

Taming the Global Financial Cycle: Central bank balance sheets and the sterilization of capital flows under the Classical Gold Standard (1891 – 1913)

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Completely monetarized communities could not have stood the ruinous effects of abrupt changes in the price level necessitated by the maintenance of stable exchanges unless the shock was cushioned by the means of an independent central banking policy. The national token currency was the certain safeguard of this relative security since it allowed the central bank to act as a buffer between the internal and the external economy. If the balance of payment was threatened with illiquidity, reserves and foreign loans would tide over the difficulty; if an altogether new economic balance had to be created involving a fall in the domestic price level, the restriction of credit could be spread in the most rational fashion, eliminating the inefficient, and putting the burden on the efficient. Absence of such a mechanism would have made it impossible for any advanced country to stay on gold without devastating effects as to its welfare, whether in terms of production, income, or employment.

Karl Polanyi, *The Great Transformation* (1944: 218)

Abstract

Countries wish to reap the benefits of financial integration while shielding themselves from the vagaries of international financial markets. Can they have it both ways? Are central banks able to isolate their domestic economy by offsetting the effects of capital flows, or are they fully constrained by international financial conditions and/or their exchange-rate regime? We provide an answer for the First Age of Globalisation based on an exceptionally detailed and standardized database of monthly balance sheets of 21 central banks (1891-1913) found in the archives of the Bank of France. Investigating the impact of a global interest rate shock on the exchange-rate, the interest rate and the central bank balance sheet, we find that not a single country played by the “rules of the game.” Core countries typically sterilized capital flows, whereas peripheral countries relied on convertibility restrictions to avoid reserve losses. Countries off gold exhibited remarkably few links to international financial markets. Our findings suggest that the Classical Gold Standard was an environment of trilemma rather than dilemma, but central banks were able to use a variety of tools to mitigate the adverse effects of financial integration.

Keywords: gold standard, sterilization, rules of the game, central banking, trilemma

JEL classification: N10, N20, E42, E50, F30, F44

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1. Introduction

Countries wish to reap the benefits of financial integration while shielding themselves from the vagaries of international financial markets. But can they have it both ways? A large body of work acknowledges the constraints of a trilemma, in the spirit of Robert Mundell's international macroeconomic model, pointing out that a fixed-exchange rate regime and full capital account openness lead countries to give up their monetary autonomy (Obstfeld Taylor 2004, Aizenman et al. 2010, Farhi and Werning 2014, Klein and Shambaugh 2015). The first era of globalization, also the period of the classical gold standard (1880s-1914), is often taken as the paradigmatic example of such constraints, with central banks changing their discount rate in function of international pressures only (Obstfeld and Taylor 2004, Bordo and James 2015). For those who believe that the constraints facing central banks do not even depend on the exchange rate regime – being a simple dilemma – (Rey 2016), the classical gold standard era (1880-1914) should have offered even fewer opportunities for any kind of monetary autonomy, given strong financial integration and the leading role of London in the international financial cycle (Eichengreen 1987).

Yet, since Arthur Bloomfield (1959)'s seminal study, economic historians have argued that gold standard's central banks could rely on various devices (sterilization, foreign exchange interventions, convertibility restrictions) which allowed them to achieve significant levels of autonomy, breaking the "rules of the game" (Keynes) and avoiding partly the constraints of international finance. Bloomfield (1963) and Lindert (1969) further supported this claim by showing the widespread use of foreign exchange interventions by central banks at the beginning of the XXth century (although they did not look at sterilization *per se*). It is based on these arguments that, for example, Davis, Hanes and Rhode (2009), and Hanes and Rhode (2013) argue that a US central bank – if it had existed before 1913 - could have sterilized domestic and international shocks by adjusting the money supply without endangering the country's commitment to the gold standard. Much has been written about the gold standard, but the debate is not over whether or not central banks sacrificed their autonomy in favor of exchange rate stability and financial globalization.

Although scholars have extended and built upon the work of Bloomfield (1959, 1963) and Lindert (1969) by providing detailed case studies of operations of several central banks, our paper is the first to go back to the original comparative ambition of these two authors.¹

¹ Lindert (1969) was the first to follow Bloomfield by studying the role of foreign exchange interventions from 1900 to 1913. His work was also comparative and, as Bloomfield, he relied on annual data. Since then, scholars have confirmed Bloomfield's results showing a negative correlation between the international and domestic assets of some

Compared to our predecessors, we provide high frequency data (monthly rather than annual), a much larger sample of countries than Bloomfield (including countries not on the gold standard, for the purpose of comparison) and a new methodology to define and measure sterilization, based on the identification of the responses of central banks to international shocks. Overall, our results show that central banks enjoyed a high degree of autonomy during the gold standard period – very far from the supposed “rules of the games” – but that the way to achieve this autonomy was very different depending on countries' integration into the rest of the international system.²

With a new database of detailed monthly balance sheets of 21 central banks from 1891 to 1913, we systematically study how central banks reacted to an increase in the Bank of England's discount rate, the leading financial institution of the day.³ Our unique dataset and our research strategy allow us to study at the same time the degree of monetary autonomy (the response of the domestic rate to the English rate) and the means employed by central banks to achieve such potential autonomy (sterilization, foreign exchange interventions or imperfect convertibility). Due to data limitations on central bank balance sheets, such an approach has not been undertaken in the extant literature.⁴ Obstfeld, Schambaugh and Taylor (2005) assess the autonomy of central bank during this period (and subsequent ones) looking at the difference between the changes in the domestic rate and the leading international rate (England in this case). Likewise, Morys (2013) studies the determinants of changes in interest rates of gold standard countries but leaves aside sterilization and foreign exchange interventions. On recent data, Kim (2001), Bruno and Shin (2015) and Rey (2016), Miranda-Agrippino and Rey (2018) use VARs to investigate the impact of the US monetary policy rate on exchange rates, financial and real cycles of other countries, but they do not study the response of monetary authorities.

Our identification strategy extends Bazot, Bordo & Monnet (2016) and consists in looking jointly – for each central bank in our sample – at the response of the domestic discount rate, the exchange rate, the domestic assets and the international assets of the central banks, to a

individuals central banks: Drummond (1976) for Russia, McGouldrick (1984) for Germany, Dutton (1984) and Pippenger (1984) for England, Bazot et al. (2016) for France, Reis (2007) for Portugal before 1887, Jonung (1984) and Ogren (2012) for Sweden and Oksendal (2012) for Norway. They have also provided a detailed description of foreign exchange intervention in some countries (Reis (2007) and Esteves et al. (2009) for Portugal, Jobst (2009) for Austria-Hungaria, Ugolini (2012) for Belgium and Oksendal (2012) for Norway).

² Bordo and Flandreau (2003) noticed that the level of financial development (measured as money over GDP) was positively associated with the probability to be on the gold standard. Our approach is different because we look at the differences within countries adhering to the gold standard.

³ **The dataset includes 19 countries and 21 central banks because the Banks of Naples and Sicily are considered as separate entities. In this first draft, we do not include all the central banks in our VAR analyses (see section 6).**

⁴ A recent collection of statistics on historical central bank balance sheets (Ferguson et al. 2015) provides only annual data and broad categories for 12 central banks over the XXth century, with unsystematic distinction between foreign exchange and domestic assets.

change in the Bank of England discount rate (in addition, we control for a proxy of the global real economic cycle). This is done by estimating a VAR with the variables mentioned above and simulating a shock to the Bank of England (BoE) rate. In a country which played the “rules of the games” and whose central bank sacrificed its autonomy, an increase in the BoE rate should be followed by a temporary depreciation of the exchange rate (within the bands, around the fixed parity) and an increase in the domestic central bank’s discount rate (which would then stabilize the exchange rate). If the shock of the BoE rate is large enough to move down the gold reserves, we should observe an equivalent decrease of the domestic assets of the central bank. The positive correlation between domestic and international assets of central banks is what Bloomfield (1959)–following Nurkse (1944)–identified as a key component of the “rules of the game” of the gold standard. On the contrary, a decrease in international assets (gold and/or foreign exchange) coupled with an increase in domestic assets (discount of commercial paper and advances on securities) is interpreted as an evidence of sterilization: the central bank compensates international assets outflows by credit creation. In a country which sterilizes, we should observe a negligible reaction of the domestic discount rate to an increase in the BoE rate but still a temporary reaction of the exchange rate.

Our estimation strategy also identifies a third case where the absence of response of the domestic discount rate to the BoE rate is not associated with sterilization, but with an absence of decrease in the gold stock. We interpret such results as evidence of imperfect convertibility which prevented gold to leave the central bank in reaction to an international shock.⁵ Imperfect convertibility could mean that central banks preferred to (or were forced to) rely on some forms of capital controls (convertibility restrictions), rather than using their balance sheet to work as a buffer between the internal and the external economy. We observe a clear distinction between countries – in the core of the gold standard – which could rely on sterilization and foreign exchange intervention to achieve autonomy, and other countries – at the periphery of international capital markets – which joined the gold standard but were protected from international shocks by imperfect convertibility. In countries with imperfect convertibility, loans of the central bank to the domestic economy increased after a rise in the BoE rate and also offset capital outflows (although central bank’s gold did not decrease).

Last, we can compare gold standard countries to countries which had a floating exchange rate during the same period. We can see whether these countries accepted fully the floating rates

⁵ Although Martin-Acena et al. (2012) claim that imperfect gold convertibility was the norm in the peripheral gold standard countries, we are only aware of White (1933), Contamin (2003), Reis (2007) and Bazot et al. (2016) which provide a detailed account of capital controls (gold premia) used by central banks. Bloomfield (1959) had already pointed out the role of premia on gold sales and other exchange controls (see p.58-59 on Russia for example: beyond 50,000 marks; foreign exchange was available to finance imports only).

and enjoyed autonomy of their policy. We find that exchange rates surprisingly did not react to international shocks in these countries. They were not enough financially integrated to the rest of the world. Hence, no country in our sample escaped the trilemma by floating its exchange rates. Financial integration and fixed exchange rates went hand in hand. In that sense, the gold standard era seemed to be truly an environment of trilemma rather than dilemma, but central banks were able to use a variety of tools to mitigate the adverse short-term effects of financial integration.

A note of caution is necessary to avoid misinterpretation of our results. We do not claim that countries enjoyed full autonomy, in the sense that they could join the gold standard without costs and that financial integration was beneficial for all. Globalization led some countries in the periphery to borrow too much and it ended in public debt crises which had negative political and economic consequences (Mitchener & Weidenmier 2010, Tuncer 2015). Our demonstration deals with how central banks could be in the position to maintain a fixed interest rate when the leader of the international system moved its interest rate. This is the narrow definition of autonomy that we have investigated here, consistent with standard international macroeconomic models. The existence of such a monetary autonomy is however striking because it explains how central banks of the gold standard era managed to achieve their dual objectives: stability of domestic interest rates and stability of the peg. Our results are also consistent with, and are able to explain, the findings of Mitchener of Weidenmier (2015) who observed persistent spreads between the English rate and the domestic rate in the peripheral countries of the gold standard. It means that peripheral countries could use tools to mitigate the adverse short-term effects of capital flows on the domestic money supply but they had to keep higher interest rates.

The remainder of the paper is as follows. The second section of the paper presents our new dataset. The third section defines sterilization during the gold standard. The fourth section gives a systematic comparison with Bloomfield's data and results. We then explain in a fifth section why Bloomfield's method is not suitable for studying precisely how central banks sterilized capital flows, and we present our new identification method. Section six studies how central banks reacted to policy shocks of the Bank of England. Section seven focuses on the cases of Italy and Russia, comparing their behaviour before and after they joined the gold standard. Section 8 concludes.

2. A unique data base on central bank balance sheets

2.1 Sources

Our dataset is based on an exceptional source that has never been exploited before. The French Central Bank (*Banque de France*) began systematically collecting the weekly or monthly balance sheets of all the world's central banks in 1891. Central banks had a legal obligation to publish these balance sheets at a high frequency, in addition to their annual reports to shareholders, which generally contain additional information and sometimes reproduce the high frequency balance sheets. The legal (or in some cases customary) obligation to publish these balance sheets was justified by the legal requirements (in terms of the relationship between the currency in circulation and the reserves, or the ceilings on circulation) to which central banks were subject. These ratios were carefully looked at by policymakers and investors; they were published in major financial newspapers, as well as data on exchange rates and discount rates (e.g. *L'Economiste Européen* in France, *The Banker* in the United Kingdom, *Le Moniteur* in Belgium, see Baubeau 2018). However, newspapers did not publish data on central bank assets, which were much more difficult to harmonize and compare, given the different financial and accounting practices of countries.⁶ On the contrary, the Banque de France took on this difficult and tedious task. Sufficient skills were needed to translate and understand the various reports. A unit was created in 1884 for this purpose within the Banque.⁷ Its sole objective was to produce harmonised balance sheets of foreign central banks (it was called the *Foreign Banking Statistics Service*), and economists were hired because of their skills in understanding foreign languages (Plessis 2005). It was not until 1891 that this unit began to systematically produce ledgers with weekly or monthly statistics for a significant number of foreign central banks.⁸ Later, in the mid-1890s, it became a real research department, broadening the scope of its studies.⁹ During this period, only the Bank of England, the Banque de France and the Reichsbank had a research department (Martin-Acena

⁶ Some comparative books on central banking written by economists or journalists during this period reproduced annual balance sheets but not the monthly or weekly ones. See for example Sumner et al. (1896), Lévy (1911), Conant (1915).

⁷The interest in comparing central bank balance sheets can be tracked to a 1881 volume published by the Italian statistical institute. It was published in French. *Statistique Internationale des banques d'émission: Autriche-Hongrie, Belgique, Pays-Bas, Suède, Norvège, Espagne*, Direzione Generale Della Statistica, Rome, Imprimerie Héritiers Botta.

⁸ Some data are available before 1891 for a limited number of central banks and several years are missing. See Archives of the Banque de France (ABF), 1377200101 /50.

⁹ It was then headed by Pierre Des Essars, who is mostly known to international historian for his wide ranging contribution to Sumner et al. (1896) on banking in European countries. Starting 1898, the unit “Statistique des banques étrangères” (Foreign Banking Statistics Service) changed its name to “Etudes économiques” (Economic studies). We thank Patrice Denis for this information.

& Tortella 2013) but we found no evidence of similar work in the other two central banks. From 1891 onwards, some of the statistics on the balance sheet of foreign central banks produced by the Banque de France were reproduced in the *Bulletin de législation et statistique comparées*, an important outlet for the dissemination of international economic statistics, published by the French Ministry of Finance.¹⁰ But they were published on a quarterly basis, without notes or sources, and were sometimes incomplete. For this reason, we use the original sources available in the archives of the Banque de France. We use monthly data to obtain comparable frequencies between central banks.¹¹ In addition, we looked at the annual balance sheets, also prepared by the Banque de France, and based on the annual reports of central banks.¹² The annual balance sheets allow us to see if some balance sheet items have been hidden in the weekly and monthly publications. On several occasions, for example, foreign exchange reserves have only been published in annual reports (it was the case only when they represented a very small share of the total portfolio). In addition, the annual ledgers contain much more information on how Banque de France economists translated foreign terms into French, as well as institutional details on foreign central banks.

2.2 Presentation of the data (see appendix for a more detailed presentation)

Following Bloomfield (1959) the analysis of central banks' sterilization and exchange rate intervention is based on the evolution of domestic and international portfolios. Fortunately, the harmonized balance sheet provided by the source helped us to build those series. We assembled five major series in this respect: (1) metallic reserves (gold plus silver); (2) foreign papers; (3) foreign funds available into banks' correspondents; (4) discount portfolio of domestic papers; (5) short term advances on securities and other collaterals. (1), (2), and (3) constitutes the international portfolio while (4) and (5) captures the domestic portfolio.

Time series #1 consists for the most part of gold coin and gold bullion. It occasionally also contains silver and other specie (e.g., copper and bronze in the case of Sweden). Time series #2 consists of bills of exchange drawn on foreign places. Such a series is recorded for all 21 banks in our sample, even if values are very small (Russia, Serbia), a monthly series is reported but begins relatively late (France in 1906) or the reported series only constitutes a lower-bound

¹⁰ The series of domestic commercial portfolios were also used (at a annual frequency) in the comparative book of Roulleau (1913) - the head of the research division of the Banque de France, and renown economist. Roulleau used such series as a proxy for domestic business cycles. He also provided a lot of institutional details on central banks.

¹¹ Archives of the Banque de France (ABF), 1377200101/51-55.

¹² Archives of the Banque de France (ABF), 1377200101/46-58.

estimate (Romania).¹³ In the cases of Germany and Portugal, such data are only available on a yearly basis and are of very small value. The very low numbers for France and Germany suggest that central banks in mature money markets bought such bills infrequently and left this business to specialised banks and brokerage firms. By contrast, central banks in peripheral countries acquired an important share of the market for the lack of strong competitors; in some situations, they have well have constituted the only domestic buyer of bills of exchange drawn on foreign places. Time series #3 consists of funds held abroad. Such funds were usually held by so-called foreign correspondents, i.e., typically a foreign commercial bank with whom the bank of note issue was in regular contact. In many cases, fund held abroad reflect bills of exchange drawn on foreign places after reaching maturity. Such bills are classified as time series #2 before the settlement date and as time series #3 thereafter. Time series #1 is typically much larger than time series #2 and #3 combined (see Table 1). The Classical Gold Standard (1870s-1914) was a specie standard at its heart and a larger role for foreign exchange was left to the interwar period. There are typically more bills of exchange drawn on foreign places than foreign funds. Banks of note issue are typically last buyers (and in peripheral countries often first buyers) of such bills in the domestic market.¹⁴

Time series #4 consists of bills of exchange drawn on domestic places and typically accounts for the majority of the domestic portfolio. (Re-)discounting bills of exchange was at the heart of central bank lending at the time (Bloomfield 1959 is particularly clear on this issue). In a limited number of cases, time series #4 potentially includes a certain amount of foreign bills of exchange (Germany, Portugal). End-of-year comparisons for Portugal and Germany suggest that foreign bills accounted for less than 1% and 10%, respectively. Time series #5 consists of advances. Such advances were typically made available against safe and liquid assets such as government bonds. Yet practice varied with local conditions and we witness a confusing variety of what exactly classifies as an advance. For most countries, a careful comparison of the monthly, quarterly and annual data of the Bank of France delivered the same result. Advances were only made available against safe and liquid assets and their size was small compared to discounted bills of exchange (typically a quarter).¹⁵ Typically, there were many more bills of exchange than

¹³ The use of foreign bills by the Banque de France indeed started in 1906, with the exception of a swap with the Bank of England in 1890 during the Baring Crisis (Bazot et al. 2016).

¹⁴ The rationale for holding foreign exchange reserves was not limited to foreign exchange interventions. For profit maximizing central banks of the time, foreign bills could earn a higher return than metallic reserves (Lindert 1969).

¹⁵ Note that in order to account for all kind of advances against safe and liquid assets, advances on real estate's short term assets have been included in series #5 for Denmark, Norway, and Sweden. Mortgage loans were excluded when they were long term loans financed by issuance of bonds rather than by money creation (Austria Hungaria, Greece, Bulgaria, Italy until 1894). In such cases, they are very stable. For a description of the use of advances on real estate by various central banks during this period, see, *Statistique Internationale des banques d'émission:*

advances (see Table 1); a predominance captured in some languages even today when a central bank's main lending rate is referred to as "discount rate" (e.g., "Diskontsatz" in German).

It is worth noting that some additional hypotheses may have been used to build the series depending on each central bank specificities. The data appendix provides all details, justifications, and comparisons in this regard.

[INSERT TABLE 1 here. See table at the end of the paper]

3. Sterilization and the "rules of the game" under the gold standard

Following Nurkse (1944), Bloomfield (1959) and Triffin (1964), the gold standard literature uses a broad definition of sterilization . Note that these three authors, writing before Mundell, used the word "neutralization" rather than "sterilization". The recent literature in international macroeconomics (Reinhart & Reinhart 2008, Aizenman & Glick 2009, Blanchard & Adler 2015) uses sterilization in both a narrow sense (i.e sterilization of foreign exchange interventions) and in a broader sense (i.e sterilization of the effect of capital flows on the domestic money supply). The study of "neutralisation" by Nurkse and Bloomfield dealt with the money supply (although they looked only at central bank assets). It did not require the existence of foreign exchange interventions. This meaning of sterilization must be understood in the context of the price-specie flow mechanism that was supposed to be at the heart of the gold standard's operation. In this context, a deficit country loses gold, which is deflationary. This deflation would then stabilize the balance of payments because domestic goods become cheaper. In such a framework, the central bank is supposed to play the "rules of the game", i.e. to strengthen the system's natural adjustment process, which involves a price adjustment driven by capital (specie) flows. The central bank should therefore increase its interest rate when the country loses gold in order to accelerate the adjustment. On the contrary, the central bank could refuse to play the "rules of the game", and "neutralize" capital outflows by expanding domestic credit and maintaining stable interest rates when the country loses gold. The conclusion reached by Nurkse (and subsequently applied by Bloomfield to the classical gold standard) was that the absence of movement of interest rates as a function of capital flows, and the negative correlation between domestic assets and the central bank's international assets, were evidence of a "neutralization" of these flows.

Autriche-Hongrie, Belgique, Pays-Bas, Suède, Norvège, Espagne, Direzione Generale Della Statistica, Rome, Imprimerie Héritiers Botta, 1881.

The significance of sterilization (or neutralization) in the context of the gold standard is the offsetting of the effect of capital flows on the money supply. It is easy to reformulate this meaning in the context of Mundell's trilemma as a policy that gives autonomy to the central bank despite the constraints of international finance. In a context of free movement of capital and fixed exchange rates, the central bank's interest rate should be concerned with defending the peg. Therefore, when capital flows out of countries, the central bank must also increase its interest rate. Breaking the "rules of the game" is therefore equivalent to escaping the trilemma.

It was unlikely that "sterilization" would be fully deliberate in the gold standard. This point was already made by Bloomfield (1959, p. 47). First, it was not deliberate because central banks did not use minimum reserve requirements, for example, to act on money supply with the clear aim of avoiding the effects of foreign capital on the domestic price level. Second, although foreign exchange interventions were sometimes deliberate (Jobst 2009), gold sales were generally not. The loss of gold reserves is due to the fact that the agents requested to redeem their notes in gold, and not to deliberate interventions in the foreign exchange market. But, as Bloomfield pointed out, this does not mean that violating the rules of the game was not an active policy. Indeed, central banks were aware that they were not raising interest rates while they were facing a decline in their international reserves and other central banks were increasing their rates. Yet, how can we observe a negative correlation between the national and international portfolios if it was not a deliberate policy? This point was explained in Bazot, Bordo and Monnet (2016). In a world where capital mobility is perfect, an increase in the international rate pushes the domestic money market rate up due to arbitrage, while at the same time agents require foreign assets (gold or foreign exchange) from the central bank to obtain a higher return. The central bank's international assets are declining and the money market rate approaches the level of the central bank discount rate. When it becomes cheaper to borrow from the central bank rather than from the market (at least for a fraction of the banking system), the demand for borrowing increases at the central bank. In response, the central bank's domestic assets increase. However, if the central bank plays the "rules of the game", it increases its discount rate; its domestic assets will then decrease. Thus, the negative correlation between the central bank's international and domestic assets is explained by the increasing demand for borrowing at the central bank's discount window when the central bank refuses to increase its rate in line with the international rate (and in accordance with the rules of the game).

One may wonder why central banks wanted to enjoy policy autonomy under the gold standard, since macroeconomic policies, inflation targets or unemployment targets were not yet a concern of monetary authorities. Although they did not have macroeconomic objectives, central

banks sought to keep interest rates as stable as possible. This objective was considered essential for the financial development of countries, and in line with the profit objective of those private institutions (Conant 1915, Bloomfield 1959, Jobst 2009, Martin-Acena et al. 2012, Bazot et al. 2016). Thus, their goal was to maintain stable domestic interest rates and stable exchange rates.

4. Comparison with Bloomfield

4.1. Countries in Bloomfield's sample

Bloomfield (1959)'s measure rested on the use of (+), (0), and (-) signs according to the covariation of international and domestic portfolios. Therefore, the use of monthly data allows us to circumvent three potential issues. First, sterilization may have occurred at a monthly frequency as observed in the case of France (Bazot, Bordo, and Monnet, 2016). In this case, using the end of December value is purely arbitrary, as acknowledged by Bloomfield himself, and using the mean of several months may miss short-term movements. Bloomfield's analysis was based on the annual mean of monthly figures for 6 over 11 cases, the remaining cases relied on December figures.¹⁶ Second, the strength of negative correlations could be small compared to the strength of positive ones. If so, central banks could have been akin to play the rules when it mattered most. Third, the number of observation produced by annual series is too small to carry out robust inferences. By contrast, high frequency data are suitable to measure the extent and intensity of central banks' sterilization.

We investigate whether Bloomfield's results are consistent with several statistical analyses based on our monthly dataset. The analysis of sterilization is based on the comparison of international and domestic portfolios monthly variations. We use two different indicators. First, we ran OLS regressions explaining the one-month change in the domestic portfolio by the one-month change in the international portfolio. Second, we used rolling regressions over 24 months and counted the share of negative and significant coefficients. Monthly data are prone to seasonality. We used an agnostic view and compare results with raw series and seasonally adjusted series. Seasonality have been captured from three different process. The first one applies the X11 algorithm to domestic and international portfolios. The second one includes monthly dummies into the regressions. Along with the addition of monthly dummies, the third process uses the year-on-year growth rate instead of the first difference of domestic and international portfolios.

¹⁶ Those countries are: Belgium, Denmark, Finland, Norway, and Sweden.

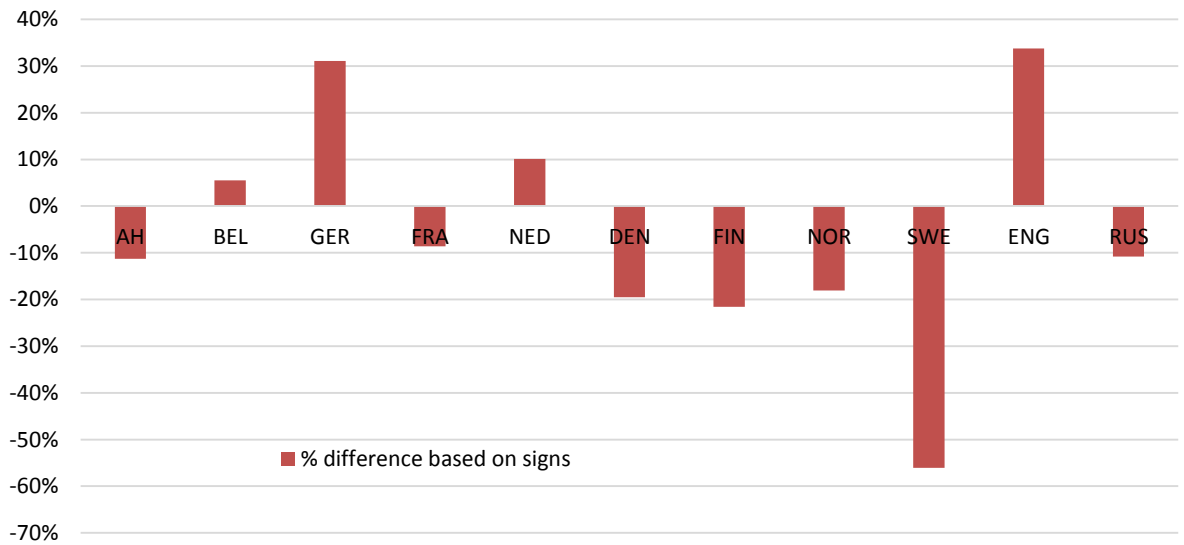
Table 2 provides a direct comparison with Bloomfield (1959).¹⁷ The first line of the table reproduces Bloomfield's annual results. Lines two to five shows the results based on monthly data whether the model accounts for seasonality or not. Line six shows the share of negative signs in Bloomfield (1959) and lines seven to ten display the share of significant negative coefficients in rolling regressions whether one account for seasonality or not.

We see from this table that annual and monthly results can strongly differ in some cases.. If one assumes that a central bank tends to sterilize when the share of negative signs is superior to 50%, Bloomfield's conclusions hold remarkably well, except for Denmark, Norway, and Sweden---which all have been studied in Bloomfield (1959) from the use of December figures. Nevertheless, we find significant differences with Bloomfield when counting the number of negative and positive signs (see Figure 1). In particular, Bloomfield's results tend to underestimate the extent of sterilization in England and Germany, while they overestimate it in Scandinavian countries.

OLS analysis leads to similar conclusions. The annual data shows no effective sterilization in the case of England, Denmark, Finland, and Norway, while none of those central banks seem to play the rules of the game, either. On the other hands, monthly regressions without seasonally adjusted data show that sterilization prevails everywhere, except in Finland and Sweden (which even displays a positive and significant sign). Those results hold when we seasonally adjust the series, except for Austria-and Sweden---which now display some monetary autonomy. It is worth noting that seasonality affects dramatically the estimated coefficient of Austria, Belgium, Germany, France, and Sweden.

¹⁷ For the sake of comparisons we used the same periodization as Bloomfield. For instances, we did not use the Risksbank data before 1900 since Bloomfield did not classify it as "real" central bank before that date. In addition, we either used the annual mean or the last month figure of the international and domestic portfolios depending on Bloomfield's use of central banks series. For details, see Bloomfield (1959) pp.48-49.

Figure 1: Comparison with Bloomfield, raw data



[INSERT TABLE 2 here. See table at the end of the paper]

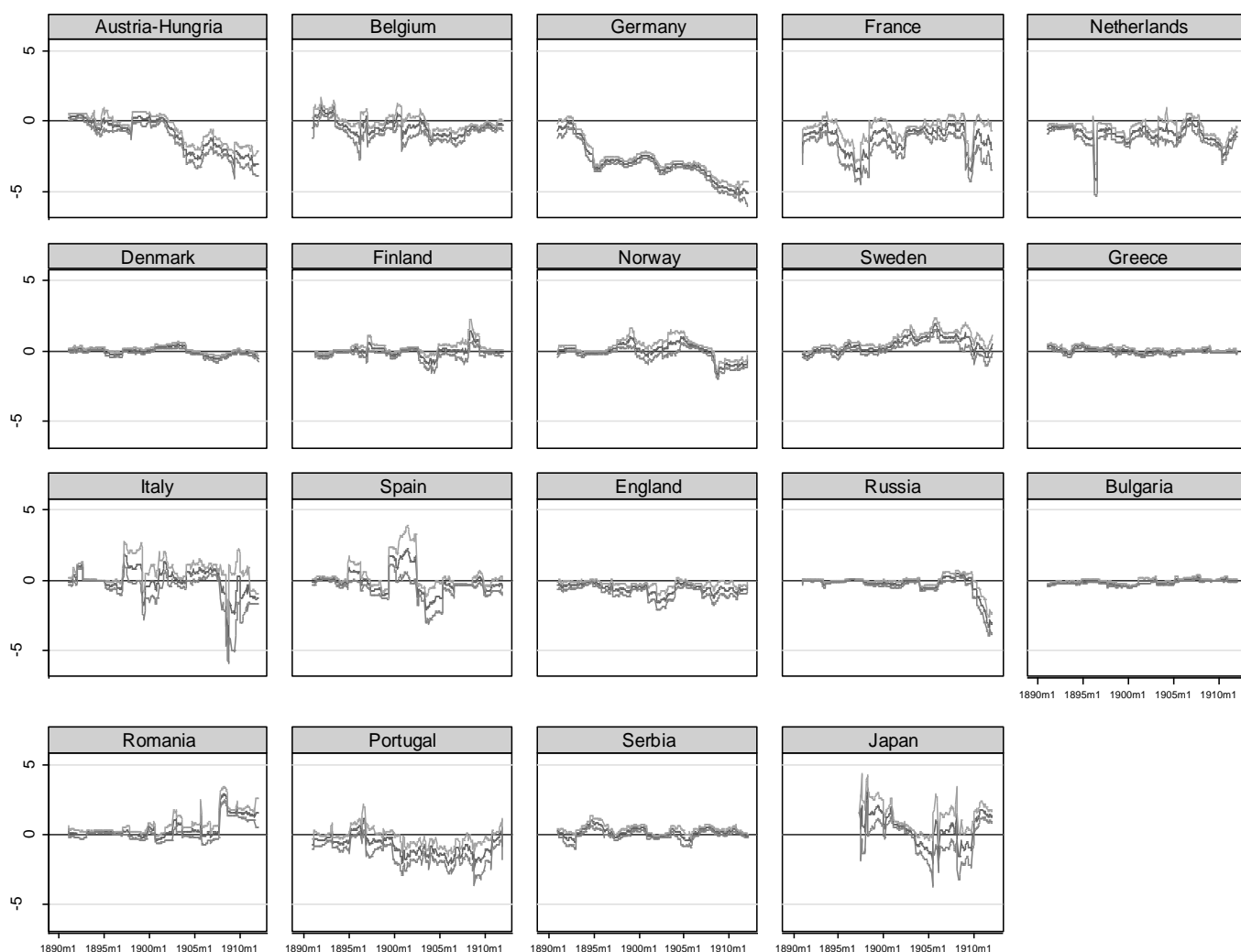
4.2 Extension to other central banks

Bloomfield data is limited to 11 central banks. Table 3 shows the results for the set of additional central banks. Whether one uses dummy variables to capture seasonality or not, Portugal is the only country for which a negative correlation between domestic and international portfolio occurs. Spain is in a similar situation, but the correlation is barely significant.

Figure 2 displays rolling regressions outputs based on a regression window of 48 months. Rolling regressions methodology helps compare sterilization across central banks and over time as it measures the extent and significance of the correlation over the past four years. Our results show that both international and domestic portfolios evolve in opposite direction in “core” countries (England, France, Germany, Austria-Hungria, Belgium, Netherlands). Except in Portugal and Russia after 1896---that is, once the country adhered to the gold standard---there is no evidence of a negative link in the other cases---this is even the contrary in Sweden, Serbia, and Romania.

[INSERT TABLE 3 here. See table at the end of the paper]

Figure 2: Rolling regressions (correlation between domestic and international assets)



5. Identification of sterilization

Comparisons with Bloomfield's results highlight two main issues. First, results are not always robust to different specifications. Second, it is almost impossible to compare results across countries, because of the absence of robustness and because the coefficients (or number of negative signs) are not straightforward to interpret without information on the openness of the capital account. Indeed, if countries were not fully financially integrated to the rest of the world, they did not need to sterilize.

These two problems are in fact caused by a similar identification issue.¹⁸ As a subsequent literature has stressed (see for example Obstfeld 1982), measuring sterilization by looking at the simple correlation between international and domestic assets suffers from strong reverse causality and omitted variable bias. For example, the evolution of the domestic portfolio can influence the change in the international assets if central banks decide to equalize their financial return. More importantly, many factors can influence the path of domestic assets, and might be linked to the balance of payments, such as seasonal economic shocks or banking crises. The historical literature on the gold standard (Dutton 1984, Pippenger 1984, Reis 2007, etc.) has not taken into consideration these discussions about identification, with the exception of Bazot et al. (2016).

Omitted variable bias is likely to be even more significant in gold standard studies because researchers take into account a much more limited set of variables, given the lack of macroeconomic data for most countries. Consider, for example, a negative domestic shock on agricultural activity that, at the same time, increases borrowing from the discount window and increases imports (to compensate for crop failure) and capital outflows (Hanes & Rhode 2013). The high seasonality of domestic credit during this period has made this case quite frequent. However, it is not enough to take seasonality into account, as such domestic shocks could also occur without being seasonal. It could be the case of a banking crisis, for example, which causes at the same time an outflow of capital and an increase in the domestic portfolio of the central bank if the latter is playing the role of lender of last resort.

It is impossible to control for (or identify) these domestic shocks in our sample of countries because we have reliable monthly data on real activity for only three countries (and they do not include agricultural activity). It is obviously interesting in itself to study how central banks smooth seasonal fluctuations in domestic credit or responded to domestic banking crises. But it is left for further research. What matters for this article is to propose an identification of sterilization which is fully consistent with the original idea of Nurkse and Bloomfield and the subsequent literature on dilemma/trilemma, that is how central banks are able to offset the effect of “exogenous” international capital flows on the domestic money supply. For this reason, we follow Bazot, Bordo & Monnet (2016) who focus on a specific international shock---e.g. a rise in the BoE discount rate---which proves to be easier to identify than a domestic shock.

¹⁸ Bloomfield was aware of the effect of the international cycle and considered the fact that there might be a negative correlation between international and domestic portfolios if the loans of the central bank varied counter-cyclically with the economy: “In some cases a more important explanation may lie in the fact that the international and domestic assets of central banks tended to move in opposite directions under the common influence of cyclical forces. In periods of business expansion, the domestic assets of all central banks tended naturally to rise, and in periods of contraction to fall. But as we have seen earlier, the international assets of various central banks tended to fall in periods of expansion and to rise in periods of contraction. In the case of these banks, then, we have another explanation for the tendency toward opposite annual movements in the two sets of assets.” Bloomfield (1959), p. 51.

The advantage of such identification is twofold. First, movements in the Bank of England (BoE) discount rate can be deemed exogenous to the behaviour of other central banks during this period. Second, we can verify – for each country – whether this shock is indeed a shock that is likely to drive capital flows, by looking at the reaction of the exchange rate. If the exchange rate does not react to an increase in the BoE rate, it means that the country was not financially integrated enough to require its central bank to offset the effects of capital flows.

6. Sterilization, imperfect convertibility, and monetary autonomy

6.1 Theoretical approach and VAR estimation

We follow the approach of Bazot et al. (2016) who analyse monetary policy based on a recursive VAR model and impulse response functions following a shock to the Bank of England discount rate. In this set-up, a change to the discount rate of the Bank of England – the conductor of the orchestra in Keynes’ famous words, an assessment supported by subsequent research (Eichengreen 1987) – is the quintessential shock to the monetary system of another country. Balance-of-payments adjustment can come by means of (here illustrated by an *increase* of the Bank of England discount rate):

- A depreciation of the (nominal) exchange-rate, stemming from capital outflows due to the increased English / global interest rate;
- Satisfy the increased demand for foreign currency by selling reserves (international portfolio), thereby counteracting – fully or partially – currency depreciation;
- An increase in the (domestic) discount rate to restore interest rate conditions preceding the international shock

Any of the three responses is referred to as **playing by the rules of the game**. Yet central banks might dislike their effect on the domestic economy and counteract as follows:

- Stop a reserve drain by imposing **capital controls** (either gold convertibility restrictions or controls on foreign exchange);
- Neutralise the effects of a reserve drain on the domestic economy by simultaneously expanding the domestic portfolio (**sterilisation / neutralisation**);
- Not increase the discount rate by the same margin as the Bank of England in an attempt to maintain a lower domestic interest rate level.

Following from this rationale, our set of endogenous variables is composed of the exchange rate on London, the discount rate, as well as the domestic and international portfolios. We add to this the UK railways bills to capture any international business cycle effect on the BoE discount rate itself.¹⁹ In a robustness check section, we account for seasonality through the use of monthly dummy variables. The UK railway freight receipts are from Lennard (2018) who himself obtained it from established historical series. The monthly exchange rate data are from Schneider et al. (1991, 1994, 1999) and Morys (2013).

In order to obtain impulse response function for each central banks of the panel we first used VAR estimation based on the following formulae:

$$y_t = c + \sum_{i=1}^p A_{t-i} y_{t-i} + e_t$$

With y_t a vector of k endogenous variables, c a vector of intercepts, A_{t-i} the $k \times k$ matrix of estimated parameters for $t - i$, p the number of lagged periods included in the estimation, and e_t the vector of error terms following a white noise.

The endogenous variables are the following: the relative change to the previous month of the UK freight receipts, the Bank of England discount rate, the relative change to the previous month of international assets, the relative change to the previous month of domestic assets, the central bank discount rate, and the exchange rate difference with mint parity. The relative change from the previous month has been used to account for non-stationarity in freight receipts, international assets, and domestic assets. Based on Hannan and Quinn information criterion, we include 3 lags in each estimation ($p = 3$).

The estimation of parameters and residuals can be used to simulate the effect of an innovation on the BoE discount rate. To give some structure to the model, we used a Cholesky decomposition to produce orthogonalized impulse response function. The variables ordering is the one displayed above. In this respect, we assume that the Bank of England discount rate does not contemporaneously depend on the other endogenous variables except the UK freight receipts. As long as we are not concerned with the effect of the BoE discount rate innovation on the business cycle---that is, freight receipts relative change---the variables ordering does not affect the IRFs. In this respect, IRFs are not subject to endogenous biases as long as central banks do

¹⁹ If there was any international business cycle, then – by definition – it should be reflected in the English business cycle.

not modify their discount rate or the composition of their balance sheet by anticipation of a change in the BoE discount rate.

6.2 Archetypal central bank reactions

Following from these considerations, we distinguish four hypothetical cases:

Scenario 1: Playing by the rules of the game

In a country which played the “rules of the games” and whose central bank sacrificed its autonomy, an increase in the BoE rate should be followed by a temporary depreciation of the exchange rate (within the bands, around the fixed parity) and an increase in the domestic central bank’s discount rate (which would then stabilize the exchange rate). If the shock of the BoE rate is large enough to move down the gold reserves, we should observe an equivalent decrease of the domestic assets of the central bank. The positive correlation between domestic and international assets of central banks is what Bloomfield (1959)---following Nurkse (1944)---identified as a key consequence of the “rules of the game” of the gold standard: a central bank was meant to exacerbate the external shock in order to accelerate the adjustment process.

Scenario 2: Sterilisation

On the contrary, a decrease in international assets coupled with an increase in domestic assets is evidence of sterilization. The central bank compensates capital outflows by credit creation. Expanded credit means that the discount rate needs to be raised by less than under scenario 1; consequently, we should observe a smaller reaction of the domestic discount rate to an increase in the Bank of England rate. By contrast, we expect the impact to the exchange-rate to be similar to the first scenario as long as the central bank is committed to convertibility (unconditional and immediate conversion of bank notes into gold).

Scenario 3: Imperfect convertibility

We expect the impact of the exchange-rate to be larger only in cases of imperfect convertibility. Gold devices widen the gold points, allowing the exchange-rate to depreciate further than in scenarios 1 and 2. Such policies aimed at protecting international reserves and reducing the interest rate adjustment; in both variables, we expect a smaller response than in scenarios 1 and 2. In the absence of a large reserve outflow, the central bank might nevertheless increase domestic credit. Imperfect convertibility mitigates the decrease of gold reserves by the central bank but

does not necessarily prevent outstanding gold from leaving the country. Thus, central bank credit must expand to avoid any increase in market rates and offset gold outflows on the aggregate money supply.

Scenario 4: Countries off gold

A fourth scenario is concerned with countries on a floating exchange-rate. If these countries have an opened capital account, the exchange rate is going to react to the shock to the BoE discount rate. The exchange rate fully absorbs the shock, so that the domestic central bank does not need to respond by expanding domestic credit or increase its discount rate. By contrast, if financial integration is weak, the exchange rate does not react and, in this case, we do not expect any reaction from the central bank either.

6.3 Results

Estimating the impulse response functions allows us to group 13 of the 20 central banks into the archetypes described above, with 7 cases awaiting further investigation (Bulgaria, Finland, Japan, Norway and 3 Italian banks of note issue).²⁰ Importantly, not a single central bank followed the rules of the game in the first scenario. Either there was low interest rate pass through, sterilisation or imperfect convertibility. Put differently, all central banks pursued policies aimed at sheltering the domestic economy from the external constraint. Our results and country groupings are as follows. In each case, we show results of a paradigmatic case as well as a panel-VAR of all countries belong to this particular group (unbalanced panel in all three cases).

Note: in the VARs below, GINT_ASSETS stands for the growth rate of international assets, GCREDIT for the growth rate of domestic assets, R_ENG for the BoE discount rate, X for the exchange rate on London, DISCOUNT_RATE for the discount rate of the domestic central bank. A shock to the BoE discount rate increases the BoE discount rate by 0.6 percentage point.

Scenario 2: sterilisation (Germany, France, Netherlands, Belgium, Austria-Hungary, Denmark)

Our results for the four core countries of Germany, France, the Netherlands and Belgium and the two semi-peripheral economies of Denmark and Austria-Hungary follow closely the pattern documented for France by Bazot et al. (2016). The quintessential example of this group is Germany, closely followed by Belgium. The exchange-rate depreciation is noticeable (+0.05%,

²⁰ The case of the Bank of England can be investigated by looking at the response to the German interest rate.

with positive values denominating depreciations), but remains within the gold points and smaller than in group 2. The interest rate pass through is much lower than 1 (for a similar finding from a different estimation perspective cf. Shambaugh et al. 2005 and Morys 2013), but at 21 basis points larger than in any of the other groups. Core countries used the discount rate tool extensively (with the possible – and well-documented (Morys 2013, Bazot et al. 2016) exception of France), but never succumbed to following Britain one-to-one. As core countries offered unlimited convertibility, the international portfolio declines quickly and substantially: Germany, continental Europe’s most important money market at the time, loses 1.4% of reserves within the first period alone. Yet all core countries dilute the impact of this reserve drain by expanding domestic credit. In all six cases, the increase of domestic portfolio is larger than the decrease of the international portfolio (as measured in percentage change to the previous month), often by more than factor 2 (Germany: +3.2% vs. -1.4%). In sum, core countries live up to the formal requirement of the gold standard – that is, convertibility – while sheltering the domestic economy from the vagaries of the international cycle as best they can.

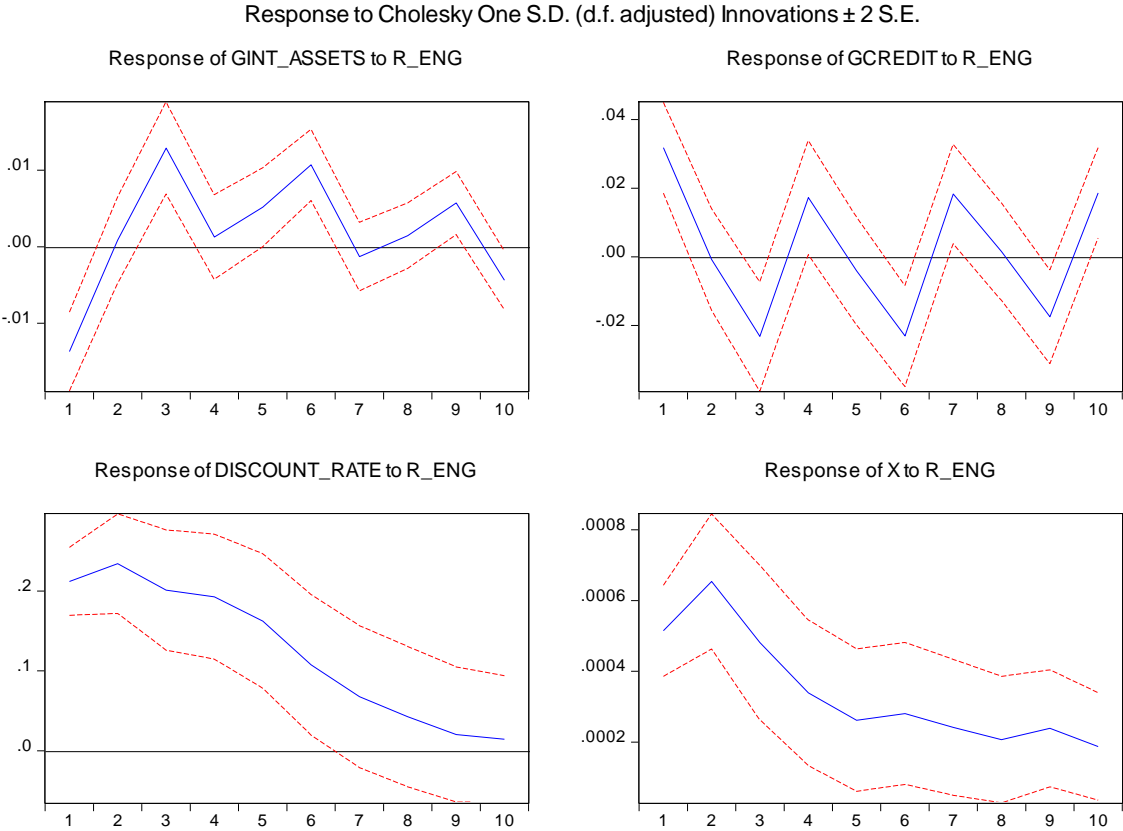


Figure 3: Response of international portfolio (NW), domestic portfolio (NE), discount Rate (SW) and exchange-rate (SE) to English interest rate shock (Cholesky). **Germany.**

Sources: Own calculations based on sources as described in the appendix.

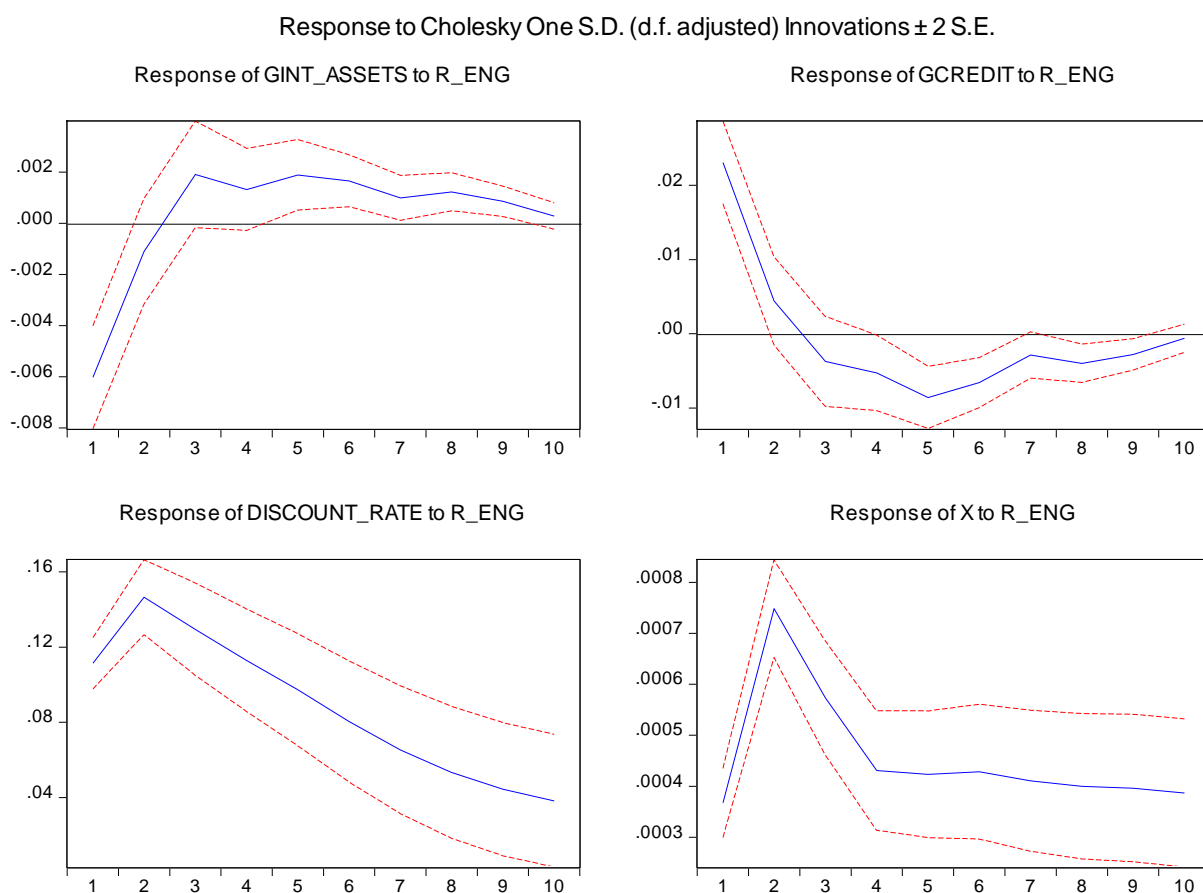


Figure 4: Response of international portfolio (NW), domestic portfolio (NE), discount Rate (SW) and exchange-rate (SE) to English interest rate shock (Cholesky decompos.).
(Unbalanced) panel VAR estimation of core and semi-peripheral countries.
Austria-Hungary (1896m4-1913m12 only), Belgium, Denmark, France, Germany, the Netherlands.

Sources: Own calculations based on sources as described in the appendix.

Scenario 3: imperfect convertibility (Romania, Russia 1897-1913, Sweden)

Romania, Russia (while operating the gold standard after 1897) and Sweden followed a different strategy. We choose Romania as the paradigmatic case, partly for the clarity of the results, partly as we possess (rare) qualitative evidence of imperfect convertibility in this particular case.²¹ Imperfect convertibility allows countries to let the exchange-rate depreciate far more strongly than under the second scenario: Romania's exchange-rate depreciates more than thrice as strongly as Germany's (0.17% vs. 0.05%). Core countries could not afford such depreciation, as gold points were narrow between Europe's financial centres and their commitment to convertibility beyond doubt. Yet in the case of Romania, for instance, it was well understood at the time that the National Bank of Romania typically sought to delay convertibility and/or put upper ceilings to the amount the central bank converted (Sonndorfer 1905). While in theory committed to convertibility to boost the country's credentials, practice often fell short of it.

Imperfect convertibility protects currency reserves; as evidenced by the unclear response (statistically insignificant) of the international portfolio to the English / global interest rate shock. As reserves losses are smaller in scenario 3 compared to scenario 2, peripheral countries under gold needed to raise their discount rate far less in response. The Romanian response, for instance, was less than half of the German response (9 basis points compared to 21 basis points). In sum, peripheral countries were able to shelter from the global cycle by potentially imposing capital controls. This deviation from a central pillar of the gold standard made their adherence less credible (Mitchener&Weidenmier 2015), but did allow them to combine quasi fixed-exchange rates (with larger bands) with a certain level of monetary policy autonomy.

²¹ We thank Anders Ogren for sharing similar observations with us for the Swedish experience.

Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

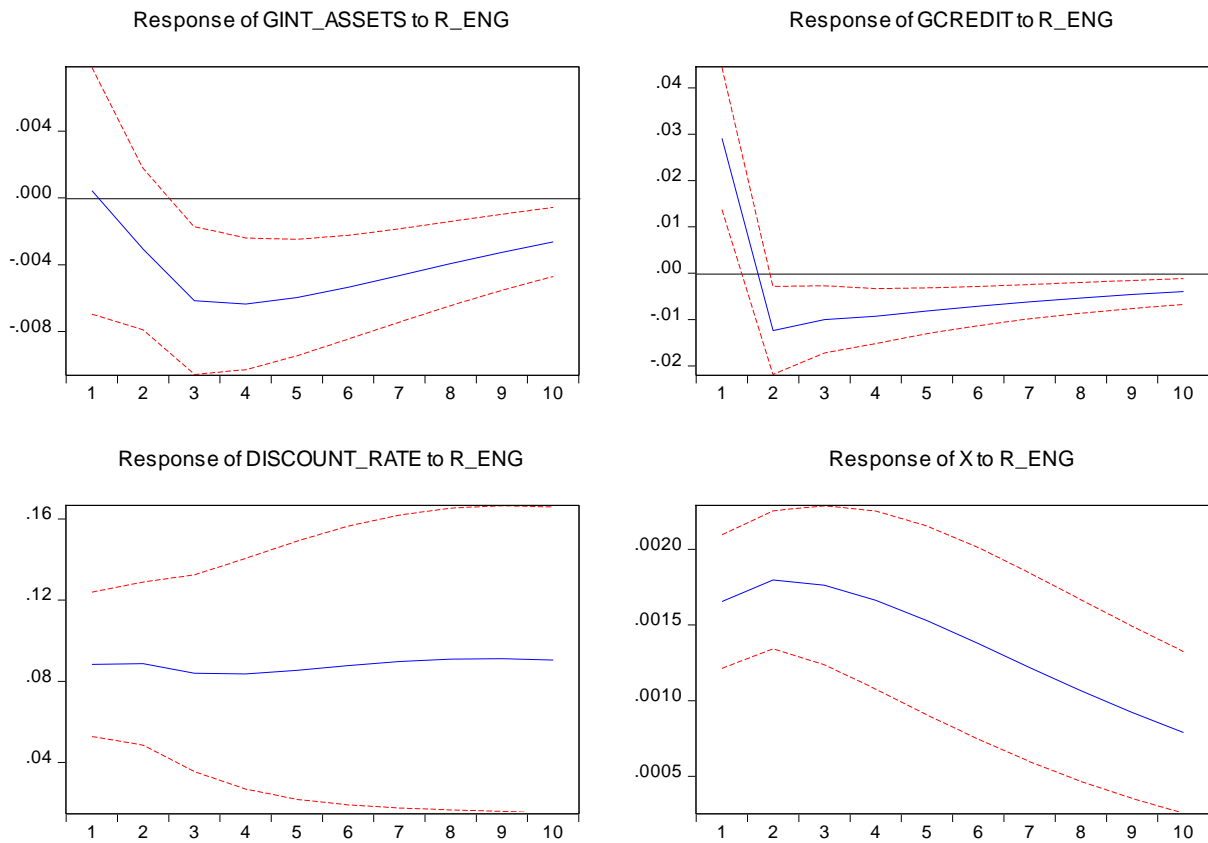


Figure 5: Response of international portfolio (NW), domestic portfolio (NE), discount Rate (SW) and exchange-rate (SE) to English interest rate shock (Cholesky).
Romania.

Sources: Own calculations based on sources as described in the appendix.

Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

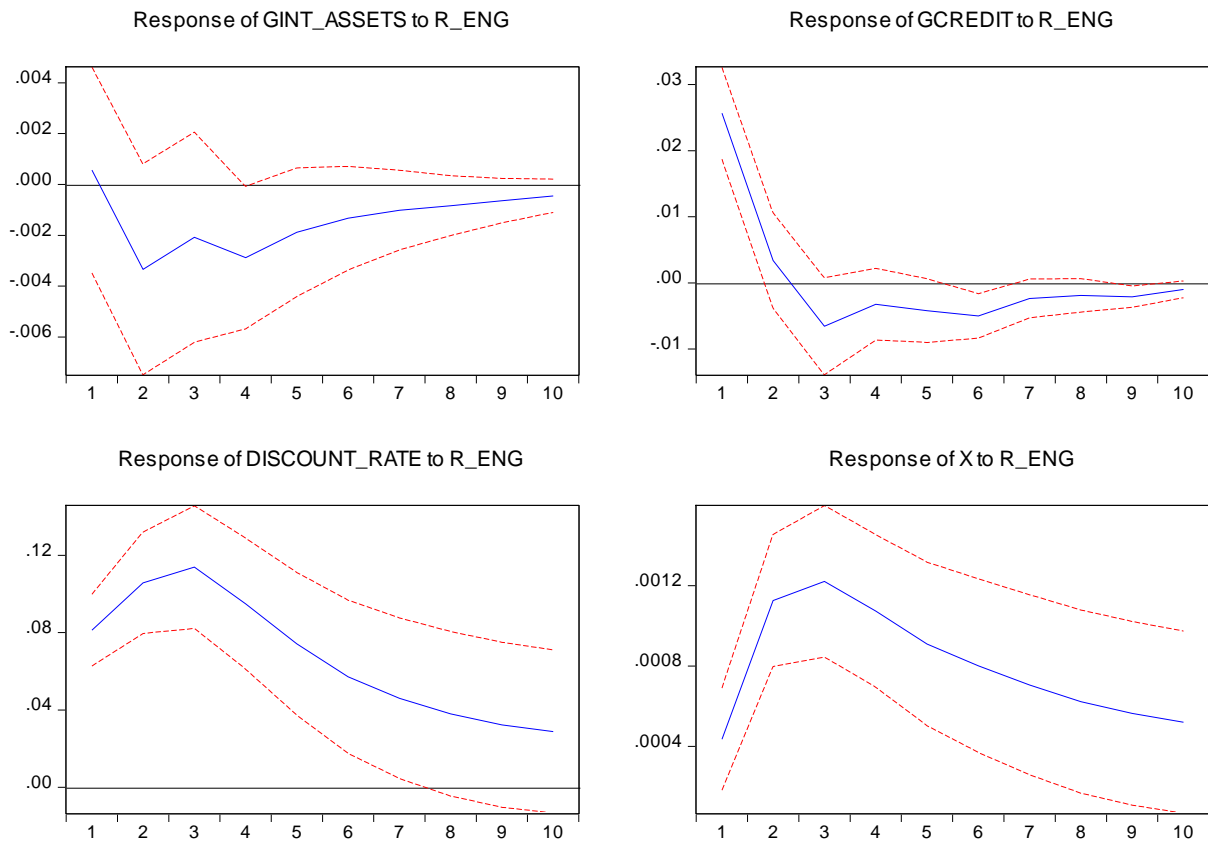


Figure 6: Response of international portfolio (NW), domestic portfolio (NE), discount Rate (SW) and exchange-rate (SE) to English interest rate shock (Cholesky). (Unbalanced) panel VAR estimation of peripheral countries on gold. **Romania, Russia (1897m1-1913m12 only), Sweden.**

Sources: Own calculations based on sources as described in the appendix.

Scenario 4: countries off gold (Spain, Portugal, Greece 1891-1910, Serbia 1891-1906)

Some peripheral countries did not operate the gold standard at all during the period of our study (Spain, Portugal) or only very late (Serbia: 1906; Greece: 1910). They show only a very small response to a global interest rate increase (or even none at all). Likewise, the response of the discount rate, the international portfolio and the domestic portfolio are either small or statistically insignificant. The paradigmatic case for this group is arguably Greece.

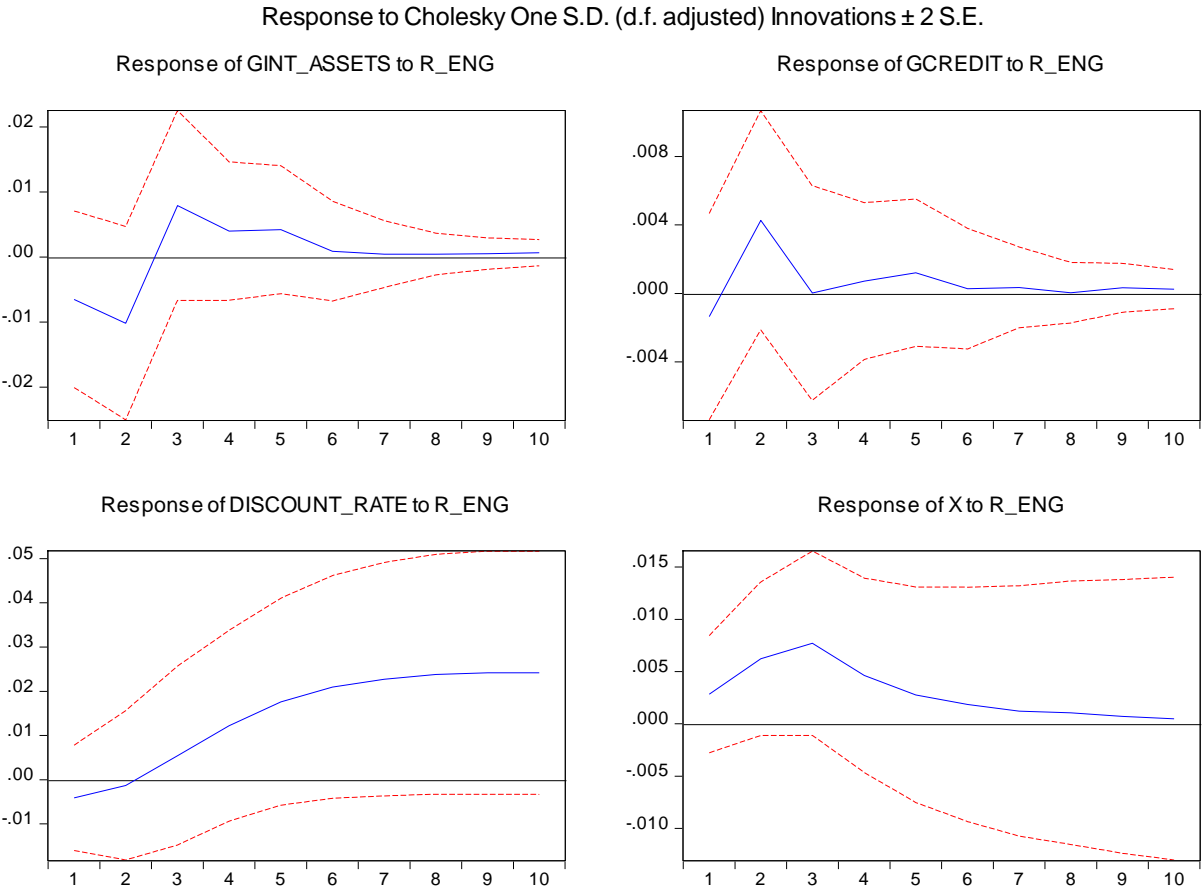


Figure 7: Response of international portfolio (NW), domestic portfolio (NE), discount Rate (SW) and exchange-rate (SE) to English interest rate shock (Cholesky). **Greece, 1891m1 – 1910m3.**

Sources: Own calculations based on sources as described in the appendix.

Our findings are consistent with the view that the four countries under investigation were not integrated into global money markets and hence did not need to react. Greece and Serbia might stand for the latter case: the two Balkan countries defaulted in 1893 and 1895, respectively, and appear to have been cut off from financial markets for a prolonged period of time (Tuncer 2015, Morys 2018).

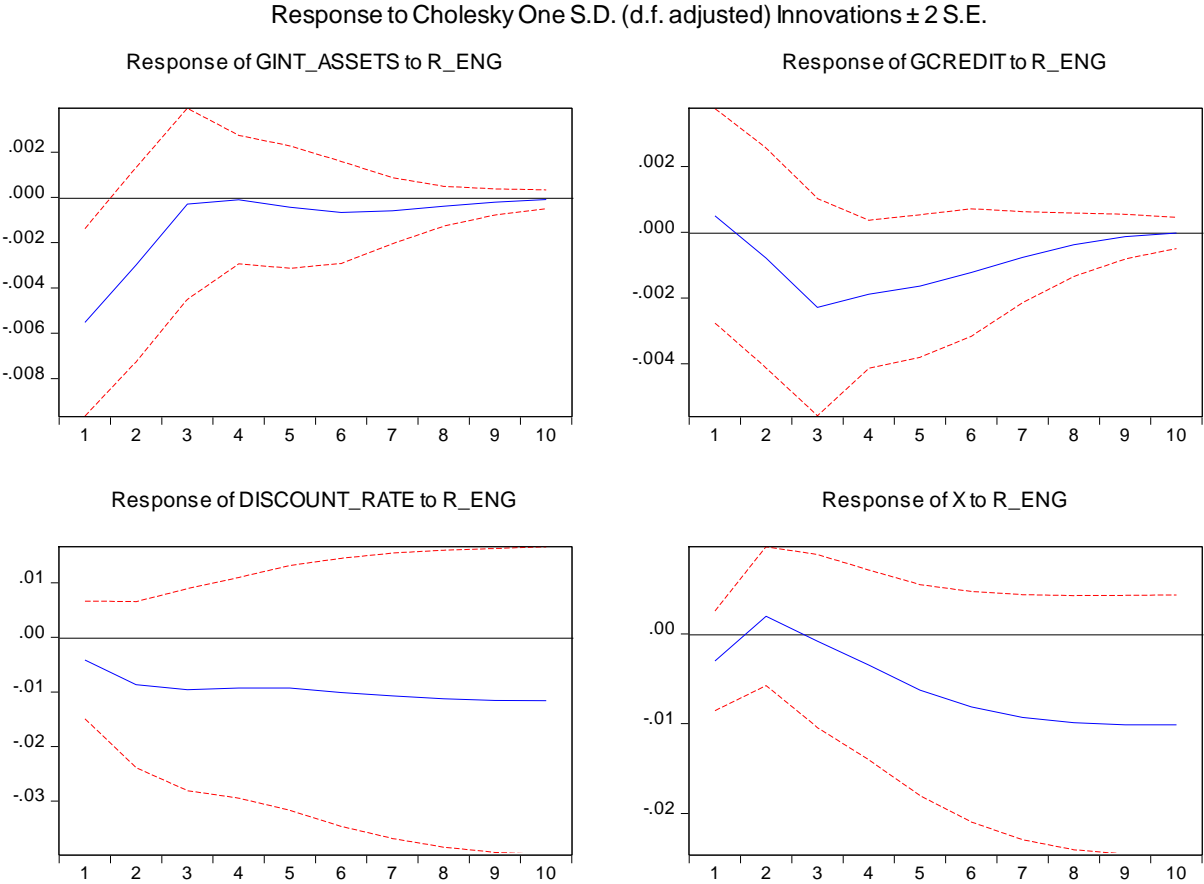


Figure 8: Response of international portfolio (NW), domestic portfolio (NE), discount Rate (SW) and exchange-rate (SE) to English interest rate shock (Cholesky). (Unbalanced) panel VAR estimation of countries off the gold standard. **Spain, Portugal, Greece** (1891m1 – 1910m3), **Serbia** (1891m1-1909m7)

Sources: Own calculations based on sources as described in the appendix.

7. Joining the gold standard

Two countries in our sample (Russia and Italy) joined the gold standard at the turn of the century and we have sufficient data to estimate the behaviour of the central bank before and after adherence. Russia joined in 1897 and Italy from 1903 to 1911.²² Japan joined in 1899 but we do not have the balance sheet of the Bank of Japan before this date. The Russian and Italian experiences provide key cases to study whether the exchange rate regime mattered for central bank reactions to international financial cycles. Results are striking as they show that these two central banks reacted very differently when they were in the gold standard. Before entering the gold standard, they behave like a typical out of gold country, with little financial integration and, de facto, no reaction of the exchange rate and central bank's balance sheets to a rise in the BoE rate. Once in the gold standard, they behave like countries on gold with imperfect convertibility. The exchange rate responds – with a stronger response than in countries that did not fully sterilize –, the international portfolio remains stable and domestic credit increases slightly.

We do not consider that joining the gold standard is an exogenous event. Indeed it was an endogenous process. Countries with already more developed financial markets were more likely to join. As shown by Bordo & Flandreau (2003), adherence to the gold standard was positively correlated with financial development (without obvious direction of causality). For this reason, countries on floating exchange rates in our sample did not have their exchange rate reacting to an international shock. Put differently, floating exchange rate was not used as a tool for to allow monetary autonomy by absorbing the effect of international shocks. In this respect, countries out of the gold standard were in a dilemma situation where the exchange rate regimes did not matter for monetary autonomy. The reason why they avoided the effect of the fluctuations in the BoE rate was simply because they were not integrated enough to international financial markets. When they became more financially integrated and joined the gold standard (or the other way round), they started to face constraints due to international capital flows and the fixed exchange rate. In this respect, they were now in a trilemma (although they found ways to round the corner of the trilemma through imperfect convertibility and sterilization), and the central bank was gaining a new role as a buffer between international and domestic finance.²³

This discussion points out that - at least during the first era of globalization - the distinction between dilemma and trilemma might not be so clear-cut because the choice of the exchange rate

²² Italy was in fact in a ‘gold shadowing’ system from 1903 to 1911 (Cesarano, Cifarelli, & Toniolo, 2012).

²³ It is consistent with the fact that – as claimed by Martín-Aceña et al. 2012 – the Bank of Spain (a country out of the gold standard) was performing few functions of what we would call a central bank.

regime is endogenous to the degree of financial openness of a country. At that time, the global financial cycle was more likely to affect countries that were in a fixed exchange rate regime.

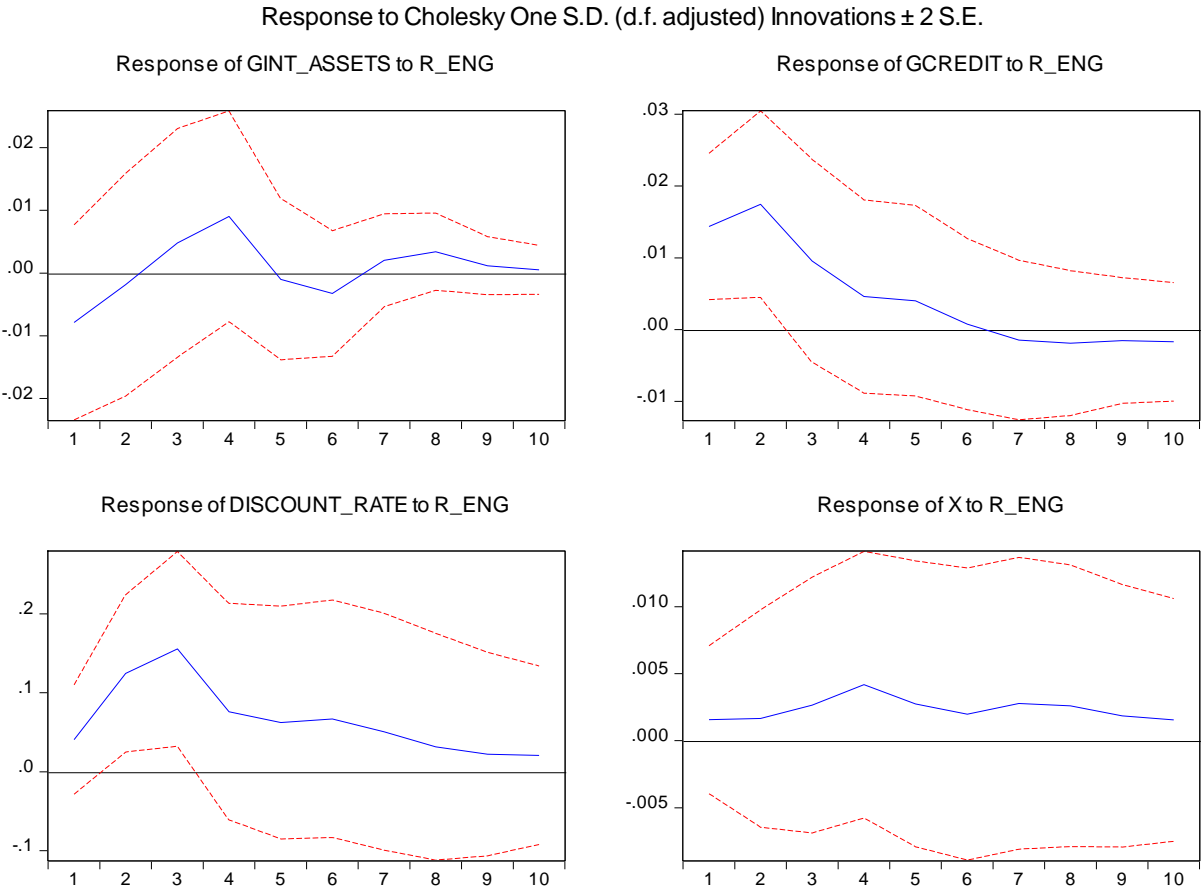


Figure 9: Response of international portfolio (NW), domestic portfolio (NE), discount rate (SW) and exchange-rate (SE) to English interest rate shock (Cholesky decompos.). **Russia, 1891-1906.**

Sources: Own calculations based on sources as described in the appendix.

Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

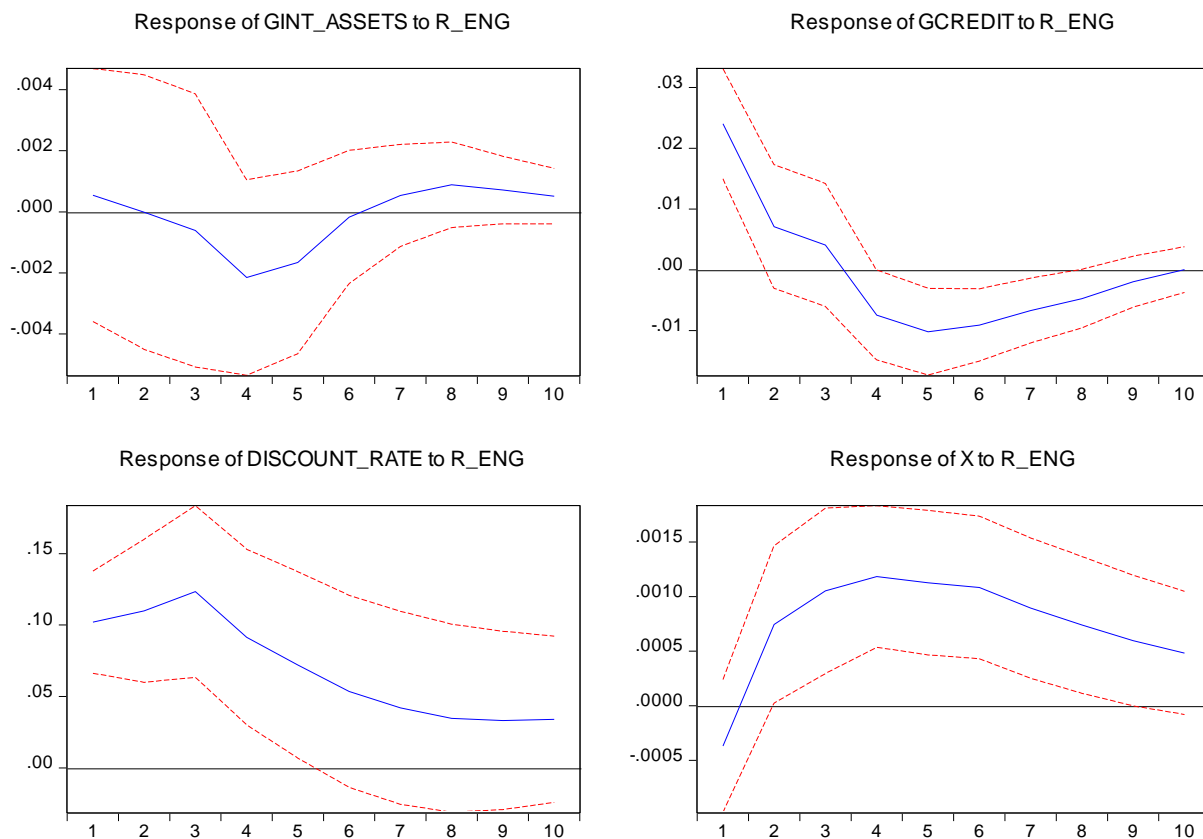


Figure 10: Response of international portfolio (NW), domestic portfolio (NE), discount rate (SW) and exchange-rate (SE) to English interest rate shock (Cholesky decompos.).
Russia, 1897-1913.

Sources: Own calculations based on sources as described in the appendix.

Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

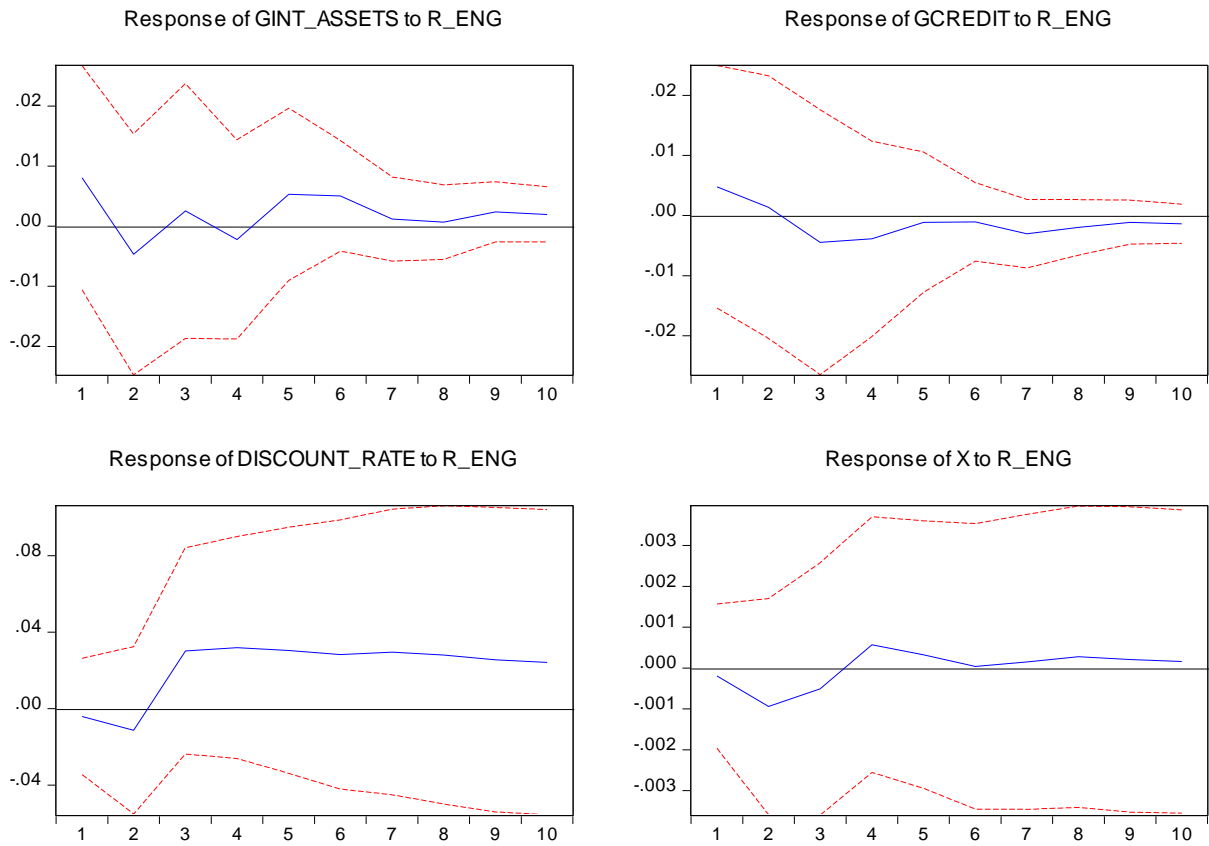


Figure 11: Response of international portfolio (NW), domestic portfolio (NE), discount rate (SW) and exchange-rate (SE) to English interest rate shock (Cholesky decompos.). **Italy, 1891-1902.**

Sources: Own calculations based on sources as described in the appendix.

Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

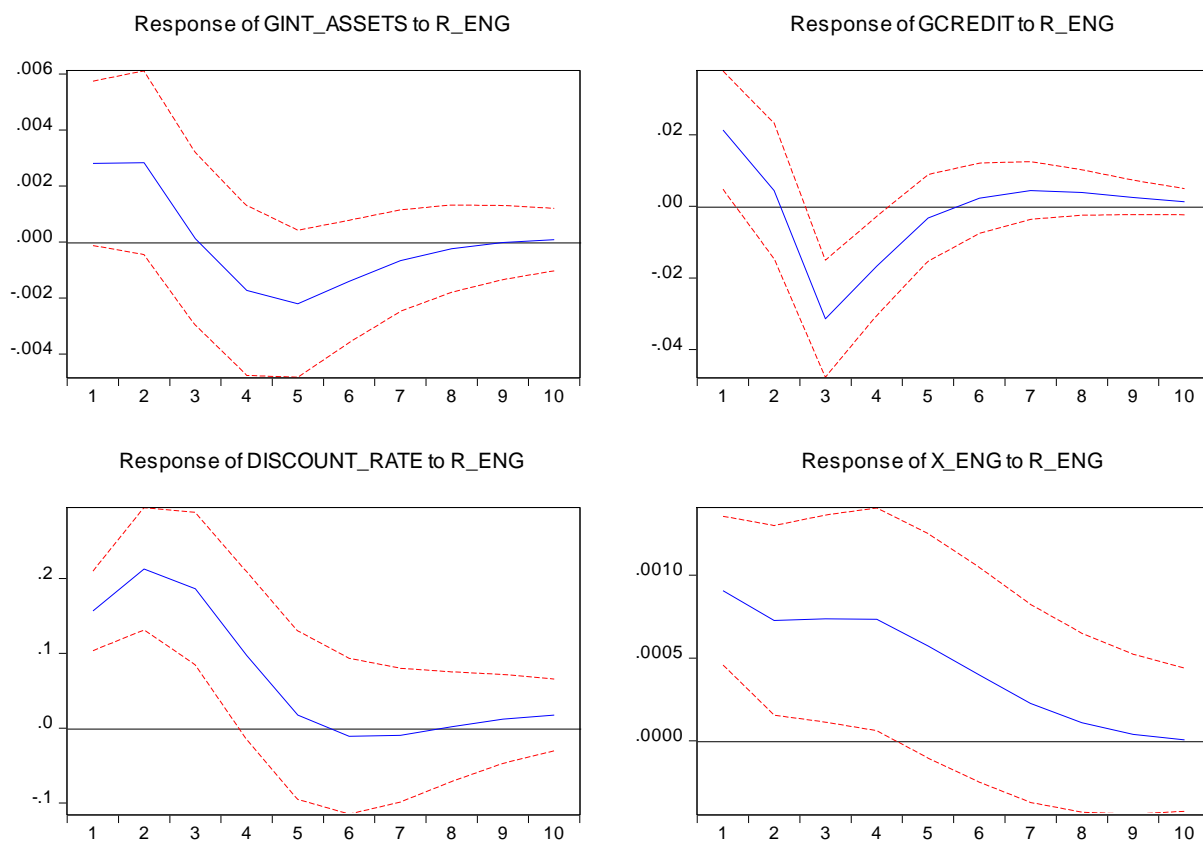


Figure 12: Response of international portfolio (NW), domestic portfolio (NE), discount rate (SW) and exchange-rate (SE) to English interest rate shock (Cholesky decompos.). **Italy, 1903-1911.**

Sources: Own calculations based on sources as described in the appendix.

8. Conclusions

Based on monthly balance sheets of 21 central banks during the gold standard period, this paper investigates how foreign central banks reacted to an increase in the Bank of England interest rate. We consider the BoE rate as a driver of the international financial cycle and, thus, as an exogenous shock on foreign countries. Indeed, the exchange rate responds significantly to this shock in financially integrated countries. With this new dataset and identification method, we revisit the standard debate on sterilization and the rules of the game during the gold standard,

offering the first comparative perspective on the matter since the work of Bloomfield (1959). Our work also informs the current debate on dilemma/trilemma and on the potential effect of movements in the US interest rate on foreign economies. We show that not a single central bank followed the “rules of the game”. Instead, we identify different patterns of behaviour among central banks. Central banks in core countries sterilized fully their decrease in international assets whereas central banks in the periphery relied on imperfect convertibility. Countries out of the gold standard show no evidence of financial integration; their exchange rate did not react to a shock to the English interest rate. Integration to the world capital markets was correlated with joining the gold standard so that, indeed, a central bank proved to be a useful buffer in countries that were on gold.

Our investigation is based on data of all central banks of the period (the Ottoman bank is considered as being more a private bank than a central bank ; the central bank of Switzerland was created in 1908 only, so is not included here for investigation). But many countries during this period were on the gold standard without having a central bank. What lessons does our study bear to them? We provide the most comprehensive investigation of how central banks used their balance sheet to tame capital flows. As such, it would serve as a benchmark for studies attempting to explain the functioning of the gold standard in countries without central banks and building counterfactuals on what would have happened if a central bank had existed (cf Hanes & Rhode 2013 for the US). Countries without a central bank could still have a Treasury imposing restrictions on gold convertibility, but no institution was in the position to offset the effects of international shocks.²⁴

Since the countries whose central banks sterilized were indeed the most financially integrated countries, our results show that a central bank was a key institution for these countries - as suggested by Polanyi in the quote in the epigraph of this article - because it served as a buffer between international capital flows and the domestic financial system. As suggested by the debates in the US at the turn of the century, it was difficult to grow as a financially integrated country without a central bank. Besides, there could be other reasons why a central bank was needed as it could use its balance sheet for lender of last resort operations and smoothing seasonal cycles (Mankiw and Miron 1986, Hanes and Rhode 2013, Hautcoeur Riva and White 2014). We leave these considerations to further research.

²⁴ Some private banks might have provided the same function, but it remains to be shown.

APPENDIX

Description of balance sheet data found in the Banque de France archives

The harmonized balance sheet provided by the source helped us to build those series. We assembled five major series in this respect: (1) metallic reserves (gold plus silver); (2) foreign papers; (3) foreign funds available into banks' correspondents; (4) discount portfolio of domestic papers; (5) short term advances on securities and other collaterals. (1), (2), and (3) constitutes the international portfolio while (4) and (5) captures the domestic portfolio.

In describing the data below, we will also provide the French terminology based on the monthly, quarterly and annual publications of the Bank of France we rely on. Some of the notions do not lend themselves to a straightforward translation into English. This largely reflects the fact that the Bank of England followed a unique classification due its separation of an issuance and a banking department (1844 Bank Act); and that the U.S. did not have a central bank at all until the establishment of the Federal Reserve in 1913. By contrast, continental European terminology and classification is often rather similar to French practice, as evidenced by country-specific balance sheet data which we have consulted on various occasions to double-check specific issues. We therefore provide below the German equivalent of a French term in some instances.

International portfolio

1. metallic reserves / “en caisse” / “Barvorrat”

Time series #1 consists for the most part of gold coin and gold bullion. It occasionally also contains silver and other specie (e.g., copper and bronze in the case of Sweden). The proportion of silver is typically large only when silver coin retained its legal tender status after the country switched to gold at some point in the 1870s. This was often the case in countries of the so-called limping gold standard (also referred to as limping bimetallism) which preserved silver as legal tender up to a certain amount. Contemporary sources refer to the entirety of specie as „metallic reserves“ (e.g., „Metallvorrat“ for the Reichsbank).

For some banks of note issue, “reserves” (Reichsbank: “Barvorrat”) are a slightly broader concept than “metallic reserves” (Reichsbank: “Metallvorrat”). In the cases of multiple banks of note issue (Germany, Italy and Sweden in our case), the category „en caisse“ / „Barvorrat“ also encompasses bank notes issued by other (domestic) banks of note issue. The Reichsbank, for

instance, was allowed to include bank notes issued by other German banks of note issue on the grounds that such notes enjoyed metallic backing by their respective issuing bank. We follow this practice, not least because the Bank of France statisticians fully subscribed to it despite coming from a single bank of note issue system.

In the cases of the Reichsbank and the three Italian banks of note issue (National Bank of the Kingdom of Italy, Bank of Naples, Bank of Sicily), we add – in line with domestic and French practice at the time – short-term treasury notes („Reichskassenscheine“ for the Reichsbank and „billets et bons de caisse de l’Etat“ for the three Italian banks). These were highly liquid debt instruments and the four banks were allowed to include them into their note cover. It remains unclear why only these four banks of note issue include such notes into their note cover, and whether there is a connection to the system of multiple banks of note issue prevalent in Germany and Italy.

The items described in the two paragraphs above were typically very small. E.g., in the case of the Reichsbank, they accounted for approximately 5% of total reserves.

2. foreign paper / “portefeuille commercial – papier étranger” / “auswärtige Wechsel”

Time series #2 consists of bills of exchange drawn on foreign places. Such a series is recorded for all 21 banks in our sample, even if values are very small (Russia, Serbia), a monthly series is reported but begins relatively late (France in 1906) or the reported series only constitutes a lower-bound estimate (Romania). In the cases of Germany and Portugal, such data are only available on a yearly basis and are of very small value.

The very low numbers for France and Germany suggest that central banks in mature money markets bought such bills infrequently and left this business to specialised banks and brokerage firms. By contrast, central banks in peripheral countries acquired an important share of the market for the lack of strong competitors; in some situations, they have well have constituted the only domestic buyer of bills of exchange drawn on foreign places.

We acknowledge that the cases of Portugal, Russia and Serbia are difficult to square with this explanation. Yet the very low numbers in these three cases might reflect country-specific idiosyncrasies. In the case of Russia, the treasury – and not the bank of note issue which we study – managed foreign bills. Portugal was not on gold in the time period under investigation. The case of Serbia might be similar to the Portuguese case. We have positive knowledge of no foreign bills until 1904 (when the country was on a fiat standard), but cannot be entirely certain for the period thereafter (data for 1905-1913 only report “portefeuille commercial” without

distinguishing between foreign and domestic) which roughly coincides with the country's de facto adherence to gold (1904-1912).

3. foreign funds / „fonds à l'étranger“ / „Auslandsguthaben“

Time series #3 consists of funds held abroad. Such funds were usually held by so-called foreign correspondents, i.e., typically a foreign commercial bank with whom the bank of note issue was in regular contact. In many cases, fund held abroad reflect bills of exchange drawn on foreign places after reaching maturity. Such bills are classified as time series #2 before the settlement date and as time series #3 thereafter.

None of the five core countries (Britain, France, Germany, Belgium and the Netherlands) report such a series, but all other countries do with the exception of Japan, Portugal and Romania. We hypothesize that core countries stabilised their exchange-rate in the currency market located in their own country, thereby avoiding the need to hold foreign funds abroad; such exchange-rate stabilisation policies pursued domestically were probably carried out by selling bills of exchange drawn on foreign places (time series #2). Such purely domestic intervention was not possible for all other countries where currency trading took place abroad rather than at home.

Japan, Portugal and Romania are the only peripheral countries to not report such a series. In the case of Portugal, the absence might be explained by the country being off gold at the time (similar to the absence of time series #2, cf. above). The annual balance sheet of the Bank of Portugal reports a very little amount of foreign bills (less than 1% of total discounts portfolio). The Romanian case might be similar to the Austro-Hungarian case where, if only relying on published documents at the time, we would only have a lower bound estimate for time series #2 and no data at all for time series #3 (Jobst&Scheiber 2014 for Austria-Hungary vs. Stoenescu et al. 2014 for Romania). The Japanese case awaits further investigation.

Comment on the relative sizes of time series ##1, 2, 3

Exceptions to #1 >> #2 + #3

Time series #1 is typically much larger than time series ##2 and 3 combined. The Classical Gold Standard (1870s-1914) was a specie standard at its heart and a larger role for foreign exchange was left to the interwar period.

Yet the gold exchange standard of the 1920s finds some precedents among late-stabilizing countries on the European periphery, namely Bulgaria (stabilises in 1906) and Greece in

particular. In the case of Greece, foreign funds account for the largest share of the international portfolio; foreign funds exceed metallic reserves by factor 7 at the time of currency stabilisation in 1910 and by factor 10 at the end of our period.

The other exception to the rule $\#1 \gg \#2 + \#3$ were the Nordic countries of Finland, Norway and Sweden (though not Denmark). The combined of $\#2$ and $\#3$ are often larger than $\#1$, and foreign funds in particular played an important role. This reflects the fact that these three countries were allowed, as members of the Scandinavian Monetary Union, to include foreign funds held at the banks of note issue of the other members countries as part of their note cover (and hence as international portfolio in our terminology) See Sumner et al. (1896), Lévy (1911), Conant (1915).

Exceptions to $\#2 > \#3$

There are typically more bills of exchange drawn on foreign places than foreign funds. Banks of note issue are typically last buyers (and in peripheral countries often first buyers) of such bills in the domestic market. We note that the only cases in which foreign exchange is typically larger than bills of foreign exchange are the four Nordic countries, Bulgaria and Greece. In the Nordic countries, this probably reflects the privileged situation which foreign funds enjoyed due to the rules of the Scandinavian Monetary Union referred to in the paragraph above. In the other two cases, it might reflect the mechanics of late stabilisation (in the case of Greece, we cannot even identify a separate time series $\#2$, even though the data description of time series $\#3$ in Lazaretou (2014) leaves open the possibility that some of the foreign funds were actually foreign bills of exchange).

Domestic portfolio

4. domestic paper / “portefeuille commercial – papier indigène” / „Diskontdarlehen“ or „Wechsel“

Time series $\#4$ consists of bills of exchange drawn on domestic places and typically accounts for the majority of the domestic portfolio. (Re-)discounting bills of exchange was at the heart of central bank lending at the time (Bloomfield 1959 is particularly clear on this issue).

In a limited number of cases, time series $\#4$ potentially includes a certain amount of foreign bills of exchange (Germany, Portugal). Yet we do know from the Bank of France Annual Data that these amounts were very small compared to domestic bills of exchange. End-of-year

comparisons for Portugal and Germany suggest that foreign bills accounted for less than 1% and 10%, respectively.

5. advances on collateral / „avances“ / „Lombarddarlehen“

Time series #5 consists of advances. Such advances were typically made available against safe and liquid assets such as government bonds. Yet practice varied with local conditions and we witness a confusing variety of what exactly classifies as an advance. For most countries, a careful comparison of the monthly, quarterly and annual data of the Bank of France delivered the same result. Advances were only made available against safe and liquid assets and their size was small compared to discounted bills of exchange (typically a quarter).

Only the cases of Bulgaria, Denmark, Greece, Norway, Russia, Serbia and Sweden posed specific problems. Incidentally, these seven countries were also the cases where time series #5 was large relative to time series #4 and in some cases even exceeded it. Given the economically backward nature of these countries (with the possible exception of Denmark and Sweden), we view these data problems as pointing to a more fundamental problem on the European periphery: how to enable short-term lending in the absence of sufficient bills of exchange (discount lending) or a scarcity of good collateral (conventional advances)?

In these seven cases, unsecured lending, lending against commodities (e.g., iron in the case of Sweden) and lending against real-estate played an important role. We have included all three categories as long as there was sufficient evidence that the lending was short-term.

Comment on the relative sizes of time series ##4, 5

Exceptions to #4 >> #5

Typically, there were many more bills of exchange than advances; a predominance captured in some languages even today when a central bank's main lending rate is referred to as „discount rate“ (e.g., „Diskontsatz“ in German). In the cases of Denmark, Norway, and Sweden, #4 remains larger than #5 even if we include marginal balance sheet items such as lending against iron (cf. our description of time series #5 above). The only exceptions are found in Bulgaria, Greece, Russia and Serbia. This dichotomy between the Balkans (and possibly Russia) on the one hand, and all other peripherals countries on the other hand, is consistent with recent interpretations that South-East Europe (and Russia) were particularly backward even when

compared to other peripheral countries, resulting in the development of a distinctively different monetary system (Morys&Ivanonv 2015, Morys 2017).

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Table 1: summary statistics

	England	Austria	Belgium	Germany	France	Netherlands	Sweden
Share metallic reserves	1	0,9169	0,4974	1	0,9986	0,9079	0,5849
share foreign bills	0	0,0593	0,5026	0	0,0014	0,0921	0,1317
share foreign funds	0	0,0238	0	0	0	0	0,2834
share discount	1	0,8737	0,9095	0,8826	0,6462	0,4841	0,6108
share advances	0	0,1263	0,0905	0,1174	0,3538	0,5159	0,3892
discount rate	3,7407	4,2963	3,471	4,2572	2,8833	3,3768	4,8714

	Denmark	Norway	Italy	Italy before 1903	Italy after 1902	Russia 1897	Russia before 1896	Russia after Romania
Share metallic reserves	0,795	0,6395	0,8831	0,8787	0,888	0,9219	0,9799	0,9014
share foreign bills	0,0607	0,0506	0,0749	0,0768	0,0729	0	0	0,2208
share foreign funds	0,1443	0,3099	0,042	0,0446	0,0391	0,0781	0,0201	0,0986
share discount	0,5528	0,8552	0,8589	0,8731	0,8434	0,5031	0,5096	0,5007
share advances	0,4472	0,1448	0,1411	0,1269	0,1566	0,4969	0,4904	0,4993
discount rate	4,6667	5,0109	4,596	4,7604	4,4167	5,163	4,6042	5,3603

	Greece	Spain	Bulgaria	Portugal	Serbia	Japan	Finland
Share metallic reserves	0,1553	0,9162	0,9012	1	0,9016	0,9025	0,5314
share foreign bills	0,8447	0,0478	0,0146	0	0	0,0975	0,0548
share foreign funds	0	0,036	0,0842	0	0,0984	0	0,4138
share discount	0,7244	0,7211	0,5477	0,7127	0,4346	0,3321	0,6423
share advances	0,2756	0,2789	0,4523	0,2873	0,5654	0,6679	0,3577
discount rate	6,3304	4,5688	7,4946	5,7355	7,0225	6,6989	5,1171

Table 2: Sterilization policy, comparison with Bloomfield (1959)

	AH	BEL	GER	FRA	NED	DEN	FIN	NOR	SWE	ENG	RUS
(1) Annual (Bloomfield replication)	-0,591*** (0.192)	-0,528*** (0.102)	-0,546*** (0.186)	-0,726*** (0.114)	-0,746*** (0.0739)	-0,374 (0.238)	-0,171 (0.394)	0,199 (0.203)	-1,475*** (0.400)	-0,155 (0.331)	-0,453** (0.177)
(2) Monthly, raw	-1.273*** (0.358)	-0.421*** (0.147)	-3.372*** (0.128)	-1.000*** (0.194)	-0.876*** (0.128)	-0.145*** (0.0495)	-0.0418 (0.0801)	-0.195** (0.0915)	0.632*** (0.205)	-0.552*** (0.115)	-0.258** (0.128)
(3) Monthly, deseasonalized data (X11 algorithm)	-0.125 (0.311)	-0.238* (0.128)	-0.851*** (0.211)	-0.478** (0.191)	-0.671*** (0.115)	-0.164*** (0.0396)	-0.0669 (0.0771)	-0.132** (0.0612)	-0.451*** (0.0998)	-0.539*** (0.165)	-0.275** (0.114)
(4) Monthly with monthly dummies	-0.649 (0.396)	-0.307** (0.132)	-2.062*** (0.351)	-0.479** (0.196)	-0.748*** (0.112)	-0.202*** (0.0410)	-0.0114 (0.0636)	-0.201*** (0.0695)	-0.389*** (0.138)	-0.596*** (0.0972)	-0.249*** (0.0952)
(5) Monthly growth variation with monthly dummies	0.0925 (0.954)	-0.192*** (0.0675)	-1.255*** (0.202)	-1.642*** (0.511)	-0.992*** (0.143)	-0.345*** (0.0754)	0.00227 (0.0559)	-0.131** (0.0626)	-0.473*** (0.106)	-0.325*** (0.0472)	-0.444** (0.201)
(6) % negative in Bloomfield (1959)	0,68	0,52	0,61	0,82	0,74	0,57	0,48	0,52	0,57	0,52	0,59
(7) %negative in rolling regressions, raw	0,57	0,58	0,92	0,74	0,84	0,37	0,26	0,34	0,01	0,86	0,48
(8) %negative in rolling regressions (deseasonalized with X11)	0,59	0,39	0,76	0,38	0,70	0,59	0,41	0,30	0,84	0,68	0,59
(9) %negative in rolling regressions with monthly dummies	0,51	0,51	0,68	0,34	0,75	0,49	0,38	0,31	0,73	0,65	0,54
(10) %negative in rolling regressions with growth variation and monthly dummies	0,47	0,51	0,72	0,34	0,75	0,49	0,35	0,31	0,84	0,66	0,57

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: raw means that no deseasonalization has been employed. X11 is an algorithm used to deseasonalized time series. Each regression is based on the same period and method of calculation than in Bloomfield (1959); for details see Bloomfield (1959) pp. 48-49.

Table 3: Sterilization policy, other central banks

Panel A: simple regressions								
	Greece	Italy	Spain	Bulgaria	Romania	Portugal	Serbia	Japan
Δ international assets	-0.0861 (0.0692)	0.0189 (0.0442)	-0.298* (0.174)	0.00844 (0.0375)	0.605*** (0.168)	-0.914*** (0.330)	0.0330 (0.0666)	0.144 (0.402)
Constant	0.284*** (0.108)	0.595 (2.082)	1.991 (2.003)	0.366*** (0.120)	0.403 (0.696)	0.133** (0.0614)	0.0914 (0.0835)	-0.125 (2.805)
Monthly dummies	no	no	no	no	no	no	no	no
Observations	272	275	275	275	275	261	275	179
R-squared	0.032	0.000	0.028	0.000	0.075	0.065	0.002	0.001
share of significant negative signs	20%	14%	43%	48%	2%	66%	11%	13%
Panel B: regressions with monthly dummy variables								
	Greece	Italy	Spain	Bulgaria	Romania	Portugal	Serbia	Japan
Δ international assets	-0.0863 (0.0682)	-0.0110 (0.0559)	-0.299 (0.184)	0.0400 (0.0308)	0.252 (0.183)	-0.766** (0.322)	-0.0538 (0.0578)	-0.599 (0.429)
Constant	-0.910* (0.548)	-45.13*** (11.10)	-9.530 (6.359)	-1.002* (0.607)	-11.16*** (2.410)	-0.0558 (0.122)	-0.921*** (0.209)	-43.01** (19.03)
Monthly dummies	yes	yes	yes	yes	yes	yes	yes	yes
Observations	272	275	275	275	275	261	275	179
R-squared	0.133	0.436	0.084	0.243	0.239	0.201	0.431	0.289
share of significant negative signs	11%	20%	41%	34%	28%	58%	34%	38%

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

