Taming the Global Financial Cycle: Central Banks and the Sterilization of Capital Flows under the Classical Gold Standard (1891 – 1913)

This draft: 3rd May 2019[1]

Guillaume Bazot (University Paris 8)
Eric Monnet (Banque de France, Paris School of Economics & CEPR)
Matthias Morys (University of York)

Abstract
Are central banks able to isolate their domestic economy by offsetting the effects of foreign capital flows? 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). 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 fully sterilized capital flows, while peripheral countries relied on convertibility restrictions to avoid reserve losses. These features allowed central banks to round the corner of the *trilemma* and serve as a buffer between the internal and the external economy. In contrast, in the United States, a gold standard country without a central bank, the reaction of the money market rate was three times stronger than that of interest rates in countries with a central bank. In line with the predictions of the *trilemma*, the exchange rate absorbed the shock fully in countries off the gold standard (i.e., with a floating exchange rate), whereas the central bank's balance sheet and interest rate were not affected.

Keywords: gold standard, sterilization, rules of the game, central banking, trilemma
JEL classification: N10, N20, E42, E50, F30, F44

---

1 gbazot@gmail.com; eric.monnet@banque-france.fr; matthias.morys@york.ac.uk
We gratefully acknowledge financial support by the Fondation Banque de France, the Labex OSE (Paris School of Economics) and the University of York. The results presented in this paper do not reflect the views of the Banque de France or the Eurosystem. Earlier versions of this paper were presented at the annual meetings of the AEA, the Economic History Society and the Verein für Socialpolitik (Wirtschaftshistorischer Ausschuss); at seminars and conferences at the U.S. Federal Reserve Board and the Universities of Buckingham, Lund and Strassbourg. We are grateful to all participants for their spirited discussion and helpful comments, and in particular to Michael Bordo, Eric Hilt, Clemens Jobst, Lars Jonung and Marc Weidenmier. We owe a special thanks to the following people for sharing data or helping us collect, systematise and interpret data: Fabrice Reuzé, Patrice Denis and Frederik Grelard (Bank of France Archives), Juha Tarkka and Vappu Ikonen (Bank of Finland), Peter Lindert, Jonas Lundberg and Masato Shizume.

Table of Contents

> 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. [...] 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)

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 (Obsteld and Taylor 2004, Aizenman et al. 2010, Farhi and Werning 2014, Bordo and James 2015, Klein and Shambaugh 2015, Jorda, Schularick and Taylor 2019). 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 (Eichengreen 1992, 2008, Obstfeld and Taylor 2004, Bordo and James 2015). Yet, beyond the focus on interest rates, there is a lack of quantitative information on what central banks actually did during this period, and especially how they adjusted their portfolio in response to international shocks. A historical detour can show us how strong the constraints of international finance used to be, and what solutions have been devised in the past to meet the challenges we face today.

In the spirit of the recent literature looking at the influence of US interest rates on the global financial cycle and foreign monetary policy (Rey 2013, 2016; Bruno and Shin 2015; Miranda-Agrippino and Rey 2018, Jorda et al. 2019), we revisit the history of the classical gold standard by examining the response of central banks to an increase in the interest rate of the Bank of England – then the leader of global financial markets (Lindert 1969, Eichengreen 1987). In a fixed-exchange rate regime with capital mobility, an increase in the leading international interest rate attracts capital flows to the centre country, and it forces foreign central banks to increase their rate in a similar way. Our study is based on an exceptional dataset of detailed monthly balance sheets of all central banks in the world from 1891 to 1913, as well as interest rates and exchange rates. This is a first time that such a comprehensive and high frequency dataset is assembled to study central banking during the pre-WWI gold standard.[1]

[1] 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.

Three important results stand out. First, as already suggested by Bloomfield (1959), central banks in the gold standard did not follow the "rules of the game". That is, they did not raise their interest rates by the same order of magnitude as the Bank of England (the average pass-through was around 20% only). By contrast, they "sterilized" the effect of international shocks on the domestic money supply: they increased their loans to the domestic economy to offset capital outflows. Second, while central banks in core countries relied fully on sterilization to offset short-term international shocks, the central banks in the periphery of the gold standard also used restrictions on gold convertibility (i.e. capital controls) to minimize their losses of foreign reserves. Such strategy allowed them to operate with a wider exchange rate band, without suspending officially their adherence to the gold standard. Third, none of the mechanisms described above was observed for central banks in countries off the gold standard: in floating countries, the exchange rate absorbed fully the international shock.

By comparison, we study the response of gold held by the Treasury and interbank interest rates in the United States, a major country without a central bank during the classical gold standard. We find that the response of the US money market interest rate to a change in the English rate was three times as large as the response of rates in countries with a central bank. Consistent with a strong and rapid response of interest rates, the exchange rate between New York and London adjusted more quickly than in countries with a central bank. The United States enjoyed much less autonomy and – as suggested by Davis, Hanes and Rhode (2009) and Hanes and Rhode (2013) – lacked a central bank that could have sterilized the effects of shocks on the domestic money supply.

Taken together, our results show in a novel way why a central bank matter. They also highlight the different ways – combining sterilization and convertibility restrictions akin to capital controls – that were used by central banks during the first globalization to mitigate the potential adverse effects of short-term international shocks. The immediate response of foreign exchange rates to an increase in the interest rate of the Bank of England confirms that the integration of global financial markets during this period was high. Our findings also confirm the textbook trilemma (Obtsfeld and Taylor 2004), as a floating exchange rate gave full autonomy to domestic monetary policy. Questions remain about whether the second era of financial globalization, since the 1990s, is different in this respect (Rey 2013). But it is worth emphasizing that – despite the apparent benefits of floating exchange rates – most countries in the first era of financial globalization preferred to join the gold standard in order to attract capital flows (Bordo and Rockoff 1995, Mitchener and Weidenmier 2015), while letting their central bank using various devices to offset undesired effects of international capital flows. The most important conclusion of this study is that the era of the first globalization was not a period of total submission of

countries to the fluctuations of international financial markets. The balance sheets of central banks stood as a buffer between the domestic economy and the global financial cycle.

Sections I defines sterilization in the context of the gold standard. It also explains why previous empirical studies failed to identify sterilization and the method we propose to achieve such robust identification. Section II presents our method of estimation and identification, based on simple theory of international macroeconomics. Section III describes our original historical database on monthly central bank balance sheets, and presents the different groups of central banks that we are investigating. Section IV deals with the main results of the paper, including a comparison between countries with a central bank and the United States. Section V discusses alternative specifications, endogeneity issues and robustness checks.

Sterilization, the "rules of the game" and the trilemma: the gold standard view

This paper is the first to study in detail short-term (monthly) adjustment and responses of central banks to international shocks during the gold standard. Yet, our main argument is not entirely new. Since Arthur Bloomfield (1959)'s seminal study, economic historians have argued that gold standard's central banks could temporarily suspend convertibility and "sterilize" the effects of international capital flows on the domestic money supply, which allowed them to achieve significant levels of autonomy, breaking the "rules of the game" (Keynes) and avoiding partly the constraints of international finance.[2] 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. However, Bloomfield (1959)'s argument was based on a limited set of countries (without comparisons with countries off the gold standard) and annual data. Moreover, as we explain below, his definition of "sterilization"

[2] Scholars have confirmed Bloomfield's results about sterilization showing a negative correlation between the international and domestic assets of some 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. Following Bloomfield (1963) and Lindert (1967), 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. Ford (1962) provided landmark evidence of the use of imperfect gold convertibility in England and, most of all, Argentina. The paper by Bazot et al. (2016) on France was the first to suggest a different methodology than Bloomfield in order to assess the extent of sterilization. The present paper follows and expands this idea to a much larger set of countries.

(negative correlation between international and domestic assets of the central bank) suffers from a severe identification problem, and is thus not able to examine the response of central banks to a shock on international financial markets. We will also show in section 5 that a well-identified sterilization is in fact not observable with annual data.

Definition of sterilization and "rules of the game"

Following Nurkse (1944), Bloomfield (1959) and Triffin (1964), the literature on the gold standard uses a broad definition of sterilization. Note that these three authors, writing before Mundell (1963), used the word "neutralization" rather than "sterilization". The recent literature in international macroeconomics (Reinhart & Reinhart 2008, Aizenman & Glick 2009, Blanchard & Adler 2015, Fratzscher et al. 2019) 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 foreign capital flows on the domestic money supply). The study of "neutralisation" by Nurkse and Bloomfield – which is also the focus of this paper – dealt with the broad sense. 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 (Bordo & Schwartz 1984, Eichengreen 2008, chp.2). 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.

The significance of sterilization in the context of the gold standard is the offsetting of the effect of foreign capital flows on the domestic money supply (hence on the domestic price level). It is easy to reformulate this meaning in the context of the trilemma (Obstfeld and Taylor 2004) 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.

Sterilization in practice

Contrary to central banks' operations today, it is unlikely that "sterilization" was fully deliberate in the gold standard. As we will explain below, central banks were reacting to the borrowing demand of banks at a fixed rate, rather than purchasing or selling bills on an open market or setting reserve requirements. As already pointed out by Bloomfield (1959, p. 47) - in his own vocabulary – central banks' actions were not "deliberate", but violating the rules of the game was an "active" policy. Indeed, central banks were fully aware that they were often *not* raising interest rates despite facing a decline in their international reserves. How can we observe sterilization (a negative correlation between the national and international portfolios) if it was an "active" but 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.[3]

[3] 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, Reis 2007, 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.

Identification of sterilization

In order to assess whether central banks offset capital flows, Nurkse (1944), Bloomfield (1959) and subsequent authors look at the correlation between the domestic and the international portfolio. This method suffered from a key identification problem which has been neglected in the subsequent literature on the classical gold standard.[4] Measuring sterilization by looking at the simple correlation between international and domestic assets suffers from strong reverse causality and omitted variable bias (see, for example, Obstfeld 1982). Many factors can influence the path of domestic assets, and might be linked to the balance of payments, such as domestic economic shocks or banking crises. 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 (as described in Hanes & Rhode 2013). It could also 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.

To solve this identification problem, we need an exogenous shock that affects international capital flows in the same way in all countries in our sample. In the context of the classical gold standard, a change in the discount rate of the Bank of England provides such a shock. 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 (Lindert 1969, Eichengreen 1987, Morys 2013, Bazot et al. 2016) – is the quintessential shock to the monetary system of another country. An *increase* in the Bank of England discount rate would attract capital to England and create capital outflows and exchange rate depreciation in foreign countries.

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 (such assumption is the basis for the work of Obstfeld and Taylor 2014, Jordà et al. 2019 on the trilemma during the gold standard period).[5] 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.

[4] Bloomfield (1959, p. 51) in fact noticed this caveat, without implementing an alternative method.
[5] Jorda et al. (2019) instrument domestic monetary policy shock with the BoE rate during the gold standard (and Fed rate thereafter).

This identification is consistent with the recent literature looking at the influence of US interest rates on the global financial cycle and foreign monetary policy during the second era of financial globalization starting in the 1980s (Rey 2013, 2016; Bruno and Shin 2015; Miranda-Agrippino and Rey 2018, Jordà et al. 2019). We will show in a robustness section that our conclusions still hold if we use a measure of English monetary policy shocks during the gold standard that is free of endogenous reactions to the domestic and international economy.

Theory, identification and methods of estimations

Theoretical predictions

Consistent with the previous definition of sterilization, the work of Nurkse (1944), Bloomfield (1959), Mundell (1963) and recent reformulations of the trilemma in international macroeconomics (Obstfeld & Taylor 2004, Farhi & Werning 2014) imply the following theoretical predictions and four potential scenarios after an increase in the discount rate of the Bank of England. The first scenario ("rules of the game") is equivalent to the plain *trilemma* case with fixed exchange rate and full capital mobility. Scenario 2 is the same case where we consider the role of effective central bank sterilization rounding the corners of the *trilemma*, as explained in the previous section. Although discussed in theory (Mundell 1963, Obstfeld 1982), this scenario is usually not investigated in empirical studies of the trilemma. Scenario 3 is the *trilemma* case with fixed exchange rates and capital controls. Scenario 4 is the case with floating exchange rates.

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 similar increase in the domestic central bank's discount rate (which would then stabilize the exchange rate). If the foreign central bank increases its rate by the same magnitude as the BoE, the reaction of the exchange rate may not be visible at a monthly frequency since the exchange rate adjusts quickly through the uncovered interest rate parity. If the exchange rate does not adjust immediately and the shock of the BoE rate is large enough to move down the gold reserves of the domestic country, 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 the second 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: Sterilization

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.

As long as the central bank is committed to convertibility (unconditional and immediate conversion of bank notes into gold), the exchange rate should be quick to come back to mint parity because of gold outflows or foreign exchange intervention. This is reinforced if investors themselves expect the exchange rate to come back to mint parity, and if uncovered interest rates parity holds (Bordo and MacDonald 2005). Sterilization does not prevent the global functioning of the Gold Standard either, i.e gold flows playing a strong stabilizing role on the exchange rate.[6]

Scenario 3: Imperfect convertibility

We expect the impact of an increase on the BoE rate on the exchange-rate to be larger only in cases of imperfect convertibility (restrictions on convertibility between notes and gold at the central bank). Restrictions on gold convertibility 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 the effect of gold outflows on the aggregate money supply.

[6] To understand this point let's assume that an investor wants to invests its French franc (Ff.) on bills. If the interest spread with London is negative, she prefers to invest in English bills. However, the success of such operation declines as the Ff. depreciates along with arbitrage activities (the uncovered interest rate parity holds). Because the mint parity is fixed, investors may find profitable to change their Ff. into gold and change gold into £ to invest in England. Therefore, as the exchange rate approach the gold point, it becomes more lucrative to send gold into London despite gold transportation cost. As explained in Morys (2013), gold point violation was not infrequent over the considered period. In other words, as the gold point threshold is reached, investors convert their Ff. into gold, transport gold to London, and convert gold into £ to buy English bills. As gold inflows into England, the £ depreciates while the supply of money increases and the London open market rate declines. This ultimately leads the BoE to bring the discount rate back to its previous value (Jeanne, 1995).

Scenario 4: Countries off gold

A fourth scenario is concerned with countries on a floating exchange-rate. If these countries have an open capital account – which was the norm during this period – 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.

Methods of estimation

We study the reaction of central banks' balance sheets, exchange rates and interest rates to an exogenous increase in the Bank of England (BoE) rate. Our identification strategy allows us to study simultaneously 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 autonomy (sterilization, foreign exchange interventions, floating exchange rates or imperfect convertibility).

Following a now well-established literature on the effects of monetary policy shocks (Ramey 2016, Jordà, Schularick & Taylor 2019), we look at the effect of a shock on the BoE interest rate based on local projections (Jordà, 2005). This method allows estimating impulse-responses (IR) directly from an exogenous shock without relying on a predefined model. By contrast with VAR methodology, the IR is not based on the assumption that the true model has been estimated. Local projections are particularly well suited for panel data since it is straightforward to include country-fixed effects in the estimations of the impulse response functions.

Let K be the dimension of the vector of macroeconomic aggregates of interest. M is the number of countries, T is the time dimension, and H the time horizon for which we want to measure the response to a shock. Let $y_{i,t+h}^{k}$ be the value of variable $k = 1, \dots, K$ observed for a country $i = 1, \dots, M$, for which we measure the response to a shock on the Bank of England rate in horizon $0 \leq h \leq H$. Lastly, let $Y_{i,t}$ denote the vector of $y_{i,t}^{k}$ variables.

If r_t^{BoE} is the Bank of England discount rate, the impulse response to a shock (δ) on r_t^{BoE} is measured as:

$$IR\left(y_{i,t+h}^{k}, \delta\right) = E_{it}\left(y_{i,t+h}^{k} | \delta = 1; Y_{i,t}, Y_{i,t-1}, \dots\right) - E_{it}\left(y_{i,t+h}^{k} | \delta = 0; Y_{i,t}, Y_{i,t-1}, \dots\right)$$

A shock $\delta = 1$ means that r_t^{BoE} increases by 100 basis points.

The local projections consists in measuring $IR\left(y_{i,t+h}^{k}, \delta\right)$ based on a sequence of predictive fixed effects panel regressions of the variable of interest on an exogenous shock to horizon h:

$$y_{i,t+h}^{k} = \alpha_i + \Phi_h(L)Y_{t-1} + \beta_h \Delta r_t^{BoE} + \varepsilon_{h,it} \text{ for } h = 0, 1, 2, \dots, H$$

where $\Phi_h(L)$ is the polynomial set of lag operator (which is set at 3 in our analysis), Δr_t^{BoE} the unanticipated change in the Bank of England discount rate, α_i the country fixed effects, and $\varepsilon_{h,it}$ the residual. The IR is the set of estimated $\widehat{\beta_h}$ from $h = 0$ to $h = H$. There are as many sequences as there are variables of interest.

Starting with h = 0 rather than h= 1 is a timing restriction, implying that domestic macroeconomic variables can respond immediately to a change in the interest rate of the BoE.[7] This timing restriction is consistent with our assumption that this particular variable is exogenous to economic variables in other countries, and with the empirical observation in our data set that central banks moved their own discount rate typically a few days after the BoE changed its rate (for a similar observations cf. Lindert 1969).

Local projection offers numerous advantages. First, the non-parametric feature is particularly effective in panel data analysis since the set of endogenous variables that should be included in the predefined model explodes along with the number of countries. For that reason, the chance to rely on the true model before simulating the shock gets smaller. Second, because it estimates rather than simulates the effect of a shock, a local projection does not have to define a set of endogenous variables. Thus, each IR can be estimated independently using the right set of control variables. However, local projection may also come at some costs. First, observations from the end of sample are lost as h increases. Second, as shown in Ramey (2012) and Ramey and Zubairy (2018), short run analysis should be given priority due to erratic and oscillating responses as the horizon gets large. Because our analysis is mostly based on short-run (monthly) adjustment, we do not see this as a fundamental issue.

[7] See Barnichon and Brownlees (2018) on timing restrictions in local projections and a comparison with recursive structural identification in VARs. An alternative assumption (starting at h=1) will not modify our main conclusions about sterilization but it lowers the effect of the shock on the domestic central bank interest rate (since, in fact, central banks that moved their rate followed the BoE few days or weeks afterwards, usually within a month).

Data and group of countries

Sources

Our dataset is based on an exceptional source that has never been exploited before. The French central bank (Bank of 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. 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.[8] On the contrary, the Bank of France took on this difficult and tedious task. Sufficient skills were needed to translate and understand the various reports.[9] We use the original sources available in the archives of the Bank of France. We use monthly data to obtain comparable frequencies between central banks.[10] In addition, we looked at the annual balance sheets, also prepared by the Bank of France, and based on the annual reports of central banks.[11] The annual balance sheets allow us to see if some balance sheet items were missing from 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).[12]

---

[8] 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).

[9] A unit was created in 1884 for this purpose within the Banque. 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. Later, in the mid-1890s, it became a real research department, broadening the scope of its studies. The 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 International des banques d'émission: Autriche-Hongrie, Belgique, Pays-Bas, Suède, Norvège, Espagne,* Direzione Generale Della Statistica, Rome, Imprimerie Héritiers Botta. During this period, only the Bank of England, the Banque de France and the Reichsbank had a research department (Martin-Acena & Tortella 2013) but we found no evidence of similar work in the other two central banks.

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

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

[12] 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.

Data

(see appendix for a more detailed presentation and summary statistics)

Following Bloomfield (1959) the analysis of central banks' sterilization 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 paper (bills of exchange drawn on foreign places); (3) funds held abroad (typically held by so-called foreign correspondents); (4) discount portfolio of domestic papers; (5) short term advances on securities and other collateral. (1), (2), and (3) constitutes the *international portfolio* while (4) and (5) capture the *domestic portfolio*. Details about all five series are available in the data appendix.

Our dataset includes 21 central banks, encompassing all central banks in the world during the period 1891-1913 (the Swiss National Bank was created only in 1908 and the U.S. Federal Reserve in 1913). As Italy had three separate central banks (Bank of Italy, Bank of Naples and Bank of Sicily), we have a panel data set of 19 countries with a central bank. In the next section, we will add one country without a central bank (U.S.) to this dataset, for the purpose of comparison. Series of discount rates of these central banks are also available in our original source (and compiled in Roulleau 1913). We gathered monthly series of exchange rates on London from various sources, mostly from Schneider et al. (1991, 1994, 1999). We use exchange rates as deviation from the mint parity (that is the official exchange rate between gold and domestic currency). Mint parities were also available in our original source in the archives of the Bank of France. Countries off the gold standard also have a mint parity, but central banks in these countries had no commitment to redeem notes in gold at such a price. Some of our discount rate and exchange rate series were already used in Morys (2013). All data are end of the month values.

For all countries except Japan, the monthly balance sheet of the central bank is available starting the early 1890s; usually as soon as January 1891. Data on Japan starts in 1899, one year after the country entered the gold standard. For a significant number of countries, we have data on their central bank both before and after they joined the gold standard (cf. below and Table 1).

Groups of countries

Section 2 presented four theoretical scenarios, each one describing a different central bank reaction to an increase in the discount rate of the Bank of England. There is no reason to believe that the 21 central banks in our sample behave in the same way, particularly because they did not all have the same exchange rate regime and level of financial integration. For this reason, we look at different group of countries – defined in a way that is consistent with the historical context and the

subsequent literature on the gold standard – and we will discuss how close they were from the theoretical predictions of section 2.

We distinguish three groups of countries with a central bank: (1) core countries on the gold standard, (2) peripheral countries on the gold standard, (3) countries with a floating exchange-rate (fiat standard). Gold standard adherence is defined broadly, i.e., either by *de jure* adherence to gold (immediate and unlimited convertibility of bank notes into gold) or *de facto* adherence (maintaining the exchange-rate within a +/- 2% band to *de jure* gold standard countries, Obstfeld et al. 2005). This is in line with widespread practice for research into Classical Gold Standard, leading to essentially the same classification by different authors in the recent literature (Flandreau and Zumer 2004, Mitchener and Weidenmier 2015, Morys 2016). The distinction between groups (1) and (2) hinges upon the definition of core versus periphery. This dichotomy is often used in the literature, but rarely defined based on rigorous foundations. In the context of our research question, any definition should capture the position in the international economy and, in particular, in the international financial system. Liquidity in the foreign exchange market, for instance, provides evidence of the ability to attract short-term capital. Similarly, core countries are likely to have more liquid money markets. A third indicator might relate to the ability to attract long-term capital: raising long-term capital is more difficult for countries suffering from original sin than for those able to access global capital markets in domestic currency.

Five countries fulfil all three criteria: England, France, Germany, Belgium and the Netherlands. Based on an econometric analysis of foreign exchange-market liquidity, Flandreau and Jobst (2005, p. 996) classify all five as "key countries" of the international monetary system between 1890 and 1910. They also possessed highly liquid domestic money markets, as evidenced by the statistical material and accompanying data description collected by the Reichsbank at the time (Reichsbank 1925, p. 212-231). Last but not least, Bordo and Flandreau (2003, p. 439) show that all of them were in a position to issue debt abroad in their own currency.

By contrast, the three criteria advanced above point to different conclusions for Austria-Hungary, Denmark, Italy and Russia. Thanks to its uninterrupted adherence to the gold standard, Denmark was the only country of the four to issue debt in its own currency throughout the Classical Gold Standard period (Bordo and Flandreau 2003, p. 439). Yet the country was small and possessed neither a fluid foreign exchange market nor a liquid money market. The cases of Austria-Hungary, Italy and Russia are the opposite. They had to insert gold clauses into their bonds to issue them abroad (Morys 2006, Tattara 2003); yet they had either liquid foreign exchange markets (Italy, cf. Flandreau&Jobst 2005, p. 996), money markets (Russia, cf. Reichsbank 1925, pp. 212-231) or both (Austria-Hungary, ibid. and Jobst 2009). Faced with conflicting evidence, we decided to classify a

country as core only if the country fulfilled at least two of our three criteria. This was only the case for Austria-Hungary.

All other countries in our sample do not fulfil any of the three criteria and are hence classified as periphery. Note that none of the empirical conclusions presented in the next section are modified qualitatively if Austria-Hungary is included in the periphery.

Table 1 summarizes our three groups of countries, with details about their date of entry into and exit from the gold standard where relevant.

Table 1
Country groups: Core countries on gold, peripheral countries on gold, fiat standard countries

	Estimation period	
Group 1: Core countries on the gold standard (5 countries)		
Austria-Hungary[1]	01/1896	12/1913
Belgium	01/1891	12/1913
France	01/1891	12/1913
Germany	01/1891	12/1913
Netherlands	01/1891	12/1913
Group 2: Peripheral countries on the gold standard (11 countries)		
Bulgaria	01/1906	09/1912
Denmark	01/1891	12/1913
Finland	01/1891	12/1913
Greece[1]	01/1910	12/1913
Italy[1]	01/1903	09/1911
Japan	01/1899	12/1913
Norway	01/1891	12/1913
Romania[1]	01/1891	11/1912
Russia[1]	01/1897	12/1913
Serbia[1]	07/1909	09/1912
Sweden	01/1891	12/1913
Group 3: Countries on a fiat standard (8 countries)		
Austria-Hungary[2]	01/1891	12/1895
Greece[3]	01/1896	12/1909
Italy[3]	01/1891	12/1902
	10/1911	12/1913
Portugal	01/1895	12/1913
Romania[3]	12/1912	12/1913
Russia[3]	01/1891	12/1896
Serbia[3]	01/1899	06/1909
Spain	01/1892	12/1913

Sources: Gold standard adherence based on de-facto exchange-rate classification proposed by Obstfeld et al. (2005) and exchange-rate sources as described in the main text and the appendix.

Notes: [1] Also in group 3 for other estimation periods. [2] Also in group 3 for other estimation periods. [3] Also in group 2 for other estimation periods.

Estimations and results

Specification and variables

Local projections are easy to estimate with state-dependent variables. We can thus include "Gold Standard" and a "core-periphery" dummy variables to interact with the set of other variables. This allows to estimate the effect of the shock for each group of countries defined in the previous section. As such, our model is the following:

$$
\begin{aligned}
y_{i,t+h}^{k} = \alpha_i \\
+core\ in\ GS_{t-1} \times \left[\Phi_h(L)Y_{t-1} + \beta_{a,h}\Delta r_t^{BoE}\right] \\
+periphery\ in\ GS_{t-1} \times \left[\Phi_h(L)Y_{t-1} + \beta_{b,h}\Delta r_t^{BoE}\right] \\
+floating_{t-1} \times \left[\Phi_h(L)Y_{t-1} + \beta_{c,h}\Delta r_t^{BoE}\right] \\
+\varepsilon_{h,it}
\end{aligned}
$$

$core\ in\ GS$ is a dummy variable equals to 1 if the country belongs to the core and adheres to the Gold Standard at time t, $periphery\ in\ GS$ is a dummy variable equals to 1 if the country belongs to the periphery and adheres to the Gold Standard at time t, $floating$ is a dummy variable equals to 1 if the country's exchange rate is floating. $\beta_{a,h}$, $\beta_{b,h}$, and $\beta_{c,h}$, are picked up from $h = 0$ to $h = H$, to build IRFs for each group. Thus, $\beta_{a,h}$ corresponds to the response of group 1, $\beta_{b,h}$ corresponds to the response of group 2, and $\beta_{c,h}$ corresponds to the response of group 3.

The variables of interest included in our estimations are the following: The BoE discount rate (in percent), the natural logarithm of total international assets, the natural logarithm of total domestic assets, the country-specific central bank discount rate, and the exchange rate deviation from mint parity (with positive values denoting depreciation). The vector of control variables is composed of three lags for each variable of interest. Panel data unit root tests have been performed based on Fisher-type tests and Im-Pesaran-Shin tests. 1 Non-stationarity is rejected in all cases at 1% confidence interval. Each regression includes fixed effects while standard errors are robust to heteroskedasticity and serial correlation due to cluster standard errors---when estimation is in panel---or Newey West estimations---when the estimation is for a single country (the US, in the next section).

In the Figures below, we look at the responses of the following variables to an increase in the discount rate of the Bank of England (BoE) by one percent (100 basis points). Given the aforementioned data manipulations, responses read in all four cases as the percentage change compared to month t= -1 (with positive values in the lower right panel meaning depreciation.[13]).

Core countries: sterilization of gold outflows

Figure 1 shows how core countries reacted to a shock on the BoE discount rate. They increased their interest rate only by a small magnitude: 28 basis points after a shock of 100 basis points. Put differently, the interest rate pass through is much lower than unity and amounts to approximately 28% (for a similar finding from a different estimation perspective cf. Shambaugh et al. 2005 and Morys 2013). This imperfect pass-through allows for arbitrage in international markets. The exchange-rate depreciation is noticeable (+0.12%, with positive values denominating depreciations), but remains within the gold points and is smaller, as well as of shorter duration, than in peripheral countries (see Figure 2).

What were the balance sheet effects? As core countries offered unconditional and unlimited convertibility, the international portfolio declines quickly and substantially: 1.8% after one month.[14] Yet core countries dilute the impact of this reserve drain by expanding domestic credit. This is exactly what Nurkse and Bloomfield called "neutralization" (sterilization). The reaction of the domestic portfolio is more than three times larger than the reaction of the international portfolio, namely 6.2% after one month (a factor consistent with the result of Bazot et al. 2016 on France). It was necessary to increase the domestic portfolio by more than the decline of the international portfolio, given that foreign assets exiting the vaults of the central bank were not the integral part of capital outflows. This expansion of lending to the domestic economy responded to the demand of domestic banks at the central bank discount window. Thus a reaction of such magnitude was necessary to keep the domestic money market rate below the official discount rate of the central bank. 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 could.

[13] A mint parity is proposed by the BdF source even if a country did not adhere to the Gold Standard. However, because the constraints of the Gold Standard were not binding for those countries, it might be more consistent to use the percentage variation in the exchange rate value in lieu of the deviation from mint parity. The results and conclusions remain the same with such alternative measure (not reproduced here).

[14] Convertibility was however not perfect, even in these countries. France used gold devices until 1900 and Austria-Hungary always maintained restrictions on gold convertibility.

Adjustment operates quickly, with the central banks' balance sheet response becoming statistically insignificant after three to four months. This short-term adjustment is consistent with the high level of financial integration that characterized the gold standard era. It also means that we would not be able to capture adequately the role of central banks as shock absorbers if we worked with quarterly or annual data.

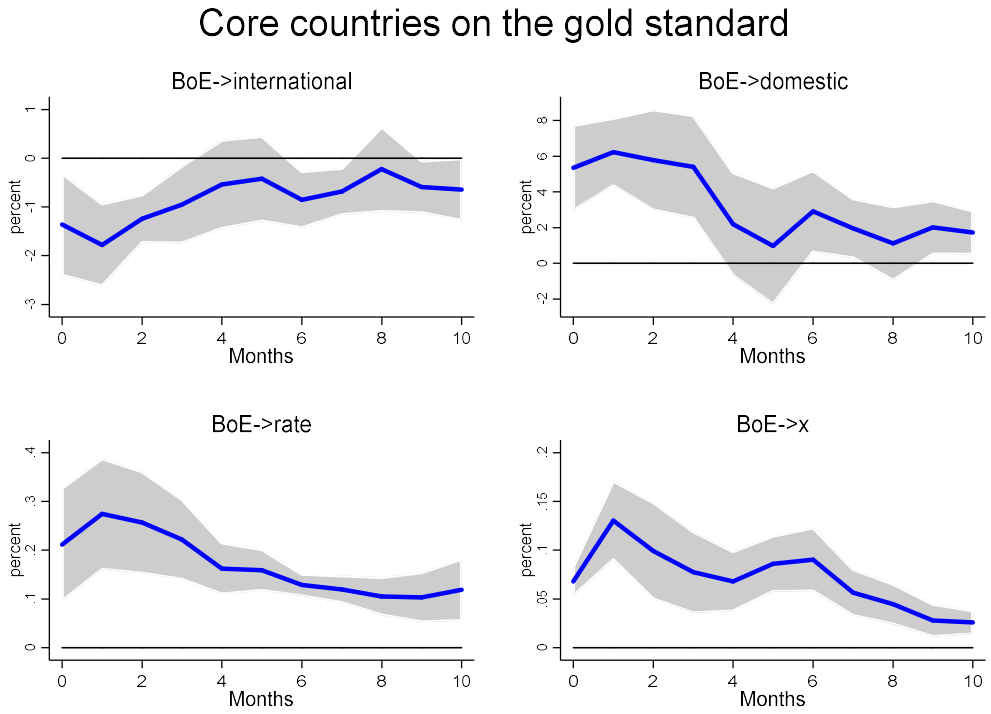

Figure 1. **The reaction of central banks in gold standard core countries to an English discount rate shock of 100 basis points in the first ten months.**

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

Units: Percentage change compared to month t = -1 (positive exchange-rate response in lower right panel indicates depreciation).

The gold standard periphery: imperfect convertibility

Countries on the gold standard periphery react fundamentally different to core countries along all four dimenstions, yet the most striking difference relates to the absence of immediate reaction in the international portfolio in the periphery. For the first four months, results are not statistically different from zero at the 5%-level. This quantitative finding confirms the qualitative statement of

Martin-Acena et al. (2012) on the absence of gold convertibility on the periphery, which – to the best of our knowledge – has never been assessed econometrically.

Not surprisingly, this is accompanied by a sharper and longer reaction of the exchange rate. The exchange-rate on the periphery declines not only by 50% more than in core countries, but it does not bounce back after month 1 but remains instead at depreciated levels for several months.. In other words, imperfect convertibility allows peripheral countries to let the exchange-rate depreciate more strongly than under the scenario of perfect convertibility between gold and domestic currency. Core countries could not afford such depreciation, as gold points were narrow between Europe's financial centres and their commitment to convertibility beyond doubt.[15]

The response of the interest rate and the domestic portfolio reveals differences and similarities to core countries. As in the core countries, the discount rate reacts significantly to the English shock, but smaller (0.16% only after one month, compared to 0.28% for the core) and in a protracted fashion (as opposed to an immediate re-bounce for the core countries). Second, the central bank's domestic portfolio increased, although there was no loss of foreign exchange reserves in the central bank. Therefore, after an increase in international interest rates, the national central bank had to extend credit to the domestic economy in response to the commercial banks' demand at its discount window. This finding means that there was still a transmission of the English interest rate increase to the domestic money market in the periphery, so that it became cheaper to borrow from the central bank than from the private market. Restrictions on gold convertibility could protect the central bank's cover ratio (ratio of reserves to banknotes) and widen the exchange rate range, but they were not sufficient to completely isolate the country from international financial markets (as shown by the fact that the exchange rate fluctuates). Sterilization was still necessary to stabilize the money supply and domestic interest rate, but of a lower order of magnitude than in the core countries.

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 and Weidenmier 2015) – or, vice versa, low credibility forced them to impose restrictions on gold convertibility -, but it did allow them to combine quasi fixed-exchange rates (with larger bands) with a certain level of monetary policy autonomy.

Incidentally, a comparison of all four responses core vs. periphery helps explain why peripheral gold standard countries limited convertibility. Core countries raise their discount rate

[15] In the case of Romania, a typical peripheral country, 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.

fast and sizeably, bringing in foreign funds quickly given high levels of financial integration between Europe's main financial centres. Adjustment was further helped by private agents who deemed the core countries' adherence to gold credible and bought domestic currency when it was "cheap", i.e. depreciated within the gold points (Bordo & McDonald 2005). By contrast, lower levels of financial integration and reduced credibility meant that the discount rate was a less sharp weapon for peripheral countries. The transmission mechanism of monetary policy (i.e a change in the discount rate) was also less likely to be effective, because of the lower development and higher fragmentation of the domestic banking system. This, in turn, created a reliance on – partial or complete – inconvertibility to make the gold standard work in this set of countries. Practice differed between countries (see Bloomfield 1959 and Ford 1989, for a review of gold devices), but immediate and unlimited convertibility remained a characteristic of the core countries until the end of the Classical Gold Standard period (Martin-Acena et al. (2012), Morys (2013, 2014, 2017)).

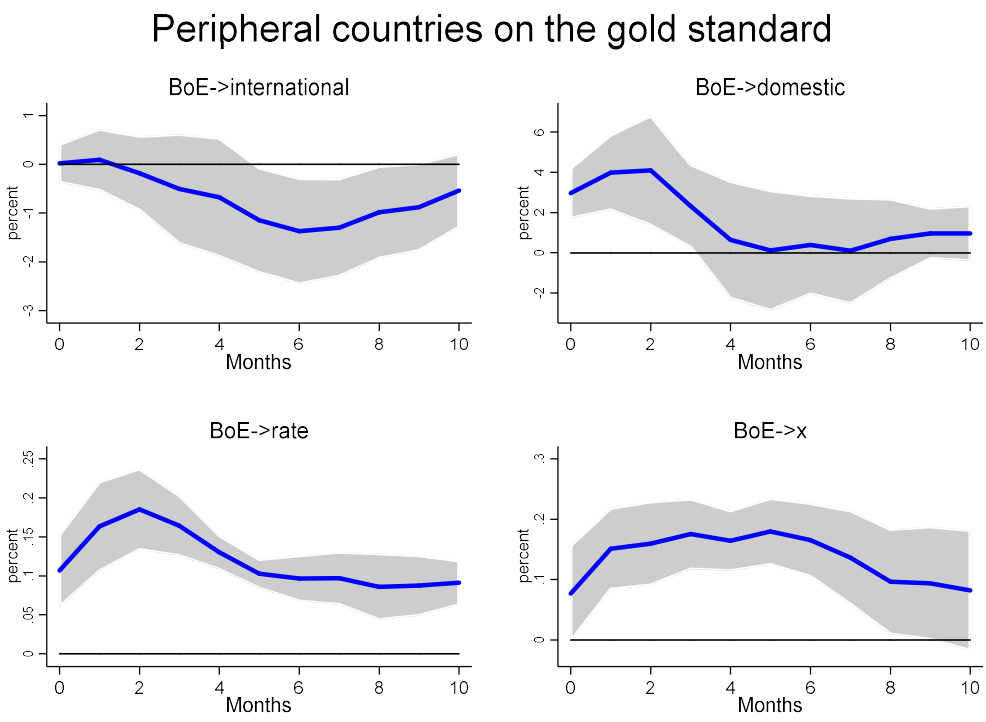

Figure 2. **The reaction of central banks in gold standard peripheral countries to an English discount rate shock of 100 basis points in the first ten months.**

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

Units: Percentage change compared to month t = -1 (positive exchange-rate response in lower right panel indicates depreciation).

Floating

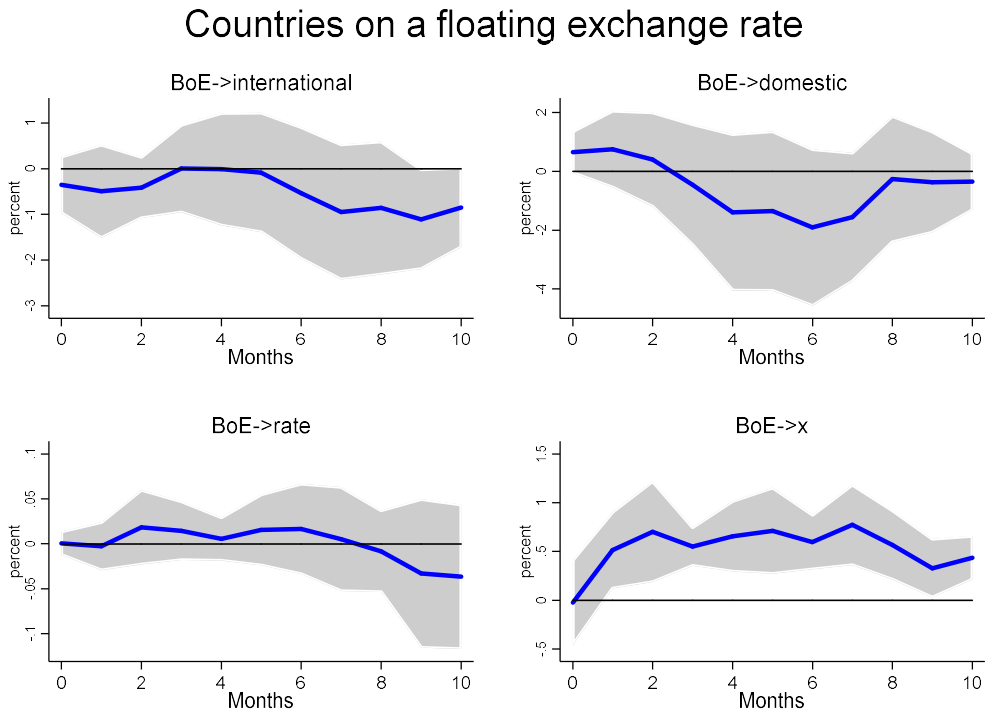

Figure 3. **The reaction of central banks in fiat standard countries to an English discount rate shock of 100 basis points in the first ten months.**

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

Units: Percentage change compared to month t = -1 (positive exchange-rate response in lower right panel indicates depreciation).

In line with the predictions of the trilemma (Obstfeld and Taylor 2004), countries that are not in the gold standard simply float their exchange rates in response to an international shock, as shown in Figure 3. Only the exchange-rate response is statistically significant, but this particular variable reacts much more strongly than in gold standard countries. It falls 0.5% percent in month 1, that is approximately three times as much as in core countries and twice as much as in peripheral countries on gold; and the exchange-rate remains at depreciated levels thereafter. In floating countries, the burden of adjustment is borne entirely by the exchange-rate, so that the central bank exhibits no statistically significant reaction either in its discount rate or on its balance sheet.

The United States of America

The most important country without a central bank during this period was the United States. It was on the gold standard although this system was more contested than in many other countries and political support for bimetallism remained strong until the 1896 US presidential election. A large number of studies have examined what could have happened to the U.S. economy if a central bank had existed there before 1913. There is consensus that a central bank would have smoothed seasonal fluctuations in credit and interest rates and perhaps reduce the frequency of banking crises (Mankiw & Miron 1986, Davis, Hanes & Rhode 2009, Hanes & Rhode 2013, Bordo & Wheelock 2011). However, precise comparisons with central bank operations over the same period remained limited due to the lack of data, and – to our knowledge – no study has investigated how the US money market was dependent on monetary shocks originating in England.

A simple extension of our previous analysis is to compare the reaction of the US economy to that of countries with a central bank. The United States had no central bank, so the Treasury was responsible for backing banknotes in circulation with gold.[16] The Treasury accepted deposits from the state and transferred private deposits between New York and other cities, but it did not lend to domestic banks or non-financial companies. Thus, there is no equivalent to the domestic portfolio of central banks. A more difficult choice concerns the relevant US market interest rate that we should compare with counterparts in countries with a central bank. The leading interest rate of central banks was the discount rate and, because they lent freely at this rate against good commercial paper, the interest rate in the interbank market for commercial paper (such as published in *The Economist*; see Neal and Weidenmier 2003) was always below the discount rate of the central bank. As already discussed by contemporaries (Roulleau 1913), the most relevant rate to compare with European discount rates would be the interest rate on 60-90 day commercial paper in New York. However, the only monthly series that is available for this commercial paper rate (published by Macaulay, 1938, and then on the NBER website) is the average of the minimum and maximum values of the month. Using this monthly average value may smooth considerably the effect of an international financial shock. For this reason, we prefer to use the call money rate in New York. This money market rate was not an interbank rate, but the rate of overnight loans from banks to stock market brokers (see Hanes and Rhode 2013, among others, for more details on this market). Although lower that the commercial paper rate, its fluctuations also reflected changing

[16] The US Treasury also conducted some unfrequent foreign exchange interventions in 1895 and 1906 (Bordo, Humpage and Schwartz 2015, p. 45). Gold held in the Treasury (monthly data) is from the NBER macroeconomic history database series m14137a. Note that the Bank of France also recorded the balance sheet of the US Treasury, together with the balance sheets of foreign central banks. The exchange rate in New York on London is from Neal and Weidenmier (2003); the average between bid and ask prices.

financial conditions in New York. It was the rate published by *The Economist*, together with European interbank interest rates. End of the month values of the call money rate in New York are available from the weekly series of Neal and Weidenmier (2003).

Figure 4 presents the results of local projections with US data, from January 1891 to December 1913. As indicated above, there are only three panels, as there is no equivalent to the domestic portfolio in the absence of a central bank. The only variable reacting in a statistically significant way is the interest rate. Please note that the interest-rate pass-through is much higher than in gold standard countries with a central bank: approximately twice as high as in core countries (0.52% after one month compared to 0.25%) and thrice as high as in peripheral countries (0.52% compared to 0.18%). Put differently, the U.S. is closest to scenario 1 outlined above (playing by the rules of the game), as the domestic portfolio – a key adjustment factor for gold standard countries with a central bank – cannot come to the rescue in the absence of a central bank. This is precisely the "sheltering" function assigned to the central bank by Polanyi in the quotation given at the beginning of this paper. Before the establishment of the Federal Reserve System in 1913, the US monetary system lacked such a "cushion" (Polanyi), and had in turn to rely more strongly on the interest rate. Our finding also supports the claim of the economic historian Alec Ford (1989, p.209) who, based on his knowledge of central bank operations rather than on quantitative evidence, claimed that "In those economies with no central bank, commercial banks could react in a similar way by raising their lending and borrowing interest rates [when confronted with a decline in international reserves] […] Such institutions had less discretion than central banks, and indeed, were more wholehearted followers of the rules of the game."

The quick and sizeable response of the interest rate in the US case also explains why neither the international portfolio nor the exchange-rate react in a statistically significant way: adjustment is borne mostly by the interest rate. This finding is consistent with Officer (1986) who found the exchange-rate adjustment between London and New York in the time period 1890-1908 to be efficient and extraordinarily quick. To be precise: an analysis of weekly data (not reproduced here) demonstrates that both variables respond; yet the effect withers away quickly and no longer shows up in our monthly estimations (as opposed to the interest rate response which remains significant for a full two months).

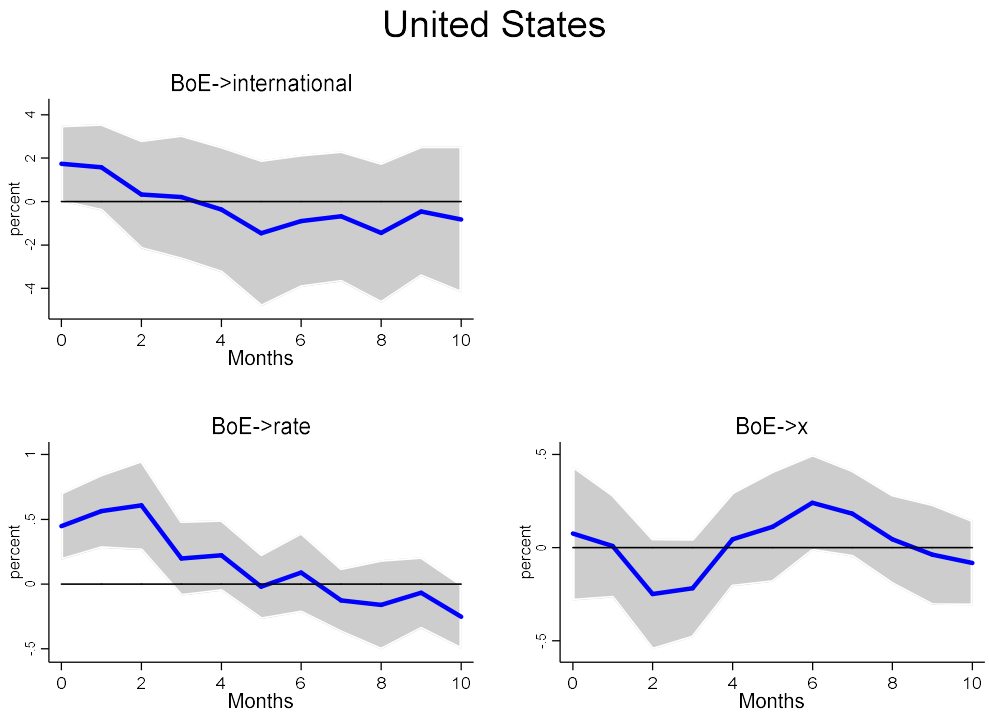

Figure 4. **The reaction of the U.S. monetary system to an English discount rate shock of 100 basis points in the first ten months.**

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

Units: Percentage change compared to month t = -1 (positive exchange-rate response in lower right panel indicates depreciation).

Figure 5 illustrates the difference between a country with a central bank and a country without a central bank from a broader angle. We compare the money market rate in New York with central banks' discount rates and money market rates in the core European countries. In core countries with a central bank, the money market rate is always below the central bank discount rate. This is true if we average the interest rates of all core European countries (Figure 5a) and if we use the maximum value of any of these European interest rates in a given month (Figure 5b). As explained above, this is because any bank can borrow from the central bank with eligible collateral if the central bank's discount rate is lower than the money market rate. Central banks therefore stabilized the money market rate around their discount rate by increasing their lending in response to bank demand at the discount window.[17] Without a central bank, the New York money market rate has a much higher volatility. It is true for the call money rate, as well as the commercial paper interest rate in New York although the later series only reports averages values between minimum and maximum values of the month (Figure 5b). Both the New York call money rate and the commercial paper rate sometimes substantially exceeded the maximum rate found in core European countries (Figure 5b). This fact is due to several factors (notably because of the absence of lender of last resort during US financial crises) and is not only a consequence of the absence of sterilization of the changes in the English rate. Even if the US Treasury used restrictions on gold convertibility, there was no central bank to provide credit and stabilize the money market rate, as it was the case in core and peripheral economies in the gold standard with a central bank.

[17] As explained in Bazot et al. (2016), the money markets for which interest rates are recorded were premium markets. So, many financial institutions did not have access to this market and faced higher interest rates. Therefore, as the market rate increased, these institutions found more profitable to ask for the central bank discount window due to its unique national discount rate. In particular, central bank local branches were used as a privileged access to credit outside large financial centres (Jobst, 2010; Bazot, 2014).

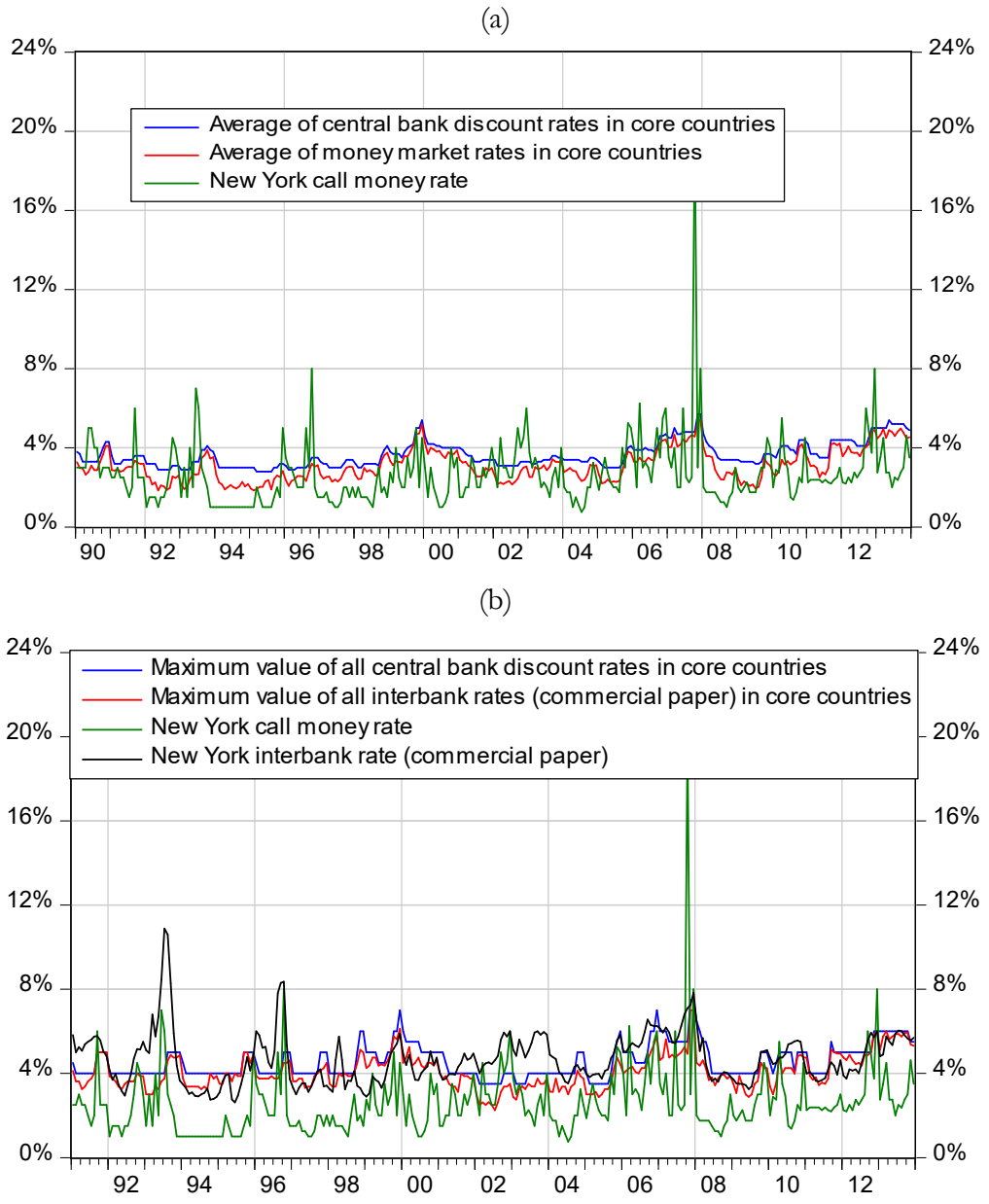

Figure 5:

(a) Comparisons of the call money rate in New York with the average of central bank's discount rates and money market rates in core countries with a central bank (Germany, Belgium, Netherlands, Austria, France; England is excluded). 1890 – 1913. End of the month values.

(b) Comparisons of the call money rate and commercial paper rate in New York with the average of central bank's discount rates and money market rates in core countries with a central bank (Germany, Belgium, Netherlands, Austria, France; England is excluded). 1890 – 1913. End of the month values, except for the commercial paper rate (average between minimum and maximum monthly values).

Sources: Sources as described in the appendix.

Discussion of endogeneity and robustness checks

So far we used the change in the BoE discount rate to estimate central banks reaction to an international shock. For our identification to be reliable, the increase in the English rate should be exogenous to the behaviour of other central banks. Several authors have shown that the BoE was first to move its rate among the other important central banks (Lindert 1969, Eichengreen 1987, Morys 2013, Bazot et al. 2016). A change in the interest rate of the Bank of England was not sufficient to lead to changes in the rates of other central banks. But it was a necessary condition. A recent literature relies on this assumption to identify monetary policy shocks in a number of countries (Jorda, Schularick & Taylor 2015, 2019). These authors call the *trilemma instrument* the identification that, in a fixed exchange rate regime, the interest rate of the leading central bank (England in the case of the classical gold standard) determines exogenously the interest rates of other central banks.

Let us discuss, however, how our results would be affected if the changes in the English discount rate takes place in reaction to changes in English variables (including the Bank of England gold reserves and the exchange rate) that would be correlated with international factors. There are three cases to discuss. First, if the BoE changes its discount rate in reaction to gold outflows, this should coincide with international reserves increase in other central banks balance sheet. This would underestimate the effect of the BoE interest rate shock on the international portfolio of foreign central banks. Second, the same reasoning applies if the BoE reacts to a depreciation of the £ compared to other currencies. Then we would underestimate the depreciation of exchange rates of foreign countries in reaction to a English monetary policy shock. Third, if the BoE increases its discount rate in response to inflationary demand pressures (high output growth), and if there is a common international business cycle, then the positive response of the domestic portfolio of foreign central banks may in fact reflect the positive international business cycle that the BoE is responding to. In this case, we would overestimate the reaction of the domestic portfolio to an English monetary policy shock.

Empirical results presented in the previous sections suggest that those potential endogeneity issues do not significantly affect our results. As a matter of fact, each group of counties react differently to the same BoE shock. It means that there is no systematic bias driving the results towards one unique conclusion. Second, if one assumes that an international business cycle is at work, its frequency was surely not of two or three months only. In our estimations of impulse response functions, the response of the domestic portfolio is a very short-term reaction, taking place within a quarter. We do not see a common mid-term business cycle across countries.

In order to address those issues with econometric robustness checks, we follow Lennard (2018) who build a series of exogenous English monetary shocks during the gold standard period, in the spirit of the narrative approach of Romer and Romer (2004).[18] To build a monetary shock, Lennard proposed to purge the series from the endogenous component of monetary policy changes. As such, the residual of a regression explaining the BoE discount rate by the BoE gold stock change, the wheat price inflation rate, and the exchange rate change with M. and Ff. among other variables is used as a measure of exogenous monetary policy shocks. In other words, the monetary policy shocks series is the deviations of the Bank of England's discount rate from the average response to current macroeconomic conditions. Figures 6 to 9 displays local projections results with monetary shock instead of BoE discount rate variation. We use the same timing restriction as in the previous estimation: the BoE monetary shock affects variable of foreign countries contemporaneously. The results appear very similar to those produced in figure 1 to 4, confirming the lack of endogenous biases affecting our estimations. As a robustness check (results not displayed here), we add English railways receipts into LP estimation, in order to control for the English (potentially international) business cycle. Results remain unchanged.

[18] An alternative – but less comprehensive – solution is to estimate "structural" local projections (Kilian & Kim 2010), that is to recover the shock from a VAR with Cholesky decomposition. When running such estimations, we find similar results as the ones displayed below.

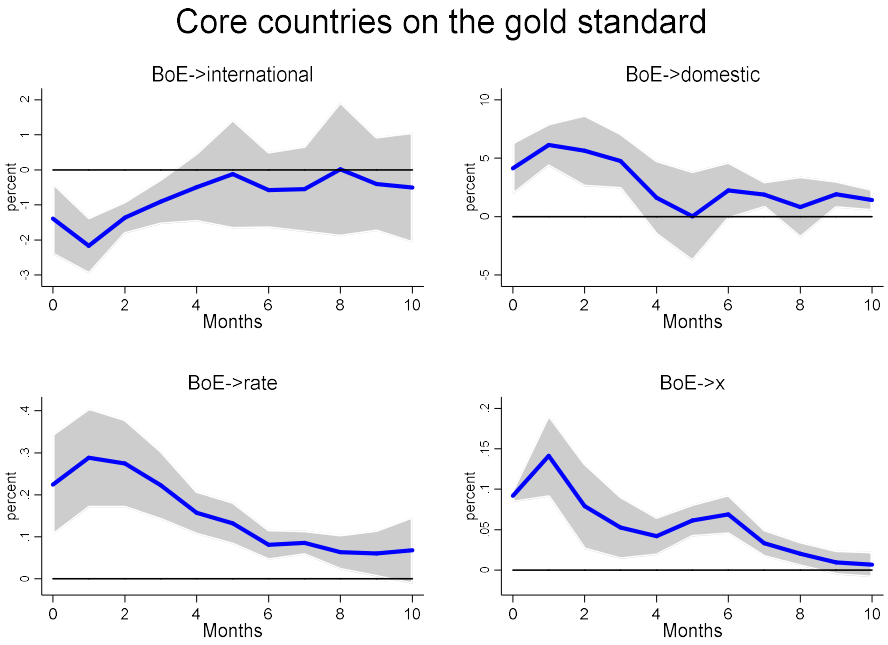

Figure 6. **The reaction of central banks in gold standard core countries to an English discount rate shock of 100 basis points in the first ten months. Alternative measure based on Lennard (2018) as discussed in this section.**

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

Units: Percentage change compared to month t = -1.

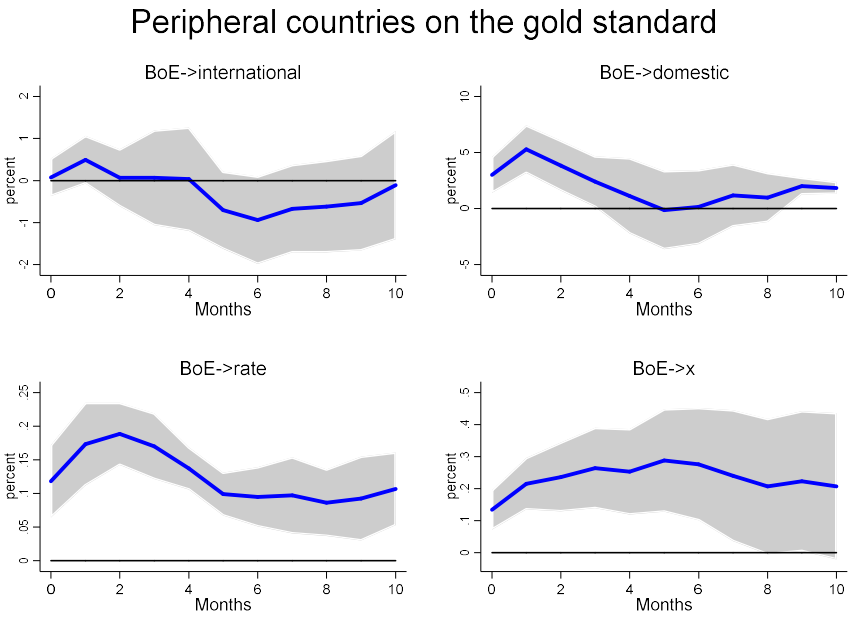

Figure 7. **The reaction of central banks in gold standard peripheral countries to an English discount rate shock of 100 basis points in the first ten months. Alternative measure based on Lennard (2018) as discussed in this section.**

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

Units: Percentage change compared to month t = -1.

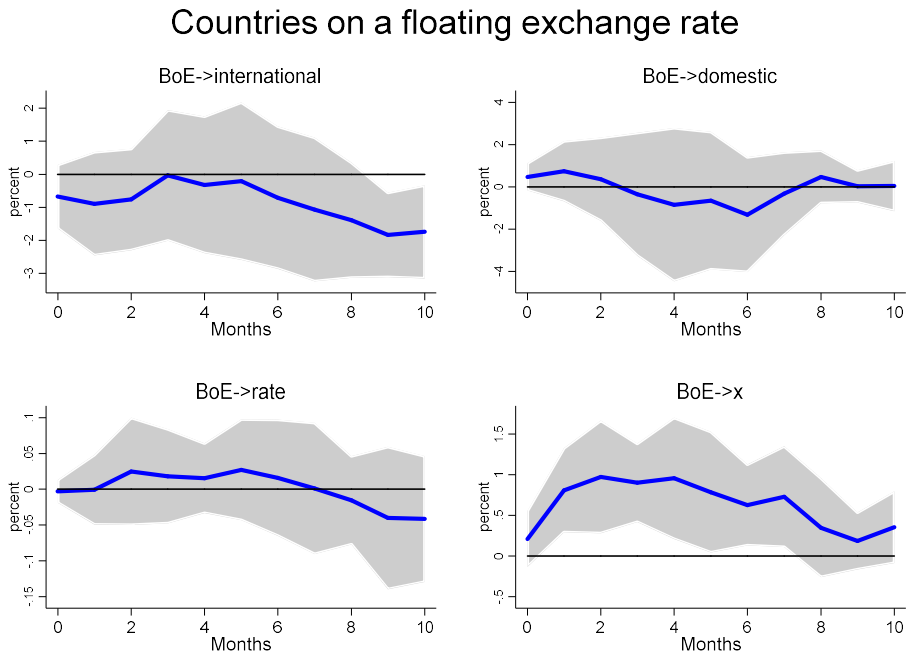

Figure 8. **The reaction of central banks in fiat standard countries to an English discount rate shock of 100 basis points in the first ten months. Alternative measure based on Lennard (2018) as discussed in this section.**

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

Units: Percentage change compared to month t = -1.

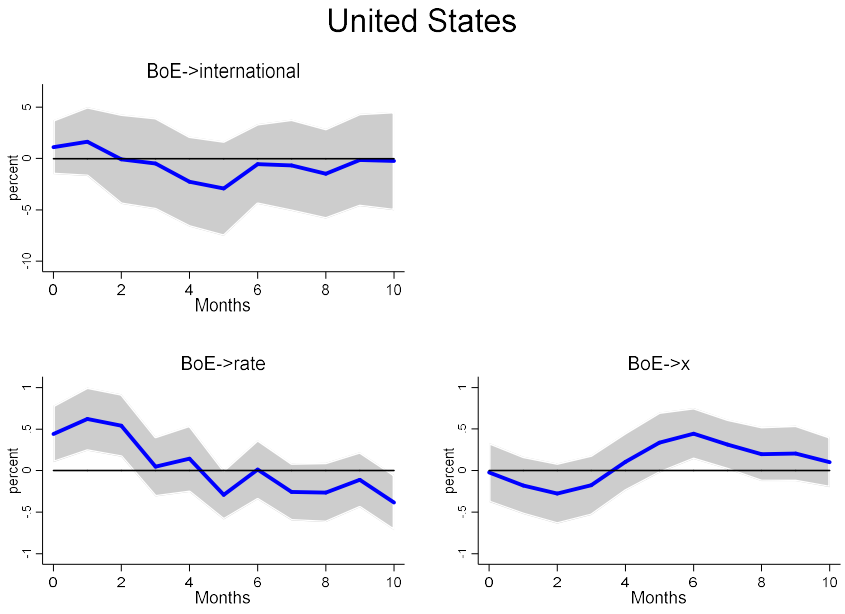

Figure 9. **The reaction of the U.S. monetary system to an English discount rate shock of 100 basis points in the first ten months. Alternative measure based on Lennard (2018) as discussed in this section.**

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

Units: Percentage change compared to month t = -1).

Conclusions

In the first era of financial globalization, before the First World War, most countries chose to link their currencies to gold. The monetary authorities committed to redeem notes in gold. In such a context of full capital mobility and fixed exchange rates, a change in the world's leading interest rate (the Bank of England discount rate, known as the "conductor of the orchestra") should be followed by a similar change in other countries. This article shows that this was not the case. Only one fifth of the variation in the English rate transmitted to foreign countries. Foreign central banks responded to the increase in domestic credit demand and offset the effects of foreign capital flows caused by the gap with the leading international interest rate. In some peripheral countries – the "emerging" markets of the time – the transmission mechanism was less efficient and monetary policy less credible, so capital controls (in the form of restrictions on gold convertibility) were imposed to widen exchange rate bands.

With a new monthly database based on original archival sources, this article is the first to provide detailed quantitative evidence on these mechanisms. These findings add to our understanding of how the gold standard worked in actual practice and supports the view of previous authors that central banks had become, during this period, essential institutions to protect their domestic economies from the vagaries of international financial markets (Polanyi 1944, Bloomfield 1959, Ford 1962, 1989). Our results raise new questions as to whether central banks today, in the second era of globalization, are in a position to fully play this role.

Quarterly, let alone monthly, macroeconomic data are almost non-existent for the Gold Standard period and are mostly confined to Britain. Using such high frequency series over the period 1890-1912, Lennard (2018) found that a one-percentage-point increase in the Bank of England interest rate caused unemployment to rise by 0.9 percentage points, while inflation fell by 3.1 percentage points. If other countries over the same period could experience similar effects of interest rate changes, the central bank's ability to sterilize capital flows and avoid following the English rate was indeed a key function in stabilizing macroeconomic outcomes.

A note of caution is necessary to avoid misinterpretation of our results. We do not claim that countries with a central bank 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). Moreover, the absorption of short-term shocks by central banks described here was very different from the ability to run persistent imbalances (Eichengreen 1992). The latter option was not possible for gold

standard countries: they had to follow tight fiscal rules to remain credible (Bordo and Kydland 1995). The way in which systematic short-term deviation from the "rules of the game" interacted with compliance with fiscal and monetary rules in the medium and long-term should be examined in further research.

References

Aizenman, J., Chinn, M. D., & Ito, H. (2010). The emerging global financial architecture: Tracing and evaluating new patterns of the trilemma configuration. *Journal of international Money and Finance*, *29*(4), 615-641.

Aizenman, J., & Glick, R. (2009). Sterilization, monetary policy, and global financial integration. Review of International Economics, 17(4), 777-801.

Baubeau, P. (2018). The Bank of France's balance sheets database, 1840–1998: an introduction to 158 years of central banking. *Financial History Review*, 25(2), 203-230.

Barnichon, R., & Brownlees, C. (2018). Impulse response estimation by smooth local projections. *Review of Economics and Statistics*, Posted Online November 02, 2018.

Bazot, G., Bordo, M. D., & Monnet, E. (2016). International shocks and the balance sheet of the Bank of France under the classical gold standard. *Explorations in Economic History*, *62*, 87-107.

Bazot, G., Monnet, E., & Morys, M. (2019), The Flexibility of the Classical Gold Standard (1870s-1914). Any Lessons for the Eurozone?, *mimeo*

Bazot, G. (2014). Local liquidity constraints: what place for central bank regional policy? The French experience during the Belle Époque (1880–1913), *Exploration in Economic History*. Vol. 52(C), 44–62.

Blanchard, O., & Adler, G. (2015). Can Foreign Exchange Intervention Stem Exchange Rate Pressures from Global Capital Flow Shocks? (No. w21427). National Bureau of Economic Research.

Bloomfield, A.I, (1959), *Monetary Policy under the International Gold Standard: 1880–1915*. New York: Federal Reserve Bank of New York.

Bloomfield, A. I. (1963). Short-term capital movements under the pre-1914 gold standard (No. 11). International Finance Section, Dept. of Economics, Princeton University.

Bordo, M. D., & Schwartz, A. J. (Eds.). (1984*). A retrospective on the classical gold standard, 1821-1931*. University of Chicago Press.

Bordo, M. D., & Kydland, F. E. (1995). The gold standard as a rule: An essay in exploration. *Explorations in Economic History*, 32(4), 423-464.

Bordo, M. D., & Flandreau, M. (2003). "Core, periphery, exchange rate regimes, and globalization". In *Globalization in historical perspective* (pp. 417-472). University of Chicago Press.

Bordo, M. D., & MacDonald, R. (2005). Interest rate interactions in the classical gold standard, 1880–1914: was there any monetary independence?. *Journal of Monetary Economics*, 52(2), 307-327.

Bordo, M. D., & Wheelock, D. C. (2011). The promise and performance of the Federal Reserve as lender of last resort 1914-1933 (No. w16763). National Bureau of Economic Research.

Bordo, M. D., Humpage, O. F., & Schwartz, A. J. (2015). *Strained Relations: US Foreign-Exchange Operations and Monetary Policy in the Twentieth Century*. University of Chicago Press.

Bruno, V., & Shin, H. S. (2015). Capital flows and the risk-taking channel of monetary policy. *Journal of Monetary Economics*, *71*, 119-132.

Cesarano, F., Cifarelli, G., & Toniolo, G. (2012). Exchange Rate Regimes and Reserve Policy: The Italian Lira, 1883–1911. *Open Economies Review*, 23(2), 253-275.

Conant, C. A. (1915). *A history of modern banks of issue*. GP Putnam's sons.

Contamin, R. (2003). Interdépendances financières et dilemme de politique monétaire. *Revue économique*, *54*(1), 157-179.

Davis, J. H., Hanes, C., & Rhode, P. W. (2009). Harvests and business cycles in nineteenth-century America. *The Quarterly Journal of Economics*, 124(4), 1675-1727

Dutton, J. (1984). The Bank of England and the rules of the game under the international gold standard: new evidence. In *A retrospective on the classical gold standard, 1821-1931* (pp. 173-202). University of Chicago Press.

Drummond, I. M. (1976). The Russian gold standard, 1897–1914. *The Journal of Economic History*, 36(3), 663-688.

Eichengreen, B. (1987). Conducting the international orchestra: Bank of England leadership under the classical gold standard. *Journal of international Money and Finance*, 6(1), 5-29.
Eichengreen, B. (2008). *Globalizing capital: a history of the international monetary system*. Princeton University Press.

Esteves, R. P., Reis, J., & Ferramosca, F. (2009). Market integration in the golden periphery. The Lisbon/London exchange, 1854–1891. *Explorations in Economic History*, *46*(3), 324-345.

Farhi, E., & Werning, I. (2014). Dilemma not trilemma? Capital controls and exchange rates with volatile capital flows. *IMF Economic Review*, *62*(4), 569-605.

Ferguson, N., Schaab, A., & Schularick, M. (2015). *Central Bank Balance Sheets: Expansion and Reduction since 1900* (No. 10635). CEPR Discussion Papers.

Fratianni, M., & Spinelli, F. (1984). Italy in the gold standard period, 1861-1914. In A Retrospective on the Classical Gold Standard, 1821-1931 (pp. 405-454). University of Chicago Press.

Fratzscher, M., Gloede, O., Menkhoff, L., Sarno, L., & Stöhr, T. (2019). When Is Foreign Exchange Intervention Effective? Evidence from 33 Countries. *American Economic Journal: Macroeconomics*, 11(1), 132-56.

Ford, A. G. (1962). *The gold standard, 1880-1914: Britain and Argentina*. Clarendon Press.

Ford, A. (1989). International financial policy and the gold standard, 1870–1914. In P. Mathias & S. Pollard (Eds.), *The Cambridge Economic History of Europe*, volume 8, Cambridge: Cambridge University Press, pp. 197-249.

Hanes, C., & Rhode, P. W. (2013). Harvests and financial crises in gold standard america. *The Journal of Economic History*, *73*(1), 201-246.

Hautcoeur, P. C., Riva, A., & White, E. N. (2014). Floating a "lifeboat": The Banque de France and the crisis of 1889. *Journal of Monetary Economics*, 65, 104-119.

Jonung, L. (1984). Swedish experience under the classical gold standard, 1873-1914. In *A Retrospective on the Classical Gold Standard, 1821-1931* (pp. 361-404). University of Chicago Press.

Jobst, C., (2010). Gouverner une banque centrale décentralisée : l'exemple austro-hongrois (1847–1914). In: Feiertag, O., Margairaz, M. (Eds.), *Gouverner une banque centrale.* Albin Michel, Paris, p. 113-142.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American economic review,* 95(1), 161-182.

Jordà, Ò., Schularick, M., & Taylor, A. M. (2015). Betting the house. *Journal of International Economics,* 96, S2-S18.

Jordà, Ò., Schularick, M., & Taylor, A. M. (2019). The effects of quasi-random monetary experiments. *Journal of Monetary Economics,* Posted online 5 February 2019

Jordà Òscar & Moritz Schularick & Alan M. Taylor & Felix Ward, 2019. "Global Financial Cycles and Risk Premiums," *IMF Economic Review*, vol 67(1), pages 109-150.

Kim, S. (2001). International transmission of US monetary policy shocks: Evidence from VAR's. *Journal of Monetary Economics*, *48*(2), 339-372.

Klein, M. W., & Shambaugh, J. C. (2015). Rounding the corners of the policy trilemma: sources of monetary policy autonomy. *American Economic Journal: Macroeconomics*, *7*(4), 33-66.

Lennard, J. (2018). Did monetary policy matter? Narrative evidence from the classical gold standard. *Explorations in Economic History,* 68, 16-36.

Lévy, R. G. (1911). *Banques d'émission et Trésors publics*. Hachette.

Lindert, P. H. (1969). *Key currencies and gold, 1900-1913* (No. 24). International Finance Section, Princeton University.

Macaulay, F.R. (1938), *The movement of interest rates, bond yields, and stock prices in the U.S. since 1856,* NBER, n°33.

Mankiw, N. G., & Miron, J. A. (1986). The changing behavior of the term structure of interest rates. *The Quarterly Journal of Economics*, 101(2), 211-228.

Martín-Aceña P. and Tortella T. (2013). Regulation and Supervision: The Rise of Central Banks' Research Departments. In Battilossi S. and Reis, J. *State and Financial Systems in Europe and the USA* (pp. 155-164). Routledge.

Martín-Aceña, P., Martínez-Ruiz, E., & Nogues-Marco, P. (2012). Floating against the Tide: Spanish Monetary Policy 1870–1931. In *The Gold Standard Peripheries* (pp. 145-173). Palgrave Macmillan, London.

McGouldrick, P. (1984). Operations of the German Central Bank and the Rules of the Game, 1879-1913. In *A Retrospective on the Classical Gold Standard, 1821-1931* (pp. 311-360). University of Chicago Press.

Miranda-Agrippino, S., & Rey, H. (2018). US monetary policy and the global financial cycle. *NBER working paper*, n°*21722*.

Mitchener, K. J., & Weidenmier, M. D. (2010). Supersanctions and sovereign debt repayment. *Journal of International Money and Finance*, *29*(1), 19-36.

Mitchener, K. J., & Weidenmier, M. D. (2015). Was the classical gold standard credible on the periphery? Evidence from currency risk. *The Journal of Economic History*, 75(2), 479-511.

Morys, M. (2013). Discount rate policy under the Classical Gold Standard: Core versus periphery (1870s–1914). *Explorations in Economic History*, *50*(2), 205-226.

Morys, M. (2014). South-East European Monetary History in a Pan-European Perspective, 1833-1948. In *South-Eastern European Monetary and Economic Statistics from the Nineteenth Century to World War II* (pp. 25-54). Austrian National Bank et al.

Morys, M. (2016). Financial Supervision to Fight Fiscal Dominance? The Gold Standard in Greece and South-East Europe between Economic and Political Objectives and Fiscal Reality, 1841-1939. University of York Discussion Papers in Economics 2016/05.

Morys, M. (2017). A Century of Monetary Reform in South-East Europe: From Political Autonomy to the Gold Standard, 1815-1910. *Financial History Review*, 24(1), 3-21.

Mundell, R. A. (1963). Capital mobility and stabilization policy under fixed and flexible exchange rates. *Canadian Journal of Economics and Political Science*, 29(4), 475-485.

Neal, L. D., & Weidenmier, M. D. (2003). Crises in the global economy from tulips to today. In Globalization in historical perspective (pp. 473-514). University Of Chicago Press.

Obstfeld, M., Shambaugh, J. C., & Taylor, A. M. (2005). The trilemma in history: tradeoffs among exchange rates, monetary policies, and capital mobility. *Review of Economics and Statistics*, *87*(3), 423-438.

Obstfeld, M. (1982). Can We Sterilize? Theory and Evidence. *The American Economic Review*, *72*(2), 45-50.

Obstfeld, M., & Taylor, A. M. (2004). *Global capital markets: integration, crisis, and growth*. Cambridge University Press.

Officer, L. H. (1986). The efficiency of the dollar-sterling gold standard, 1890-1908. *Journal of Political Economy*, 94(5), 1038-1073.

Ögren, A. (2012). Central Banking and Monetary Policy in Sweden during the long nineteenth century. In *The Gold Standard Peripheries* (pp. 17-36). Palgrave Macmillan, London.

Øksendal, L. F. (2012). Freedom for Manoeuvre: The Norwegian Gold Standard Experience, 1874–1914. In *The Gold Standard Peripheries* (pp. 37-57). Palgrave Macmillan, London.

Ouyang, A. Y., Rajan, R. S., & Willett, T. D. (2010). China as a reserve sink: The evidence from offset and sterilization coefficients. Journal of International Money and Finance, 29(5), 951-972.

Polanyi, K. (1944). *The Great Transformation. The Political and Economic Origins of Our Time*.New York. Farrar & Rinehart.

Pippenger, J. (1984). Bank of England operations, 1893-1913. In *A Retrospective on the Classical Gold Standard, 1821-1931* (pp. 203-232). University of Chicago Press.

Ramey, V. A. (2016). Macroeconomic shocks and their propagation. In *Handbook of macroeconomic*s (Vol. 2, pp. 71-162). Elsevier.

Romer, C. and D. Romer (2004). A New Measure of Monetary Shocks: Derivation and Implications. *American Economic Review*, vol. 94(4), 1055-1084.

Reis, J. (2007). An 'art', not a 'science'? Central bank management in Portugal under the gold standard, 1863–87 1. *The Economic History Review*, *60*(4), 712-741.

Reinhart, C. M., & Reinhart, V. R. (2008). Capital inflows and reserve accumulation: the recent evidence (No. w13842). National Bureau of Economic Research.

Rey, H. (2016). International channels of transmission of monetary policy and the Mundellian trilemma. *IMF Economic Review*, *64*(1), 6-35.

Schneider J., O. Schwarzer, F. Zellfelder, (1991), Europäische und nordamerikanische Devisenkurse 1777–1914. 3 vols Steiner, Stuttgart

Schneider J., O. Schwarzer, F. Zellfelder, (1994), Asiatische und australische Devisenkurse, Steiner, Stuttgart.

Schneider J., O. Schwarzer, F. Zellfelder, (1999), Dänische und nordwestdeutsche Wechselkurse, Steiner, Stuttgart.

South-Eastern European Monetary and Economic Statistics from the Nineteenth Century to World War II (2014). Austrian National Bank, Bank of Greece, Bulgarian National Bank and National Bank of Romania.

Sumner, W. G., Macleod, H. D., Horn, A. E., Townsend, J. P., Des Essars, P., Rafalovich, A., & Jensen, A. L. O. (1896). *A History of Banking in All the Leading Nations*, 3 volumes, New York, Journal of commerce and commercial bulletin.

Tunçer, A. C. (2015). Sovereign Debt and International Financial Control: The Middle East and the Balkans, 1870-1914. *Basingstoke: Palgrave Macmillan*.

Triffin, R. (1964). The evolution of the international monetary system: Historical reappraisal and future perspectives. International Finance Section, Department of Economics, Princeton University.

Ugolini, S. (2012). Foreign exchange reserve management in the nineteenth century: the National Bank of Belgium in the 1850s. In *The Gold Standard Peripheries* (pp. 107-129). Palgrave Macmillan, London.

White, H. D. (1933). *French international accounts 1880-1913. (Harvard Economic Studies, Vol. XL).* Harvard University Press, Cambridge.

DATA 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 comparable series across countries. We assembled five major series: (1) metallic reserves (gold plus silver); (2) foreign papers; (3) foreign funds; (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 intellectually 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 may 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 1905-1013 only report "portefeuille commercial" without distinguishing between foreign and domestic) which roughly coincides with the country's de facto adherence to gold (1909-1912).

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 of 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 small 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 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 > > #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) and 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 2017).

Table A1 Summary statistics

	England	Austria	Belgium	Germany	France	Netherlands	Sweden
Share metalic 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	Russia before 1897	Russia after 1896	Romania
Share metalic reserves	0,795	0,6395	0,8831	0,8787	0,888	0,9219	0,9799	0,9014	0,7792
share foreign bills	0,0607	0,0506	0,0749	0,0768	0,0729	0	0	0	0,2208
share foreign funds	0,1443	0,3099	0,042	0,0446	0,0391	0,0781	0,0201	0,0986	0
share discount	0,5528	0,8552	0,8589	0,8731	0,8434	0,5031	0,5096	0,5007	0,6858
share advances	0,4472	0,1448	0,1411	0,1269	0,1566	0,4969	0,4904	0,4993	0,3142
discount rate	4,6667	5,0109	4,596	4,7604	4,4167	5,163	4,6042	5,3603	5,5095

	Greece	Spain	Bulgaria	Portugal	Serbia	Japan	Finland
Share metalic 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