{Europe,1780} - \Delta Y_{Asia,1780})$. Italics: monetary effect for East Asia based on West European IRF estimate, scaled down by East Asia's large GDP share and small share of direct American precious metal inflows across the Pacific. When adding the Cape flow to the East Asian primary influx results in a doubling of the monetary effect for East Asia to 4%.

23% between 1530 and 1780. While the lack of annual GDP estimates for early modern East Asian economies prevents the estimation of an East Asia-specific GDP IRF, we can calculate a monetary effect for East Asia based on the West European GDP IRF, scaled down by East Asia's higher GDP level and its smaller role as a first-stage receiver of American precious metals through the Pacific.[36] The resulting GDP growth that is attributable to money in East Asia amounts to 2%. All together, these numbers imply that 72% = (41%−2%)/(77%−23%) of the early Great Divergence between West and East can be plausibly attributed to the the American precious metal windfall. While American precious metals billowed West European GDP, little comparable stimulus arrived at the Eastern end of the Eurasian landmass.

Robustness: We conduct various robustness checks and subsample analyses to explore the stability of the baseline findings (Table 2, row *Baseline*). First, a parsimonious specification that drops the control vector yields very similar results (row *Parsim.*). This is as expected under the assumption that the money inflow variable presents exogenous variation. Second, extending the lag order from 2 to 4 yields a somewhat smaller response estimate, which translates into a 25% contribution of American precious metals to West European output growth and a 45% contribution to the early Great Divergence (row *4 lags.*).

Third, the exact level of the European money stock for the early modern period is uncertain. Chen et al. (2021) present a 95% probability density interval whose upper and lower bounds deviate from the mode by around one third. When we substitute the denominator in the money-inflow-to-stock ratio in the LP regressions (4) by the upper

[36] The scaling factor amounts to 0.04, which reflects a primary influx of around 13,000 tonnes in East Asia (compared to Europe's 75,000 tonnes), and a close to four times larger GDP. Consistent with our finding that the stimulative effect of American precious metals had run its course by the time these metals arrived in Central Europe, we assume that money that arrived in East Asia across the overland silk routes from West to East developed no stimulative effect in East Asia.

Table 2: Robustness: West European output responses to doubling in money-inflow-to-stock ratio

	h=0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	$\Delta Y^M_{Eur.}$	of *GD*
Baseline	-0.3	1.6*	1.2*	1.1*	0.9	1.5*	1.4*	2.0*	1.4*	0.6	0.9*	0.1	-0.1	0.4	0.6	0.6	41%	**72%**
	(0.6)	(0.6)	(0.7)	(0.6)	(0.6)	(0.6)	(0.4)	(0.5)	(0.6)	(0.7)	(0.4)	(0.6)	(0.4)	(0.5)	(0.5)	(0.7)		
Parsim.	-0.2	1.6*	1.2	1.0*	0.8	1.4*	1.2*	1.9*	1.5*	0.8	0.9*	0.4	-0.2	0.3	0.6	0.6	40%	**71%**
	(0.6)	(0.6)	(0.7)	(0.5)	(0.5)	(0.5)	(0.4)	(0.5)	(0.6)	(0.6)	(0.4)	(0.5)	(0.5)	(0.4)	(0.4)	(0.5)		
4 lags	-0.4	1.5*	1.0	0.9	0.6	1.0*	1.0*	1.5*	1.0	0.2	0.6	-0.1	-0.3	0.2	0.5	0.4	25%	**45%**
	(0.6)	(0.6)	(0.7)	(0.6)	(0.5)	(0.5)	(0.4)	(0.5)	(0.6)	(0.7)	(0.5)	(0.6)	(0.4)	(0.5)	(0.6)	(0.6)		
High stock	-0.3	1.6*	1.2*	1.1*	0.9	1.5*	1.4*	2.0*	1.4*	0.6	0.9*	0.1	-0.1	0.4	0.6	0.6	34%	**61%**
	(0.6)	(0.6)	(0.7)	(0.6)	(0.6)	(0.6)	(0.4)	(0.5)	(0.6)	(0.7)	(0.4)	(0.6)	(0.4)	(0.5)	(0.5)	(0.6)		
Low stock	-0.3	1.6*	1.2	1.0*	0.8	1.4*	1.3*	1.9*	1.3*	0.5	0.8*	0.1	-0.2	0.4	0.6	0.5	43%	**76%**
	(0.6)	(0.6)	(0.7)	(0.6)	(0.6)	(0.6)	(0.4)	(0.5)	(0.6)	(0.7)	(0.4)	(0.6)	(0.4)	(0.5)	(0.5)	(0.7)		
MG est.	-0.2	1.5*	1.2*	1.0*	0.9	1.3*	1.2*	1.9*	1.1*	0.5	0.6	-0.5	-0.5	0.1	0.2	0.2	29%	**52%**
	(0.4)	(0.3)	(0.4)	(0.6)	(0.6)	(0.8)	(0.5)	(0.6)	(0.7)	(0.6)	(0.4)	(0.6)	(0.7)	(0.8)	(0.8)	(0.6)		
Subperiod estimates:																		
1531-1600	-0.9	-0.2	1.8	1.8	-0.3	1.6	1.7	1.8	1.3	0.3	-1.0	-2.4	2.8*	2.1	0.8	-0.2	30%	**54%**
	(1.4)	(2.3)	(1.9)	(1.9)	(2.4)	(2.5)	(1.6)	(1.4)	(1.0)	(1.1)	(1.0)	(1.6)	(1.3)	(1.5)	(2.0)	(1.6)		
1601-1650	-2.2*	2.3	-1.3	-0.3	-0.8	0.8	2.4*	3.2*	3.6*	1.2	1.7	-1.3	-3.1	-0.0	0.3	-0.1		
	(1.2)	(1.5)	(1.6)	(1.7)	(2.1)	(1.9)	(1.2)	(1.4)	(1.9)	(1.4)	(1.2)	(1.3)	(2.6)	(1.6)	(2.1)	(2.5)		
1651-1700	-0.2	2.2	3.7*	3.8	4.5*	1.9	3.0	1.8	1.3	4.2*	3.0*	0.8	2.8*	3.2*	3.0*	0.1		
	(1.7)	(1.8)	(1.9)	(2.5)	(1.7)	(2.1)	(3.4)	(1.5)	(2.4)	(1.7)	(1.5)	(1.5)	(1.6)	(1.7)	(1.5)	(2.0)		
1701-1780	0.5*	2.0*	1.5*	0.8*	0.7	0.9	0.7	1.3*	0.6*	-0.3	0.6	0.5	-0.1	0.1	0.7	0.9		
	(0.2)	(0.4)	(0.7)	(0.5)	(0.5)	(0.6)	(0.5)	(0.3)	(0.3)	(0.3)	(0.4)	(0.4)	(0.4)	(0.5)	(0.5)	(0.7)		

Notes: The table displays local projection estimates. Standard errors in brackets. * denotes significance at the 90% level. Last column (of *GD*) shows percentage contribution to early Great Divergence, calculated as $(\Delta Y^M_{Europe,1780} - \Delta Y^M_{Asia,1780})/(\Delta Y_{Europe,1780} - \Delta Y_{Asia,1780})$. MG (mean group) estimator by Pesaran and Smith (1995). ΔY^M_{ESP}: real output effect of American precious metals on the early modern Western European economy.

and lower bound stock estimates, we obtain almost identical IRF estimates[37], but owing to the level change in inflows, in_t, which enter the cumulation equation (5), the monetary contribution to West European output growth now ranges from 34% to 43%, which translates into a 61% to 76% contribution to the early Great Divergence (rows *High stock* and *Low stock*).

Fourth, we use the mean group (MG) estimator by Pesaran and Smith (1995) to account for cross-country response heterogeneities. The resulting IRF estimate indicates a somewhat smaller average response estimate (row *MG est.*), and a correspondingly smaller explanatory power for GDP growth (29%) and the early Great Divergence (52%).

Finally, we analyze four temporal subsamples, and calculate cumulation equation (5) based on period-specific $\hat{\beta}_h$'s. We find that the West European output response grows larger up to 1700, and decreases thereafter (rows *1531–1600* to *1700–1780*). The period-specific estimates imply an explanatory power of the American money influx for West European GDP growth of 30% and for the early Great Divergence of 54%.

In sum, our findings locate the explanatory potential of American precious metals for the early Great Divergence in the 45% – 76% range. While this is a wide range, it empirically substantiates the notion that American precious metals were a key contributor to Western Europe's early modern growth experience.

5.2. How did American precious metals promote growth?

How did the arrival of American precious metals affect economic activity in Western Europe. To address this question, we conduct an exploratory analysis of the industry-level output series that exist for Holland and England. To estimate IRFs for the disaggregate output series we apply the same local projection specification (4).[38] This section first presents the Dutch and English IRF results which point towards relevant monetary transmission channels that were active at the time. This is followed by a discussion of the quantitative importance of these transmission channels for economic growth.

[37] This is not surprising because rescaling by a constant would yield identical percentage changes in the log-log specification (4). The upper and lower bound money stock estimates, however, are not simple rescalings of the mean estimate, but rather reflect time-varying uncertainty in various underlying data sources (Chen et al., 2021). Hence the minor IRF differences we obtain for the *Low stock* estimate.

[38] The abundance of disaggregated output series makes an exhaustive analysis impracticable. Therefore, in the following we only highlight the most salient IRFs which help to better understand through which channels American precious metal arrivals affected real GDP. All other disaggregated output IRFs are displayed in the Appendix (Figures A.10 – A.11). Note that absent strong priors on monetary transmission mechanisms in early modern Europe the following analysis is exploratory in nature. Therefore, multiple hypothesis testing methods designed for confirmatory data analysis (e.g. Bonferroni correction) are ill-suited (Goeman and Solari, 2011). Instead, the analysis aims at letting the data suggest promising monetary transmission channel candidates while continuing to apply 90% confidence intervals. This lays the groundwork for future research to conduct confirmatory analyses based on other datasets.

Holland

Figure 5 displays the output responses of various Dutch industries. The results can be summarized into three overarching themes – capital formation, a short-run consumption boom, and trade intensification. First, the arrival of American precious metals triggered investments in capital – agricultural land, ships, and human capital. Agricultural land investment is evidenced by the persistent increase in agricultural output by around 5%.[39] This is because, besides land area, the only other variable that enters the construction of the agricultural output series is the rental value of land, which is an average that stretches over many decades, and thus cannot account for the short-run increase in agricultural output. Thus, the increase in agricultural output reflects an increase in cultivated land area, resulting from reclamation projects such as newly created polders. This is consistent with the operation of a Mundell-Tobin effect (Mundell, 1963; Tobin, 1965) that has also been noted by the historical literature: urban elites developed an interest in land investments in an attempt to avoid inflation losses on their precious metal holdings (de Vries and van der Woude, 1997; van Bavel, 2016, pp.167–196). The feared (silver) inflation losses were the consequence of the continued influx of American precious metals into Western Europe which gave rise to a positive inflation rate averaging around 0.5% per year over the early modern period.[40] Similarly, we find evidence for investments in ships and human capital. Concerning ship production, the IRF displayed in Figure 5 indicates a sizable increase of 20%, but this increase is only marginally significant in years 1 and 8. By contrast, the IRF for education is estimated more precisely.[41] The aggregate of primary, secondary, and tertiary education provided in Holland increases by around 1.5% in the aftermath of a doubling in the inflow-to-stock ratio.[42]

Second, the consumption boom theme is reflected in the responses of beer and soap production, both of which increase by around 2% within three years. While beer can be clearly categorized as a final consumption good, the attribution for soap is more ambiguous owing to the use of soap as an intermediate good in industry, especially for washing wool. However, we do not find any indication that Dutch textile production increased in the aftermath of an increase in American precious metal arrivals (Figure A.10 in the Appendix). This suggests that the short-run increase in Dutch soap output was consumed

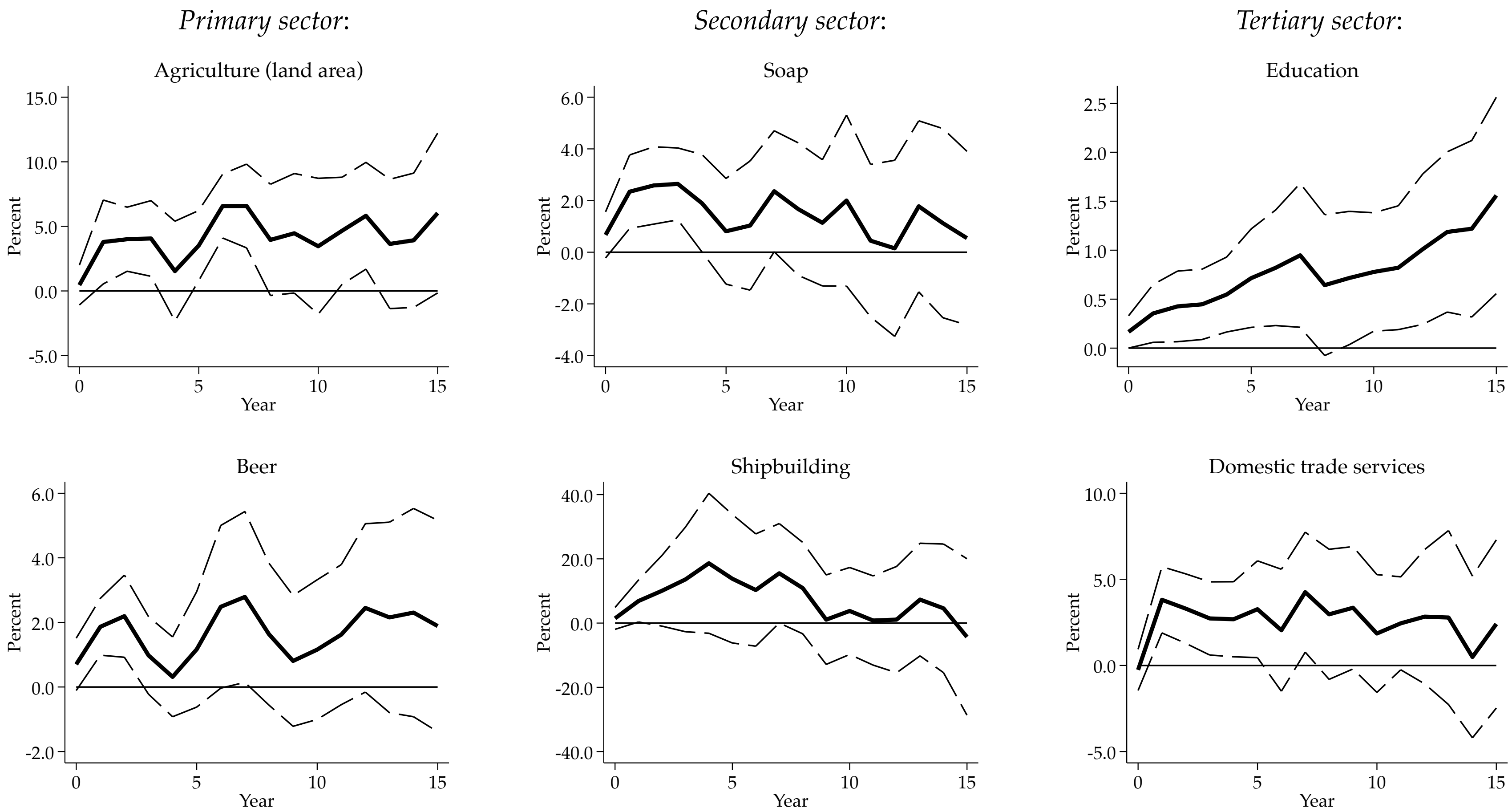
[39] Bread production followed the increase in cultivated land (Figure A.10 in the Appendix).

[40] By contrast, construction activity does not appear to have been stimulated by American precious metal arrivals (Figure A.10 in the Appendix).

[41] Eisenstein (1979), Baten and Van Zanden (2008), and van Zanden (2009, ch.6) give a prominent role to human capital accumulation in West Europe's early modern development.

[42] Note that the cumulative IRF for education is not perfectly persistent – it turns towards zero and becomes statistically insignificant within a 25-year horizon. Absent annual demographic data we are unable to determine to which extent the education response reflects population growth rather than an increase in education per capita.

Figure 5: Disaggregated output responses to a doubling in the money inflow-to-stock ratio – Holland



Notes: Dashed lines – 90% confidence interval.

domestically or exported.[43]

Finally, the increase in domestic trade services depicted in the lower right panel of Figure 5 mirrors the overall increases in agricultural and industrial production. Together with the finding that shipbuilding increased, the uptick in domestic trade services is supportive of the notion that American precious metals allowed Holland to realize gains of trade (internal and international), thus affording her an episode of Smithian growth.[44] Beyond that, Holland likely benefited from the uptick in West European GDP more generally due to its role as a key trade intermediary and financial center.[45]

England

How did American precious metals contribute to economic growth in early modern Europe's second growth star – England? Figure 6 displays IRF estimates that are indicative of the economic forces that the arrival of American precious metals set in motion there. As in the case of Holland, three themes emerge: capital formation, an increase in female employment opportunities, and trade intensification. First, agricultural output increased, in particular pastoral output (Figure 6, left panels). Pastoral output is primarily determined by the stock of animals and the 5% increase in pastoral output thus indicates that American precious metals found an outlet in livestock investments. The increase in livestock is also reflected in downstream industries in the secondary sector: woollen textile output and leather output increase in line with pastoral output (Figure 6, center panels).[46]

Second, in Western Europe's early modern economies pastoral agriculture was an important employer of women (Boserup et al., 1970 [2013]; Burnette, 1999, 2005). The increase in livestock investment that was triggered by the arrival of American precious metals thus also constituted an improvement of female labor market opportunities, possibly putting downward pressure on fertility rates (Galor and Weil, 1996; de Moor and van Zanden, 2010). Relatedly, the upper right panel of Figure 6 displays the output response of the service sector – another important employer of women. It appears that the arrival

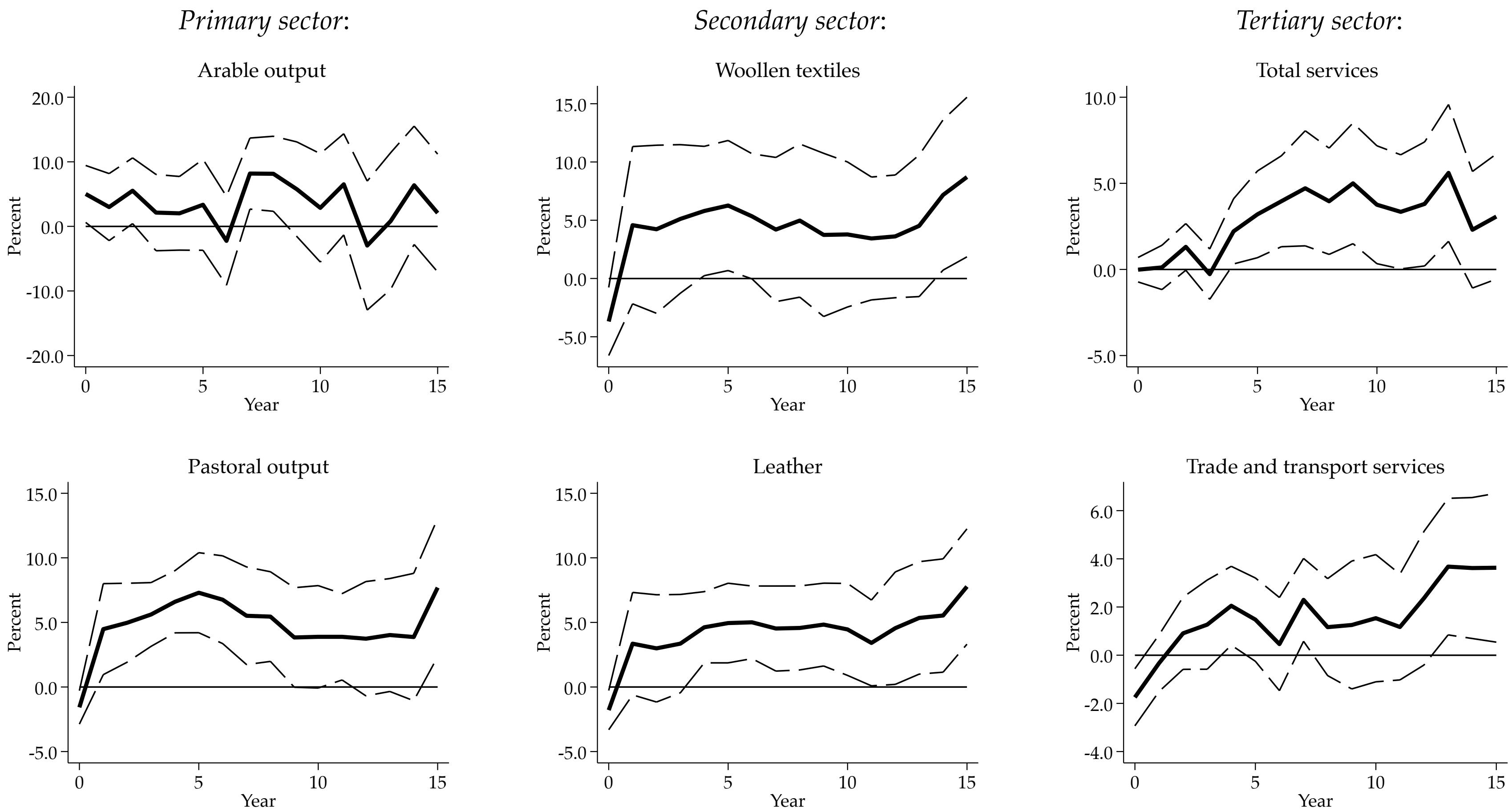
[43] Export is a distinct possibility given that 50% to 80% of Dutch soap was exported abroad (van Zanden and van Leeuwen, 2012, Data Appendix).

[44] The shipping services and international trade sector responses, however, present a caveat in this regard as they do not display a significant uptick (Figure A.10 in the Appendix)

[45] Several industries exhibit a slow increase in response to an increase in the influx of American precious metals, which only turns statistically significant after 15 years. Among these are housing services, domestic servants, clothing, and other foods. Partly, the delayed response may reflect the use of interpolations in the construction of these particular output series (van Zanden and van Leeuwen, 2012, Data Appendix). Consistent with a causal link between a country's monetary capacity and warfare intensity (Bonfatti et al., 2020) Dutch military expenditure is another tertiary sector item that significantly increased in the aftermath of an increase in American money arrivals (Figure A.10 in the Appendix).

[46] The increase in arable and pastoral output is reflected in an increase in foodstuffs output.

Figure 6: Disaggregated output responses to a doubling in the money inflow-to-stock ratio – England



Notes: Dashed lines – 90% confidence interval.

of American precious metals positively influenced service sector output and thus further enhanced employment opportunities of young women, e.g. as domestic maids.[47]

Finally, the lower right panel in Figure 6 documents an increase in trade and transport services. This increase only takes hold several years after an increase in the arrival of precious metals, but it persists beyond 15 years. As in the case of Holland, the arrival of American precious metals appears to have afforded England an increase in trade intensification with the accompanying Smithian growth (Jacks, 2004; Palma and Silva, 2024).

In sum, the evidence from Holland and England suggests that the arrival of American precious metals fostered capital formation (land, livestock, ships, human capital) and gave rise to a trade intensification (internal and international).[48] The English evidence is furthermore consistent with a demographic effect of American precious metal arrivals that was mediated through an improvement in female employment opportunities.[49]

Transmission channel importance

This section discusses the quantitative importance of the different transmission channels highlighted above. While we cannot expect to determine exact historical effect sizes, back-of-the-envelope calculations can provide theoretically and empirically informed plausibility ranges for the growth effects that were mediated by different transmission mechanisms.

The capital accumulation channel is unlikely to have been the most important transmission channel mediating between American money arrivals and Holland's early modern GDP growth. Consider a semi-log money demand function $ln(m) = constant - \eta i$, where m denotes the ratio of nominal money holdings to nominal income, and i the nominal interest rate. For the standard parameterization $\eta = 7$ (Lucas, 2000; Ireland, 2009), this equation indicates that a 0.5% annual inflation rate increase implies a money demand decrease of 3.5%. If demand for capital increased accordingly, and accounting for a capital-to-money stock ratio in the 6 to 70 range[50], this suggests that a 0.5% increase in inflation could bring about a capital stock increase in the 0.05% to 0.58% range. Cumulating over a five to ten-year horizon to account for the overlapping of persistent effects

[47] Note that the service sector output data is not purely annual as it employs a 10-year average of real government revenue to measure government services.

[48] Figure A.12 in the Appendix presents the disaggregated output findings for the more fragmentary Spanish data, which indicates that American precious metal arrivals stimulated Spanish textile production and shipbuilding.

[49] Relatedly, Galor and Weil (1996) propose that capital accumulation increased the relative wage of women vis-à-vis men, thereby increasing labor market participation and reducing fertility rates.

[50] Chen et al. (2021) summarize estimates of early modern European money velocities ranging from 1.3 to 8.8, implying a money-to-GDP ratio between 0.1 and 0.8. The closest capital-to-GDP ratios from Piketty (2014) are 7 for England in 1700, and 5 for Spain in 1901. These figures imply a capital-to-money ratio ranging from 6 to 70.

in line with our IRF estimates yields a cumulative capital stock increase in the 0.25% to 5.8% range. The upper end of this range is non-negligible, but leaves the lion's share of West European growth to be explained by other factors.[51]

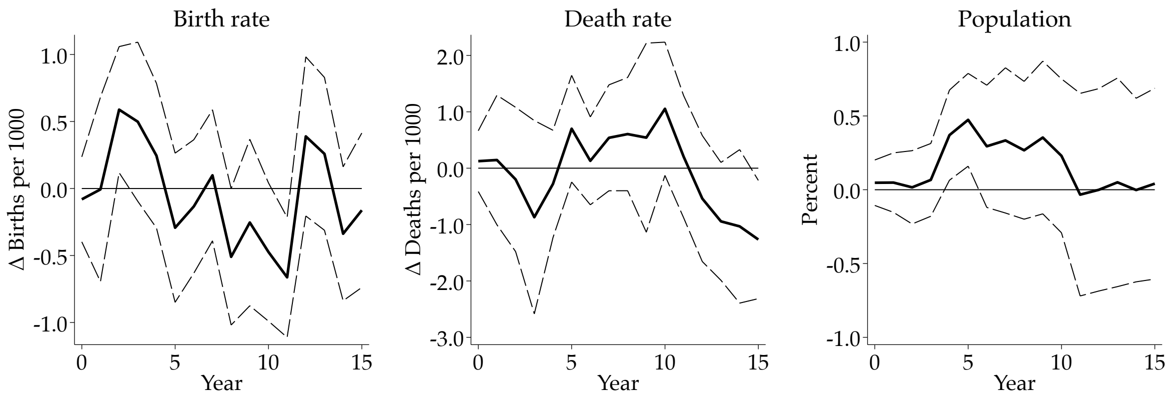
The Smithian growth effect of American precious metal arrivals presents a more promising candidate channel. The combination of increased market integration and limited learning-by-doing that is characteristic of Smithian growth is often invoked to explain pre-modern growth efflorescences – periods during which incomes exceeded the subsistence level up to five times over (Goldstone, 2002; Temin, 2012; Pamuk and Shatzmiller, 2014). Kelly (1997) simulates a Smithian growth model in which the integration of initially isolated local markets with very limited specialization gives rise to an output increase of around 50%.[52] Our finding that a doubling in the American money inflow-to-stock ratio increased trade and transport services in England and Holland by 1% to 3% for more than a decade (Figures 5 and 6) implies a substantial cumulative swelling of these sectors – 90% to 350% when cumulated according to equation (6). This suggests that the sustained injection of American precious metals into Europe that began in the late 15th century was an important contributor to the simultaneous intra- and international integration of the European economy (Jacks, 2004; Federico et al., 2021). Adam Smith was conjecturing as much about the period in question (Smith, 1776 [2007], Book III, p.458): "*...those commodities of America are new values, new equivalents, [...] By being carried thither they create a new and more extensive market...*".

Early modern trade integration in turn was closely intertwined with the spread of commerce-friendly institutions characteristic of Europe's Commercial Revolution (North, 1981; Olson, 1982; Acemoglu et al., 2005). North and Thomas (1970, p.14) explicitly highlight the nexus between American precious metals, trade, and institutional change when conjecturing that "*the importation of precious metals into Europe via Spain stimulated the growth of all the Western economies by increasing the incentive to trade. The consequence of the expansion of trade was an era of substantial institutional innovation which has commonly been described as a commercial revolution.*" Thus, the influx of American precious metals may have been a necessary prerequisite for the wide-spread adoption of novel financial instruments and the emergence of novel forms of business organization (Spufford, 2002, p.12, 59). While our analysis does not present empirical evidence on the causal connection between American money arrivals and institutional change, the latter

[51]While an increasing returns environment with multiple equilibria presents a potential caveat to this conclusion, a capital stock increase in the suggested range presents an unlikely candidate for a Big Push powerful enough to carry an economy out of a poverty trap (Murphy et al., 1989; Kraay and McKenzie, 2014; Balboni et al., 2022).

[52]Estimates of the gains of (international) trade for more modern data typically fall short of 10% (Bernhofen and Brown, 2005; Irwin, 2005; Fajgelbaum et al., 2020), possibly reflecting an exhaustion of growth opportunities from the incorporation of additional regions into an already large market (Bouët, 2008, ch.4).

Figure 7: English population response to doubling in money inflow-to-stock ratio



Notes: Dashed lines – 90% confidence interval.

is a plausible mediating variable through which quantitatively modest Atlantic flows (Engerman, 1972; O'Brien, 1982; Inikori, 2002) could have developed a more sizeable and lasting effect on European economic outcomes (Acemoglu et al., 2005).

The demographic effect of American precious metal arrivals through their stimulative effect on female employment opportunities in pastoral agriculture and services hinges on too many unknowns to be narrowed down into an informative plausibility range.[53] The available English demographic data, however, which is annual from 1541 onwards (Wrigley and Schofield, 1981), allows us to analyze the net effect of American precious metal arrivals on English demographics in some detail. This net effect contains the fertility depressing effect of increased female labor market participation and the fertility increasing effect of higher incomes in a Malthusian environment. The results in Figure 7 present only very few statistically significant response estimates among English demographic variables. If anything, the English birth rate experienced a short-run uptick and the death rate a (statistically insignificant) tendency to decline in the five years after of an increase in American precious metal arrivals ($h < 5$). As a consequence, the population level briefly increased by around 0.5% in the short run. Overall, no population-decreasing effect can be ascribed to American precious metal arrivals in the case of England.[54]

[53]Depending on the extent to which output increases were associated with employment increases, the male-female workforce ratio, and the average age of the employed women, it is conceivable that American precious metal arrivals were either an important contributor to the European marriage pattern (delayed marriages and low birth rates) in England, or entirely irrelevant. Recent research has questioned whether delayed marriages and low birth rates were relevant contributors to Europe's early modern growth to begin with (Dennison and Ogilvie, 2014), and the relationship between pastoralism and female marriage age in England (Edwards and Ogilvie, 2022).

[54]The English population response is also informative with respect to the question whether the growth effects we measure reflect extensive or intensive growth. In the case of England, the brief and modest population response suggests that American precious metals largely spurred intensive growth, rather than extensive growth.

In sum, the nexus of trade intensification and institutional change is the most plausible transmission vector through which American precious metals stimulated long-run European economic growth. Capital accumulation, while non-negligible, was likely a less potent mediator. Despite stimulating activity in pastoral agriculture – an important employer of women – American precious metal arrivals do not appear to have developed a strong demographic effect in England.

5.3. Maritime disaster insulation and monetary goldilocks zone

Why did first-stage receiver Spain, with direct colonial control over American precious metals, grew considerably less than West Europe's second-stage receivers? Existing research has focused on the detrimental impact of American precious metals on first-stage receiver price competitiveness and political institutions (Palma, 2020; Henriques and Palma, 2023). In this section we explore a novel reason for why Spain failed to benefit from the American precious metal windfall as much as some second-stage receivers did: the exposure to big maritime disaster losses that triggered severe financial crises with persistent output costs.[55]

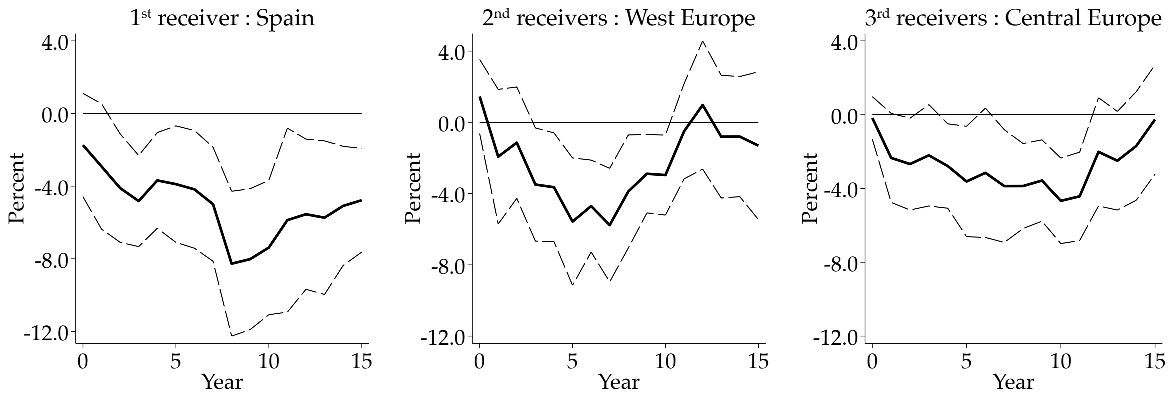
Did second-stage receivers enjoy insulation against such maritime disaster effects? Figure 8 contrasts the real GDP trajectories of first-, second-, and third-stage receivers in the aftermath of a maritime disaster loss amounting to 1% of the European money stock. First-stage receiver Spain sees its output decline by up to 8%. Output is still 4% below its baseline level 15 years after the event. As laid out above, research by Brzezinski et al. (2024) indicates that maritime disasters triggered severe financial crises in Spain. The failure of Spanish output to recover in the aftermath of maritime disasters is thus reminiscent of the finding for modern times that output costs of severe financial crises can be permanent (Cerra and Saxena, 2008; Jordà et al., 2023). Consistent with this notion, we find no indication for a recovery when scanning over a 50-year horizon (Figure A.17 in the Appendix). The Spanish economy appears to have been permanently damaged by big maritime disasters and the financial crises they caused.

Next, second-stage receivers see their output decline by around 5% within five years (Figure 8, middle panel). Thereafter, however, output makes a full recovery. In contrast to Spain, the travails of Europe's second-stage receivers in the aftermath of maritime disasters were only temporary.[56] Wald tests confirm that first- and second-stage receiver

[55] Difference in the IRF estimates compared to Brzezinski et al. (2024) result from our focus on 16 *big* maritime disaster years – those associated with financial crises – rather than the entirety of 33 maritime disaster years under analysis in Brzezinski et al. (2024).

[56] Interest rate data indicates that, whereas the Spanish interest rate level remained elevated for several years after a maritime disaster, interest rates did not increase in Europe's second-stage receivers. In fact, interest rates decreased in the immediate aftermath of maritime disaster events, possibly the result of capital flight away from Spain. This suggests that second-stage receivers were spared the financial duress that Spain experienced in the aftermath of maritime disasters. We find no indication for a response of

Figure 8: Real GDP response to negative 1 percentage point maritime disaster shock



	h=5	6	7	8	9	10	11	12	13	14	15
Difference (1^{st}-2^{nd})	1.7	0.5	0.8	-4.4	-5.1	-4.4	-5.4	-6.5	-4.9	-4.3	-3.5
1^{st}=2^{nd} (p-value)	0.47	0.83	0.77	0.16	0.04	0.09	0.11	0.09	0.17	0.06	0.29
Difference (2^{nd}-3^{rd})	-1.9	-1.5	-1.8	-0.0	0.7	1.7	3.9	3.1	1.7	0.9	-1.1
2^{nd}=3^{rd} (p-value)	0.19	0.34	0.26	0.98	0.71	0.29	0.02	0.12	0.43	0.70	0.67

Notes: The graph analyzes the real GDP response in 1^{st}, 2^{nd}, and 3^{rd} stage receivers. Dashed lines delineate 90% confidence interval. The table displays the difference between 1^{st}, 2^{nd}, and 3^{rd} stage receiver-responses for horizons $h = 5, ..., 15$. The p-values correspond to pointwise Wald tests for response equality.

IRF estimates differ significantly from each other for the majority of horizons $h \geq 9$ (Table accompanying Figure 8, second row). Also among third-stage receivers in Central Europe a recessionary effect is visible (Figure 8, right panel). The GDP response is shallower and its onset is delayed compared to the West European case. A full recovery occurs after around ten years. Wald tests, however, generally do not reject the null of equality between the second- and third-stage receiver responses (Table accompanying Figure 8, fourth row).

These findings are informative with respect to the origins of the *Little Divergence* between Europe's South and Northwest. Whereas the Spanish economy only grew around 36% between 1530 and 1780, the economies of England and Holland grew by 255% (Bolt and van Zanden, 2020). If Spain never recovered from its maritime-disaster induced crisis losses, we need to part with the assumption $\{\hat{\beta}_h\}_{h=16}^{\infty} = 0$ that was introduced section 4, and instead perpetuate the permanent loss. We do this by setting the permanent loss to the average response over the last five projection horizons: $\{\hat{\beta}_h\}_{h=16}^{\infty} = \frac{1}{5}\sum_{h=11}^{15} \hat{\beta}_h$. Then, equation (6) implies that, absent the eleven big maritime disasters that hit Spain over the early modern period, Spanish GDP would have grown by 107% instead of only 36% – a 71 percentage point difference (Table 3, first row). According to these calculations, the differential exposure of first- and second-stage receivers to maritime disaster losses

interest rates in Central Europe (Figure A.14 in the Appendix).

Table 3: Monetary origins of the Little Divergence

	Spain	Northwest Europe
Disaster effect	-71%	NA
GDP change	36%	255%
% of *Little Divergence*	**32%**	

Notes: % of Little Divergence calculated as $(\Delta Y_S^M - \Delta Y_{NW}^M)/(\Delta Y_S - \Delta Y_{NW})$. NA entry for Northwest Europe reflects absence of long-run maritime disaster cost in that region (Figure 8). As no big maritime disasters occur in the decades preceding 1780, we assume that any short-run effect from the last disaster event in our sample has already dissipated by that time.

can account for around one third of the Little Divergence between Spain and Northwest Europe's growth stars (Table 3, third row).

Robustness: We use various robustness checks and subsample analyses to probe the stability of the baseline finding (Table 4, row *Baseline*). First, a parsimonious specification yields very similar findings, corroborating the exogeneity of the disaster loss variable (row *Parsim.*). Second, changing the lag order from 2 to 4 gives rise to a somewhat weaker output response, which cumulates to a -66% contribution of maritime disaster losses to Spanish GDP growth, and a 30% contribution to the Little Divergence (row *4 lags*).

Third, the high stock estimate yields a larger Spanish output response estimate, which together with the lower inflow measure, in_t, in cumulation equation (5) yields an output growth contribution of -53% and a Little Divergence contribution of 24% (row *High stock.*). For the low stock case, a smaller response estimate offsets the higher inflows in (5), yielding a growth contribution of -62% and a Little Divergence contribution of 28% (row *Low stock.*).

When the permanent output loss is determined as the average response over the last three projection horizons, $\frac{1}{3}\sum_{h=16-3}^{15}\hat{\beta}_h$, the resulting average implies a cumulated output contraction of 69% (row *3 years*). The corresponding maritime disaster contribution to the Little Divergence is 32% (after rounding). When using the average response over the last seven projection horizons instead, the analogous figures are 77% and 35% (row *7 years*).

Finally, the four subsample IRFs indicates similarly sized permanent output losses as measured by the average coefficient size over horizons 11 to 15 (rows *1531–1600* to *1701–1780*). Plugging the time-varying permanent output loss estimates into the cumulation equation (5) puts the growth effect of maritime disaster losses at -58%, and the explanatory power for the Little Divergence at 31%.

Table 4: Robustness: Spanish output response to negative 1 percentage point maritime disaster shock

	h=0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	ΔY^M_{ESP}	of LD
Baseline	-1.7	-2.9	-4.1*	-4.8*	-3.7*	-3.9*	-4.2*	-5.0*	-8.3*	-8.0*	-7.4*	-5.9*	-5.5*	-5.7*	-5.1*	-4.8*	-71%	**32%**
	(1.7)	(2.1)	(1.8)	(1.5)	(1.6)	(2.0)	(2.0)	(1.9)	(2.4)	(2.4)	(2.3)	(3.1)	(2.5)	(2.6)	(2.0)	(1.7)		
Parsim.	-1.7	-2.8	-3.9*	-4.6*	-3.6*	-3.8*	-4.1*	-4.9*	-8.3*	-8.0*	-7.6*	-6.3*	-5.8*	-5.7*	-5.2*	-4.9*	-73%	**33%**
	(1.7)	(2.1)	(1.8)	(1.4)	(1.6)	(2.0)	(1.9)	(2.0)	(2.4)	(2.3)	(2.2)	(2.8)	(2.3)	(2.4)	(1.9)	(1.7)		
4 lags	-1.3	-2.3	-3.2	-3.9*	-2.1	-2.6	-3.2	-4.2*	-7.2*	-6.9*	-6.6*	-5.0	-4.7*	-5.4*	-4.7*	-4.2*	-66%	**30%**
	(1.8)	(2.2)	(2.0)	(1.7)	(1.7)	(2.1)	(2.2)	(2.1)	(2.6)	(2.6)	(2.8)	(3.5)	(2.8)	(2.8)	(2.5)	(2.3)		
High stock	-2.1	-3.5	-4.8*	-6.0*	-4.5*	-5.0*	-5.2*	-6.2*	-10.0*	-10.1*	-9.3*	-6.8*	-7.1*	-6.2*	-4.7*	-4.4	-53%	**24%**
	(2.2)	(2.7)	(2.3)	(2.1)	(2.2)	(2.9)	(2.7)	(2.8)	(3.4)	(3.2)	(3.0)	(4.1)	(3.4)	(3.3)	(2.6)	(2.7)		
Low stock	-1.4	-2.2	-3.1*	-3.8*	-2.8*	-3.2*	-3.4*	-4.0*	-6.3*	-6.4*	-5.9*	-4.3*	-4.5*	-4.1*	-3.1*	-2.9*	-62%	**28%**
	(1.3)	(1.6)	(1.4)	(1.2)	(1.2)	(1.6)	(1.4)	(1.4)	(1.8)	(1.7)	(1.5)	(2.3)	(2.0)	(1.8)	(1.5)	(1.5)		
3 years	-1.7	-2.9	-4.1*	-4.8*	-3.7*	-3.9*	-4.2*	-5.0*	-8.3*	-8.0*	-7.4*	-5.9*	-5.5*	-5.7*	-5.1*	-4.8*	-69%	**32%**
	(1.7)	(2.1)	(1.8)	(1.5)	(1.6)	(2.0)	(2.0)	(1.9)	(2.4)	(2.4)	(2.3)	(3.1)	(2.5)	(2.6)	(2.0)	(1.7)		
7 years	-1.7	-2.9	-4.1*	-4.8*	-3.7*	-3.9*	-4.2*	-5.0*	-8.3*	-8.0*	-7.4*	-5.9*	-5.5*	-5.7*	-5.1*	-4.8*	-77%	**35%**
	(1.7)	(2.1)	(1.8)	(1.5)	(1.6)	(2.0)	(2.0)	(1.9)	(2.4)	(2.4)	(2.3)	(3.1)	(2.5)	(2.6)	(2.0)	(1.7)		
									Subperiod estimates:									
1531-1600	0.1	1.6	-2.7	-4.8*	-3.9*	-6.8*	-6.3*	-5.3*	-6.4*	-5.0*	-3.9	-2.4	-5.9*	-5.4*	-5.7*	-6.8*	-68%	**31%**
	(1.8)	(2.2)	(2.2)	(2.0)	(2.4)	(1.9)	(2.4)	(2.3)	(2.6)	(2.3)	(2.4)	(3.8)	(3.3)	(2.9)	(2.7)	(3.5)		
1601-1650	-2.5	-4.3*	-2.7	-3.2	-2.1	-2.5	-3.7	-5.4*	-9.8*	-8.8*	-7.6*	-5.8*	-3.7	-6.2*	-6.1*	-3.1		
	(1.9)	(2.6)	(2.1)	(2.5)	(2.7)	(3.2)	(2.9)	(3.0)	(3.1)	(2.1)	(2.0)	(3.3)	(2.6)	(2.9)	(2.9)	(2.3)		
1651-1700	0.1	-2.4	-5.8*	-5.7*	-5.2*	-2.7	-3.3	-2.6	-6.0	-8.6*	-6.2*	-5.4*	-6.7*	-6.0*	-4.6*	-3.3		
	(2.0)	(2.3)	(2.9)	(1.9)	(1.8)	(2.4)	(3.9)	(3.0)	(3.7)	(3.3)	(2.7)	(2.9)	(3.2)	(3.2)	(2.2)	(2.7)		
1701-1780	-4.9*	-7.1*	-6.8*	-6.7*	-4.8*	-3.4	-3.2	-6.3*	-7.6*	-7.7*	-10.3*	-10.0*	-6.9	-5.0	-4.5*	-9.4*		
	(1.8)	(3.0)	(3.9)	(2.0)	(2.2)	(3.7)	(3.5)	(3.3)	(2.9)	(3.0)	(3.5)	(4.2)	(4.6)	(3.9)	(2.5)	(3.4)		

Notes: The table displays local projection estimates. Standard errors in brackets. * denotes significance at the 90% level. Last column (of LD) shows percentage contribution to Little Divergence, calculated as $(\Delta Y_S^M - \Delta Y_{NW}^M)/(\Delta Y_S - \Delta Y_{NW})$. ΔY_{ESP}^M: real output effect of maritime disaster losses on the early modern Spanish economy.

5.4. How did maritime disasters hurt Spanish economic development?

To better understand how maritime disasters hurt Spanish economic development, we again turn to disaggregated output indicators. Figure 9 displays the trajectories of several disaggregated output series that cover Spain's primary, secondary and tertiary sectors.[57] As the Spanish output data is of a more fragmentary nature, the panels additionally indicate the timespan covered by each series. Agricultural output shows no sign of being negatively affected by disaster losses. By contrast, fish consumption undergoes a 50% contraction after three years. Relatedly, ship production contracts by almost 50% within the first two years after a large maritime disaster loss.[58] More generally, the shipbuilding contraction is indicative of a disruption to proto-industrial capital formation in the aftermath of large maritime disaster losses.

Coarse cloth production (Figure 9, upper middle panel) exhibits a large persistent decline of around 30%.[59] Brzezinski et al. (2024) document the difficulties Spanish merchants faced in supplying their manufacturing networks with intermediary inputs as credit supply dried up in the aftermath of maritime disasters. The long-run IRFs displayed here, suggest that Spanish textile manufacturing underwent a persistent contraction as a result of such credit crunches.

The available data for the tertiary sector is comparatively brief – covering around 50 years and straddling only two large maritime disaster events. Nevertheless, the data for Toledean theater and brothel revenues points towards a contractionary effect of maritime disaster losses on tertiary sector activity (Figure 9, right panels). Theater visits almost come to a halt within the 10 years after a large maritime disaster loss. After that, there are some indications of a recovery taking hold. Brothel visits temporarily decline by around 10% before returning to trend.

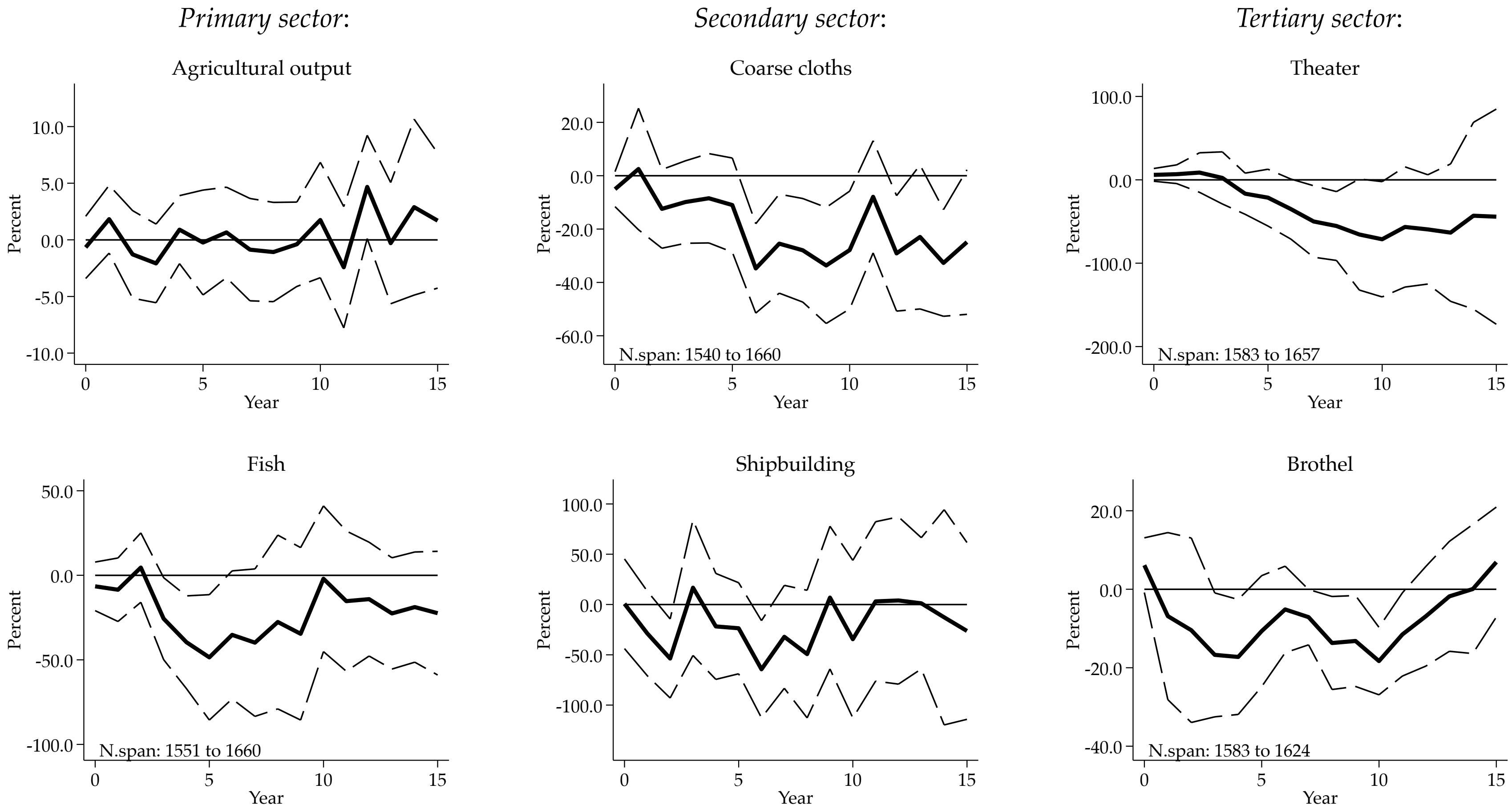
In sum, the disaggregated output data for Spain suggests that maritime disaster-induced financial crises dealt severe blows to Spain's non-agricultural production. Textile manufacturing, in particular, experienced very persistent contractions. In addition, the shipbuilding response indicates that maritime disaster losses may have acted as a drag on Spain's proto-industrial capital formation.

[57] As in the case of the disaggregated output analysis for Holland and England, this section reports IRFs which are indicative of the channels through which American precious metals affected European output. The remaining disaggregated output IRFs are displayed in the Appendix (Figure A.13).

[58] When including 20 smaller maritime disasters into the analysis, Brzezinski et al. (2024) find that there is no systematic ship production response to maritime disaster shocks. This suggests that the contraction in shipbuilding is specific to large maritime disasters that trigger severe financial crises. Similarly so, Toledean theater and brothel revenues (see below).

[59] Relatedly, fine cloth production initially declines more rapidly, experiences a brief recovery between years five and ten, and then declines again without recovering for 25 years after a disaster event (Figure A.13 in the Appendix).

Figure 9: Disaggregated output responses to 1 percentage point maritime disaster loss – Spain



Notes: Dashed lines – 90% confidence interval. N.span: timespan covered by outcome series (only if not the entire period from 1531 to 1780 is covered).

6. Conclusion

The influx of vast amounts of American precious metals into Europe is a salient feature of the economic history of the early modern period. So is Europe's early modern growth performance which by the mid-18th century had carried Europe to the doorstep of the Industrial Revolution. While traditionally a causal connection between American precious metals and European growth has been discouraged by the principle of long-run money neutrality, our findings lend support to the conjecture that American precious metals played an important role in facilitating the *Rise of the West*.

Our findings are consistent with a sizable effect of American precious metals on West European growth. By the end of the 18th century the sustained injection of American precious metals has become an important contributor to the early *Great Divergence* between Western Europe and the East Asia. An analysis of industry-level output series suggests that American money arrivals stimulated West European growth by accelerating capital formation and intensifying trade.

While our analysis thus identifies American precious metals as a blessing for West European growth in the early modern period, the Spanish experience was more ambiguous. As the almost exclusive first-stage receiver of American precious metals, it was uniquely exposed to Atlantic transport losses – the main source of the high volatility of the American precious metal inflow into Europe. Big maritime disasters triggered severe financial crises in Spain that caused lasting damage. By contrast, Europe's second-stage receivers were sufficiently insulated from maritime disaster losses to avoid the same fate. As a consequence, Northwestern Europe's early modern growth stars – England and Holland – were located in a *monetary goldilocks zone* which benefited from monetary injections that were sizable as well as sufficiently stable to avoid repeated financial turmoil.

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Appendix

to *"Goldilocks: American precious metals and the Rise of the West"*

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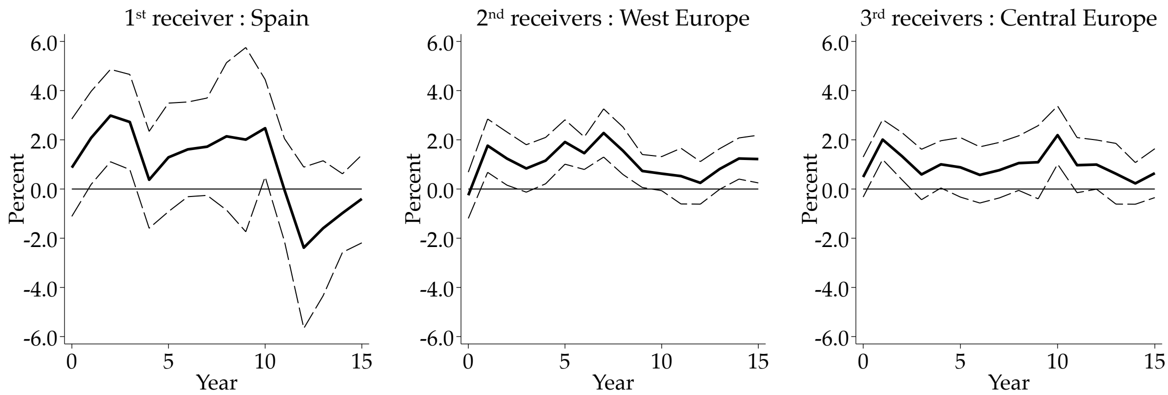
Contents

A. Additional results

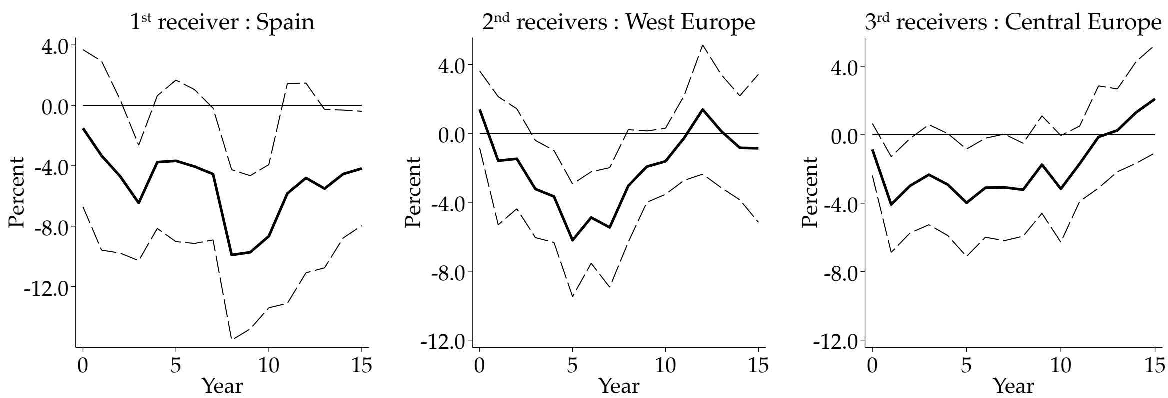
A.1. No urbanization rate data

Figure A.1: Real GDP response to doubling in money inflow-to-stock ratio (no urbanization rate)



Notes: Dashed lines – 90% confidence interval. Interpolated urbanization rate data excluded.

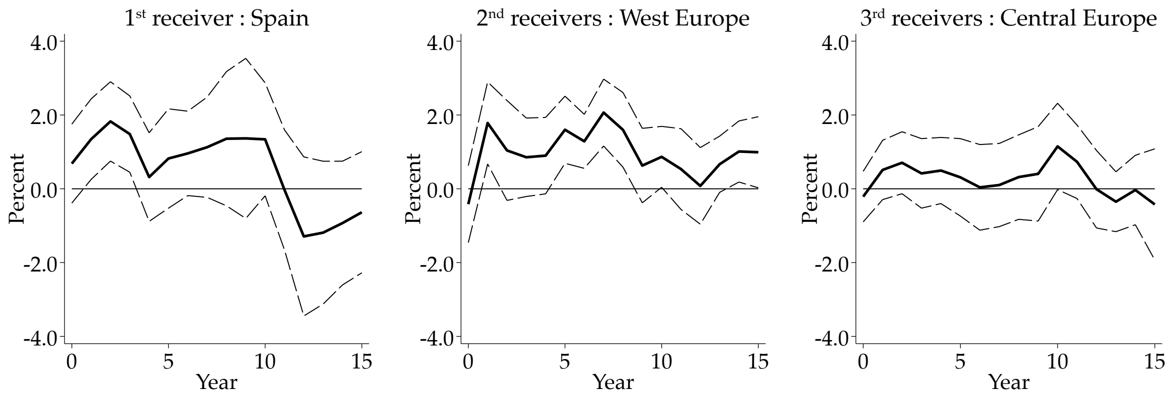
Figure A.2: Real GDP response to negative 1 percentage point maritime disaster shock (no urbanization rate)



Notes: Dashed lines – 90% confidence interval. Interpolated urbanization rate data excluded.

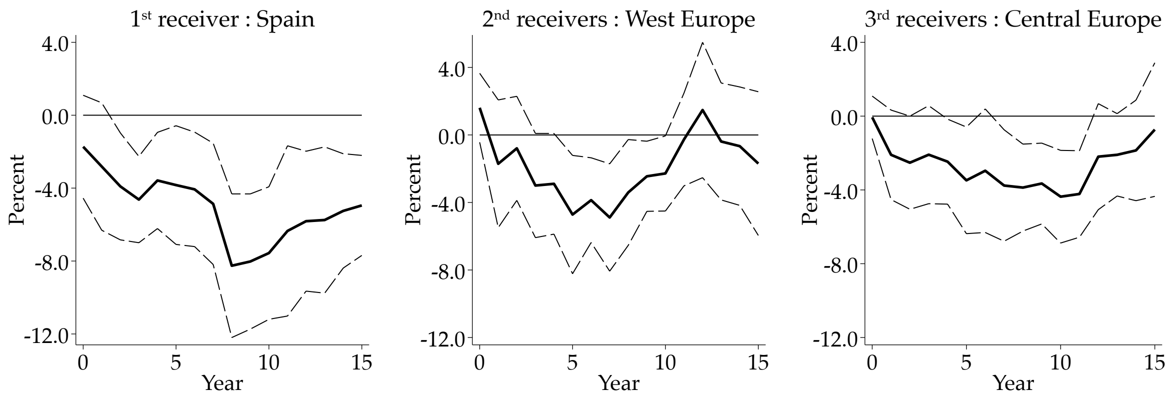
A.2. Parsimonious specification

Figure A.3: Real GDP response to doubling in money inflow-to-stock ratio



Notes: Dashed lines – 90% confidence interval. Parsimonious specification, excluding all controls $X_{i,t}$.

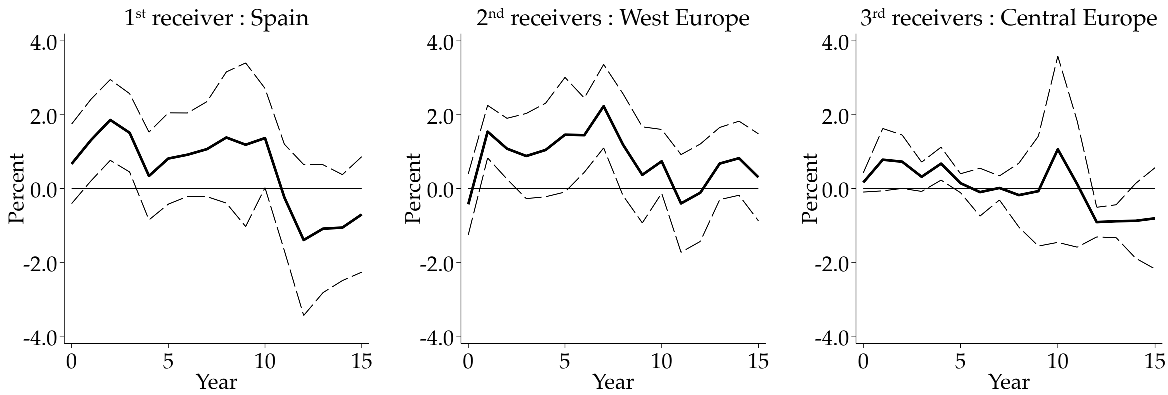
Figure A.4: Real GDP response to 1 percentage point maritime disaster shock



Notes: Dashed lines – 90% confidence interval. Parsimonious specification, excluding all controls $X_{i,t}$.

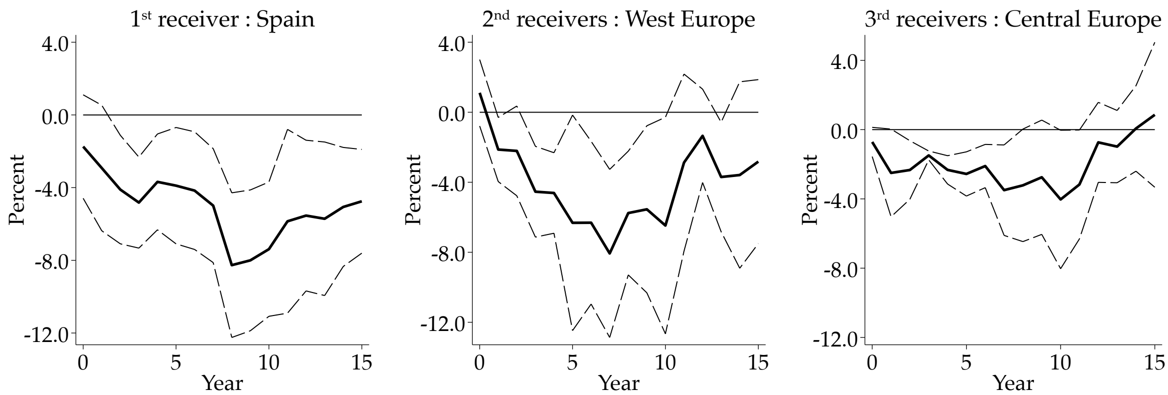
A.3. Mean group estimator

Figure A.5: Real GDP response to doubling in money inflow-to-stock ratio



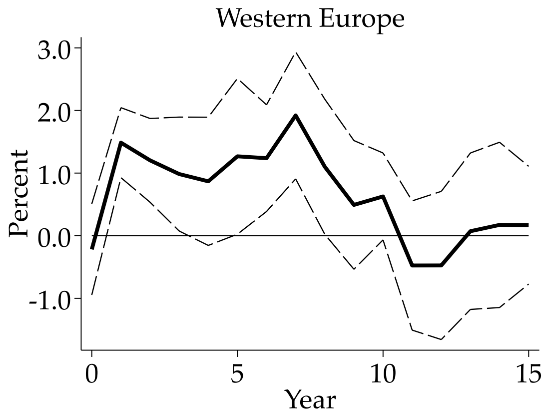
Notes: Dashed lines – 90% confidence interval. Local projections for West Europe and Central Europe groups based on mean group estimator (Pesaran and Smith, 1995).

Figure A.6: Real GDP response to 1 percentage point maritime disaster shock



Notes: Dashed lines – 90% confidence interval. Local projections for West Europe and Central Europe groups based on mean group estimator (Pesaran and Smith, 1995).

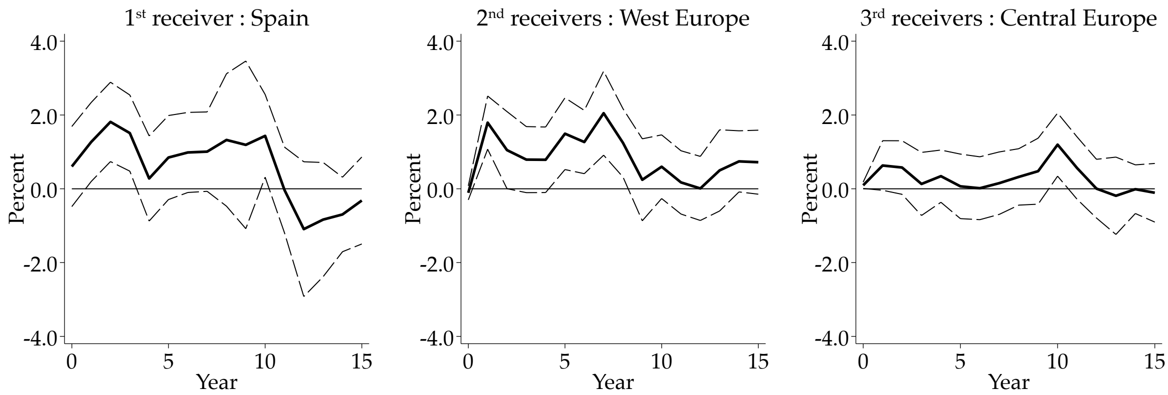
Figure A.7: Real GDP response to doubling in money inflow-to-stock ratio



Notes: Dashed lines – 90% confidence interval. Mean group estimator local projections for all West European countries (Pesaran and Smith, 1995).

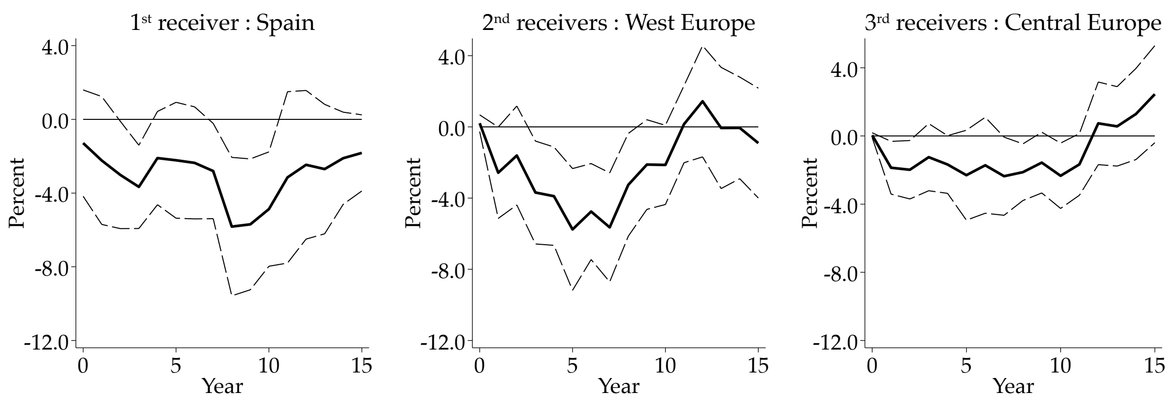
A.4. Per capita GDP responses

Figure A.8: Real GDP per capita response to doubling in money inflow-to-stock ratio



Notes: Dashed lines – 90% confidence interval.

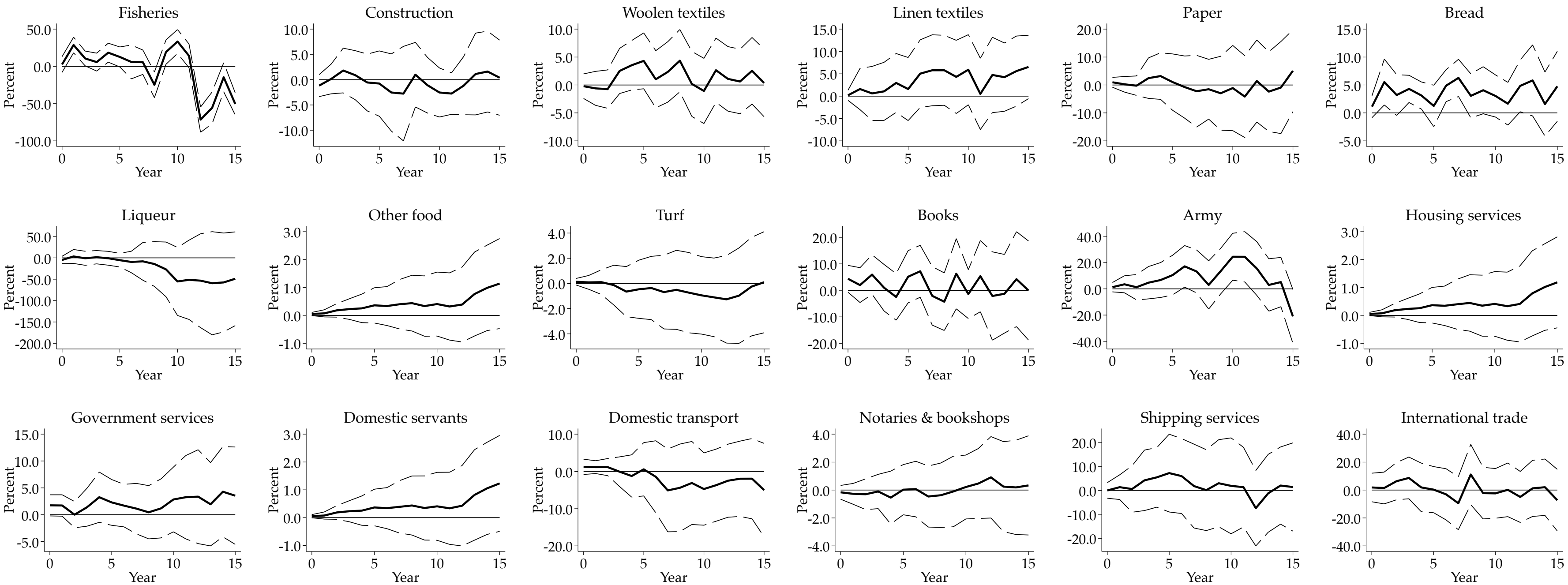
Figure A.9: Real GDP per capita response to 1 percentage point maritime disaster shock



Notes: Dashed lines – 90% confidence interval. While the 15-year response for 1st receiver Spain suggests a less persistent response than in the case for GDP, this is not born out by the long-run response estimate over a 50-year horizon (Figure A.18).

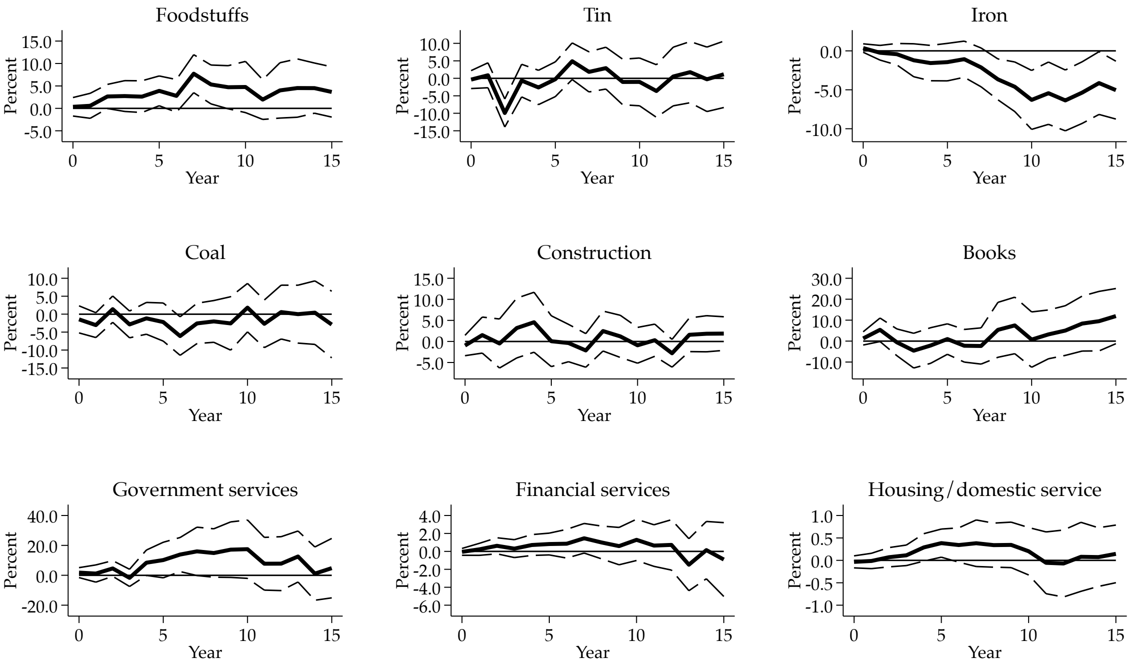
A.5. Disaggregated industry responses

Figure A.10: Disaggregated output responses to doubling in money inflow-to-stock ratio – Holland



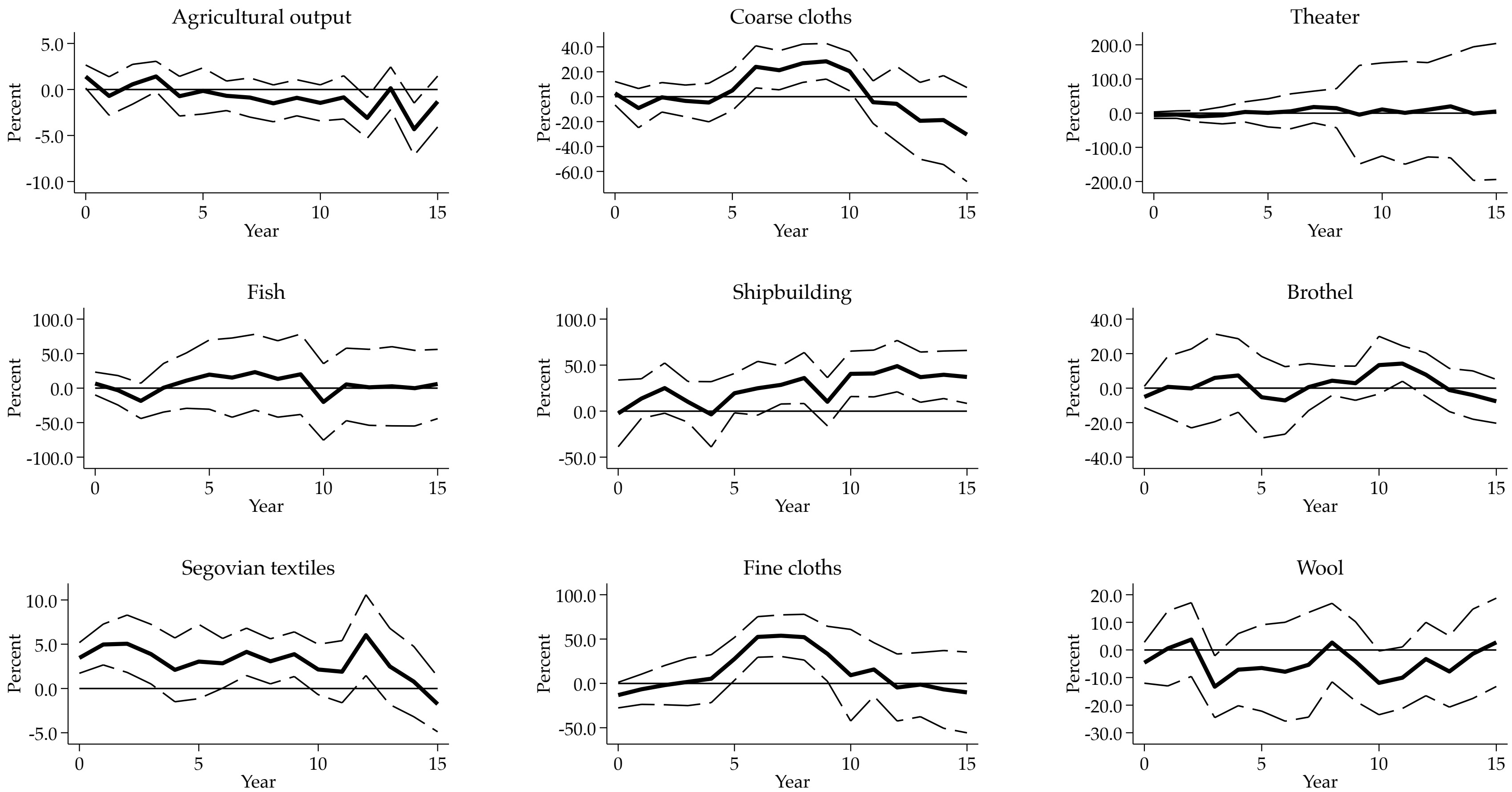
Notes: Dashed lines – 90% confidence interval. Time series too short to include: banking (only important after 1750), sugar. Outliers in the following variables: fisheries, books, woolen textiles, linen textiles, army, international trade. We winsorize these time series and downweigh the remaining outliers.

Figure A.11: Disaggregated output responses to doubling in money inflow-to-stock ratio – England



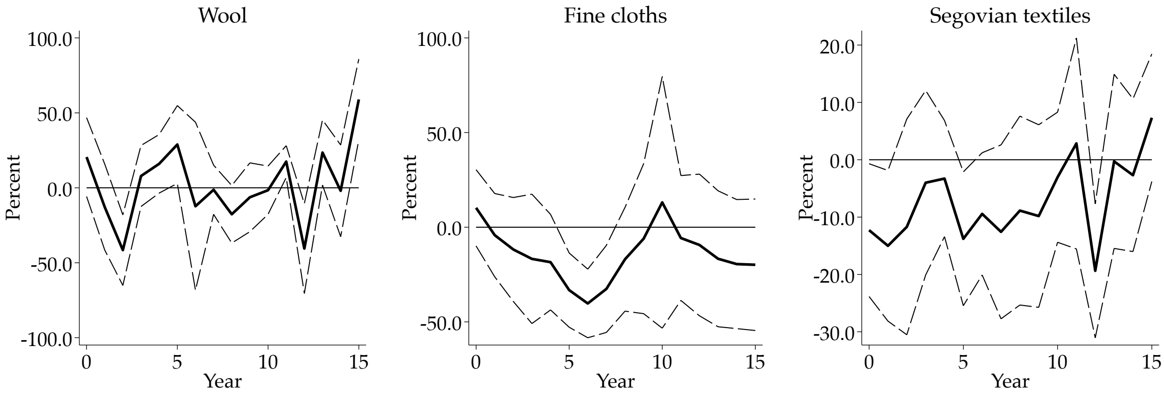
Notes: Dashed lines – 90% confidence interval. Outliers in the following variables: tin, financial services. We winsorize these time series and downweigh the remaining outliers.

Figure A.12: Disaggregated output responses to a doubling in the money inflow-to-stock ratio – Spain



Notes: Dashed lines – 90% confidence interval. Outliers in the following variables: fish, wool. We winsorize these time series and downweigh the remaining outliers.

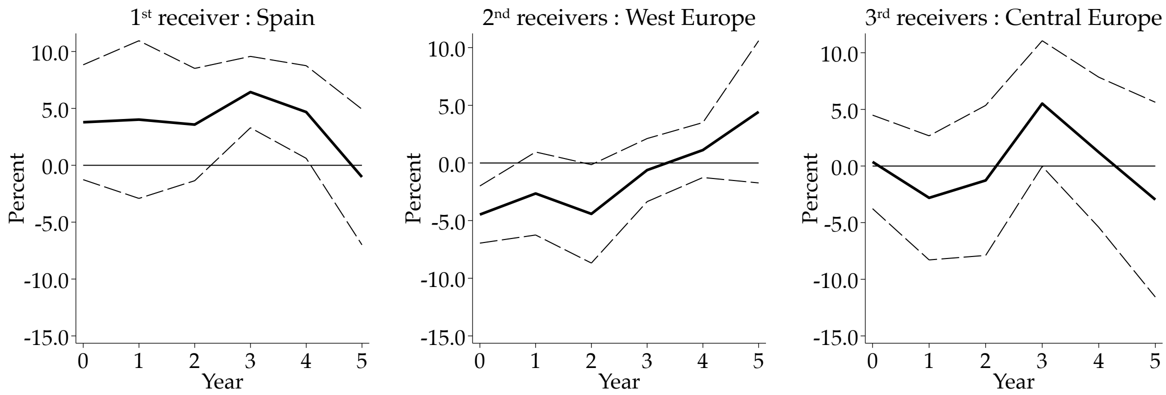
Figure A.13: Additional output responses – Spain



Notes: Dashed lines – 90% confidence interval.

A.6. Interest rate results

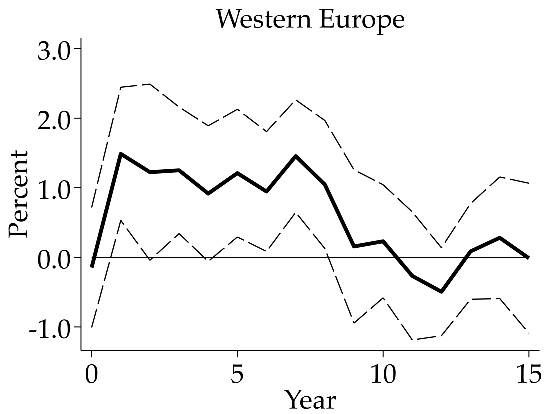
Figure A.14: Lending rate response to negative 1 percentage point maritime disaster shock



Notes: Dashed lines – 90% confidence interval.

A.7. Including Portugal as 1st stage receiver

Figure A.15: Real GDP response to doubling of money inflow-to-stock ratio



Notes: Dashed lines – 90% confidence interval. Results including Portugal.

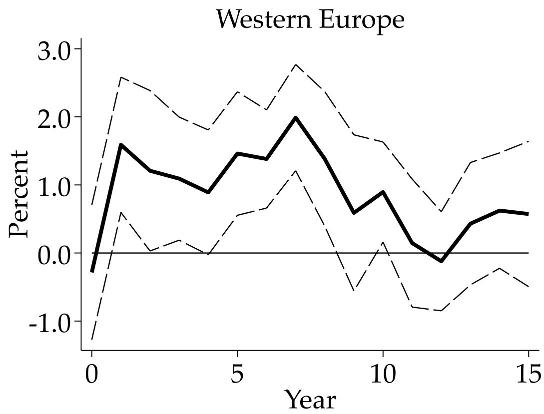
Table A.1: Monetary origins of the early Great Divergence

	Western Europe	East Asia
Monetary effect	26%	*1%*
GDP change	80%	23%
% of early *Great Divergence*	**44%**	

Notes: % of early Great Divergence calculated as $(\Delta Y^M_{Europe,1780} - \Delta Y^M_{Asia,1780})/(\Delta Y_{Europe,1780} - \Delta Y_{Asia,1780})$. Italics: monetary effect for East Asia based on West European IRF estimate, scaled down by East Asia's large GDP share and small share of direct American precious metal inflows across the Pacific. Results including Portugal.

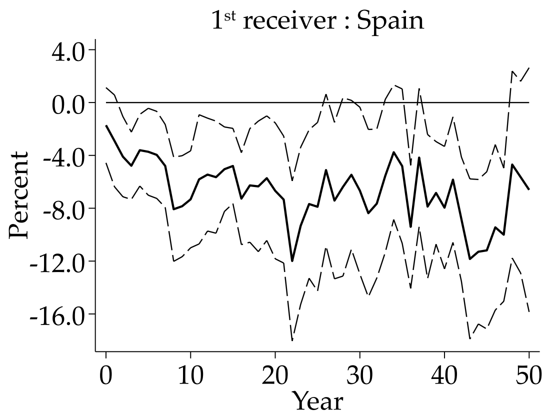
A.8. Other results

Figure A.16: Real GDP response to doubling in money inflow-to-stock ratio



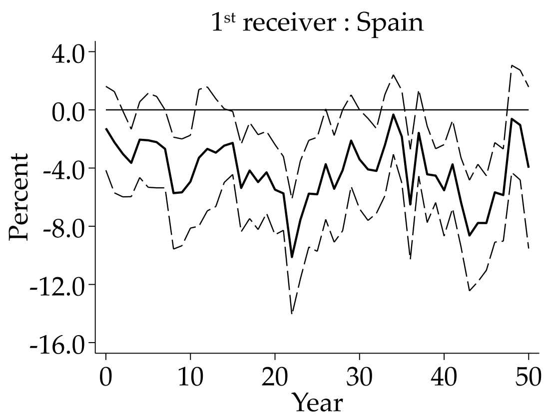
Notes: Dashed lines – 90% confidence interval.

Figure A.17: Real GDP response to negative 1 percentage point maritime disaster shock (long horizon)



Notes: Dashed lines – 90% confidence interval.

Figure A.18: Real GDP per capita response to negative 1 percentage point maritime disaster shock (long horizon)



Notes: Dashed lines – 90% confidence interval. The per capita GDP response is similarly persistent as the GDP response, though somewhat weaker, suggesting somewhat slower population growth in the aftermath of big maritime disaster events.

Appendix references

Pesaran, M. Hashem, and Ron Smith. 1995. Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics* 68(1): 79–113.