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International shocks and the balance sheet of the Bank of France under the classical gold standard

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ABSTRACT

Under the classical gold standard (1880–1914), the Bank of France maintained a stable discount rate while the Bank of England changed its rate very frequently. Why did the policies of these central banks, the two pillars of the gold standard, differ so much? How did the Bank of France manage to keep a stable rate despite international constraints? This paper tackles these questions and shows that the domestic asset portfolio of the Bank of France played a crucial role in smoothing international shocks and in maintaining the stability of the discount rate. As a result, the French discount rate was only changed in exceptional circumstances, for which a change in the English rate was not a sufficient condition.

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1. Introduction

The textbook account of the classical gold standard emphasizes the crucial role of the "rules of the game" in international adjustments. Two components of the "rules of the game" should be observed in central banks' practices (Whale, 1937; Nurkse, 1944; Bloomfield, 1959). First, central banks should raise their discount rate when their gold reserves decrease. Second, they should not sterilize gold flows; that is, it is unwise to expand (or reduce) domestic assets to offset outflows (or inflows) of gold. Adherence to these "rules" implies that domestic assets of central banks are positively correlated with international assets (e.g. gold) but negatively correlated with the domestic interest rate. It is well known that the Banque de France (BdF henceforth) – one of the main pillars of the classical gold standard along with the Bank of England and the Reichsbank – did not frequently change its discount rate between 1880 and 1913.[1] Regarding the second component of the rules of the game, Emanoil (1932); White (1933), and Bloomfield (1959) claimed – using annual data – that the BdF did not behave as expected: its discount portfolio varied negatively with gold flows between 1880 and 1913.[2]

In this article, we show that keeping the BdF discount rate stable required a negative correlation between domestic and foreign assets. This made it possible for the BdF to maintain a stable rate when the Bank of England (BoE) changed its discount rate. Since the world money and capital markets were centered in London, the BoE's rate pushed other central banks to align their interest rates to the English rate (Eichengreen, 1987). An increase in the English rate pushed the liquidity ratio and gold reserves of the Banque de France down, and pushed the money market rate in Paris up. However, the BdF did not generally increase its discount rate in response to such market pressures. Instead, the domestic portfolio of the BdF (domestic discounts and advances) increased in response to higher demand by banks at the central bank's discount window. As a consequence, the expansion of the domestic assets of the BdF stabilized the spread between the French money market rate and the BdF discount rate, it sterilized the effects of gold flows on the economy, and the BdF discount rate could remain much more stable than the BoE discount rate. Narrative evidence from the minutes of the BdF's board meetings and contemporary writings support the view that the central bank sought to preserve the stability of the French discount rate and that French policymakers were well aware that it

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[1] Gallarotti (1995, p.219) claims that the BdF was the true hegemon of the gold standard as it served as a lender of last resort to England in 1890 and 1906–1907. Between 1880 and 1914, there were only 30 changes in the French official rate of discount versus 194 in the Bank of England's rate. Such a peculiar behavior was the subject of many discussions by contemporaries in France and other countries alike and it has always been treated as a curiosity in the subsequent literature on French monetary policy under the gold standard (White, 1933; Whale, 1937; Bopp, 1952; Nishimura, 1995; Gallarotti, 1995; Contamin, 2003; Rodgers and Payne, 2014). See our discussion in Section 2. It strongly differed from BdF policy under bimetallism when the official discount rate changed frequently (Roulleau, 1914; Bopp, 1952; Flandreau, 2004).

[2] We show in Section 4.1 that this correlation is actually not statistically significant at the annual level. It is observed, however, at the monthly level after an increase in the English interest rate.

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implied sterilization of gold flows. In order to explore these mechanisms and channels, as well as to quantify both their timing and their magnitude, we use a VAR analysis to study the response of French financial and economic variables to an increase in the BoE discount rate. Consistent with previous literature on France under the gold standard, our results emphasize that the BdF used the gold premium (until 1900), the foreign portfolio (after 1906), and, most of all, its large gold stock to avoid following the official discount rate of the BoE. The BdF – unconstrained by a legal reserve ratio – could allow for short-term gold losses in order to keep the discount rate stable. We then show that it nevertheless needed to be supported by the adjustment of the domestic portfolio within the balance sheet of the BdF, since demand for liquidity increased at the discount window. Gold losses and the increase in the domestic portfolio were two sides of the same coin. Both were necessary to stabilize the money market rate and avoid changes in the official discount rate. The previous literature has neglected this key mechanism in favor of focusing on gold and the gold premium, although Pallain (1908) and Emanoil (1932) mentioned it clearly, if briefly. In our VAR estimations, we control for imports, prices, and railway revenues in order to show that a reaction to an international shock (i.e. a change in the BoE rate), not domestic business cycles, indeed caused these adjustments. Moreover, the fact that a decrease in the liquidity ratio occurred immediately after an increase in the BoE rate (and was accompanied by an increase in the BdF domestic portfolio and a decrease in the spread between money market and official discount rates) makes it unlikely that short-term changes in French preferences caused the short-term changes in the liquidity ratio observed in the VAR.

This article also contributes to the literature by accounting for non-linearities in the determination of the official discount rate of the Banque, a point that follows directly from our analysis of the central bank's balance sheet. The balance sheet of the BdF reacted to changes in the English discount rate and international capital flows immediately and systematically while the BdF discount rate was modified very infrequently. As a result of this, the official discount rate of the BdF did not depend linearly on either domestic variables (domestic interest rates, discounts and advances) or international variables (gold flows, exchange rate). However there were a few occasions when the Banque de France did change its discount rate in response to the Bank of England. Looking at the transcripts of BdF policy decisions available in the archives, we show that these interest rate changes required the presence of additional factors, especially undue pressure on the gold stock and on the exchange rate. Previous studies of French central banking based on OLS estimations found that neither exchange rate deviations (Gallarotti, 1995; Morys, 2013) nor the level of the liquidity ratio (Tullio and Wolters, 2003) affected the discount rate. Not surprisingly, these studies concluded that standard reaction functions explain little of the variation of the French discount rate compared to other countries (Gallarotti, 1995; Contamin and Denise, 1999). In the last part of this paper, we propose to account for the prevalence of a "switch" in the policy reaction function of the BdF, using methods (Markov switching estimations) that no scholar has yet applied to the study of central banking under the gold standard. Two cases, or regimes, as the econometric literature terms them, stand out. The first regime allowed for the discount rate to remain stable, whereas the second regime led the BdF to change its discount rate because of exceptional pressure on the gold stock and on the exchange rate. Accounting for the regime switch, we find that the BoE rate, the gold stock, and the deviation of the exchange rate from the gold points in fact determined the BdF's decision to change its discount rate. Thus, we show that, although normally the BdF did not follow the BoE, it did on some occasions when both the state of the gold stock and the exchange rate had deteriorated more than usual.

Multiple economic historians consider the BoE and the BdF to be the two extremes of the spectrum of the monetary regime during the classical gold standard (Whale, 1937; Bloomfield, 1959; Gallarotti, 1995; Reis, 2007). While extensive work has addressed the objectives and interventions of the BoE under the gold standard, this paper focuses on the opposite side of the spectrum.[3] This new perspective adds key dimensions to the traditional view that assumes that central banks' discount rates and gold devices were the most important monetary policy instruments. Focusing solely on interest rates to study domestic policy and international adjustment provides an incomplete picture of central banking under the gold standard.

2. Discount rate stability as a primary objective

The key focus of BdF policy under the gold standard was to keep a stable official discount rate. The contrast between France and England is especially striking, as shown in Fig. 1. Between 1880 and 1913, the French official rate of discount changed only 30 times while the BoE rate changed 194 times and the Reichsbank rate 116 (White, 1933, p.139). The average discount rates of the Bank and the Reichsbank over the period were respectively equal to 3.4% and 4.2% while the Banque rate equaled 3.0%. Although the French official discount rate was on average lower than the British rate, the most striking difference is in the volatility and the number of changes in the discount rate: The standard deviations of the discount rates of the Bank of England, Reichsbank, and Banque de France from 1880 to 1913 are, respectively, 0.99, 0.93, and 0.57.

Policy makers as well as economists both in France and abroad have widely discussed the difference in policies across the Channel, and not in the light of random idiosyncratic economic factors. The BdF never hid the fact that it sought a stable and low discount rate above all else (Neymark, 1884; Nitti, 1898; Liesse, 1910, p.212; Ansiaux, 1910; Roulleau, 1914, and several other references quoted by Patron, 1910, p.27 and Sayers, 1976, p.43–44).[4] Recent works on French central banking in the late nineteenth century inform us about the rationale behind this "mission." In particular, the Banque was a private financial institution with a profit objective: competition with other large commercial banks led the central bank to keep a low and stable discount rate (around 3%) to avoid being crowded out of the market (Baubeau, 2004; Bazot, 2014).[5] In addition, inside influence from the State, merchants, and industrialists incited the BdF to stabilize interest rates in order to avoid volatility and to support their business transactions (Leclercq, 2010).[6] So, in an interview with Senator Aldrich for the US National Monetary Commission, the Governor of the BdF proudly stated:

> The stability and the moderation of the rate of discount are considered as precious advantages, which the French market owes to the organization and traditional conduct of the Bank of France (Pallain, 1908, p.215).

Members of the General Council thought that the objective of a stable discount rate had two implications. First, Governor Pallain explained

[3] Studies of the BoE under the gold standard include Goodhart (1972), Sayers (1976), Dutton (1984), Pippenger (1984), Ogden (1991), Officer (1996), Davatyan and Parke (1995), Jeanne (1995).

[4] White (2007) and Hautcoeur et al. (2014) show that this objective of discount rate stability, together with financial stability, also influenced the policy responses of the BdF during the financial crises of 1882 and 1889.

[5] Using annual and regional data, Bazot (2011, 2014) and Bignon and Jobst (2013) have provided evidence that, despite competition between the BdF and other commercial banks, the provision of credit by the BdF fostered French financial development and could mitigate negative macroeconomic shocks. The perspective of these papers differs from ours as we focus on short-term adjustments (shorter than a year) following changes in international conditions.

[6] Bopp (1952) also noticed that a stable discount rate was the main objective of the BdF since its creation by Napoleon, and that the BdF attempted to turn to a policy of flexible rates only from the 1850s to the early 1870s. Regarding the stability of the discount rate at 4% in the first half of the century, he said "I am unable to give a convincing analysis of how the Bank was able to maintain a fixed rate for such a long period. It is scarcely possible that 4% was the "equilibrium" rate continuously from 1820 until 1847. In principle, however, a discrepancy between the two would have touched off cumulative inflation or deflation. Clearly, a hiatus should have developed between a fixed rate on the one hand and either convertibility or profits on the other. How was the gap filled?" (Bopp, 1952, p.233).

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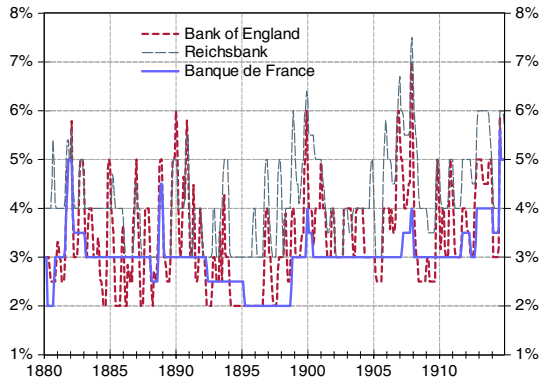

Sources: see Appendix. Monthly data.

Fig. 1. Discount rates of the Banque de France, the Bank of England and the Reichsbank (1880–1914). *Sources:* see Appendix. Monthly data.

in his interview with Senator Aldrich (see also Liesse, 1910, p.212), the BdF had to keep high metallic reserves in order to avoid raising the BdF rate systematically when gold was flowing out of the country:

> It is a principle consecrated by experience that the supreme means of defense for an issue bank, to protect its metallic reserve, is to raise the rate of discount, and we never lose sight of this principle. However, the extent of our reserves allows us to contemplate without emotion important variations of our metallic stock, and we only exceptionally have recourse to a measure which is always painful for commerce and industry (Pallain, 1908, p.215).

Second, as we will show in Section 4, the BdF had to provide liquidity to banks such that the spread between the official BdF discount rate and the money market rate (*taux du marché libre*) did not vary too much.[7]

Supporting Pallain's first claim about the gold stock, the standard explanation for Banque policy under the gold standard states that huge reserves and the absence of a formal reserve ratio allowed the monetary authorities to let gold flow out without having to follow increases in the BoE's discount rate (White, 1933; Bloomfield, 1959; Tullio and Wolters, 2003). Until 1900, the BdF also used gold devices so that an increase in foreign rates had a less adverse effect on the domestic gold stock (White, 1933; Bopp, 1952; Bloomfield, 1959; Gallarotti, 1995; Contamin, 2003). The BdF offered a premium on gold and could increase it when necessary to mitigate the demand for gold. The fact that the Banque could legally redeem its notes in either French gold coin or 5 franc silver coin made the use of a premium on gold possible. Since the silver value of the latter was lower than the nominal value of the coin, the BdF had strong control over gold sales: when the BdF wanted to discourage gold exports, it accepted to redeem its notes in silver only. Banks in need of gold to export could then purchase bullion or foreign gold coins from the BdF only at a premium. The premium on gold sales was used to circumvent the law that prevented the BdF from redeeming notes in gold at a premium.[8] Figs. 1 and 2 provide some evidence for this strategy. Fig. 1 shows a weak correlation between the discount rate of the BdF and the changes in the English and German discount rate. On the contrary, Fig. 2 shows that the gold premium the BdF applied in Paris closely followed the BoE discount rate. The BdF thus preferred to raise the gold premium instead of its discount rate to prevent gold outflows.

3. Effects of the English discount rate on the French gold stock

Addressing a gap in the literature, we focus on the quantitative impact of France's policies with respect to gold devices and gold reserves and assess the extent to which the BdF used its gold stock and gold premium to avoid raising the discount rate in response to international shocks. To do so, we estimate a VAR and simulate the effect of an increase in the BoE discount rate on the balance sheet as well as on the instruments (discount rate and gold premium) of the BdF.[9]

3.1. VAR estimations: specification and identification

A VAR is well suited for our analysis since it accounts for simultaneous relationships between macroeconomic and financial variables. In particular, gold flows and interest rates depended on other economic variables that they also influenced. In addition, we apply a Cholesky (or "recursive") decomposition to solve the VAR model. One variable affects others immediately but there is a lag before they affect the first variable in turn. A shock to this variable in period t is defined as orthogonal to the shocks on other variables during the same period. Studies using VARs usually refer to such a shock as "unsystematic" (Christiano et al., 1999).

The identification of the VAR is particularly relevant for our study since we want to know how French economic variables responded to changes in the discount rate of the BoE.[10] We simulate a shock of one standard deviation increase in the residual of the Bank rate equation. The shock is orthogonal to the current value of the other parameters of the model affecting the BoE rate (including our main variables of interest: the BdF balance sheet and discount rate). Thus we do not define the immediate response of the BoE to a BdF decision as a shock in our model, although such a response may have happened. Studies that identify monetary policy shocks in fixed exchange rate regimes often use this identification procedure. The procedure is straightforward in the case of the gold standard due to the international role of the BoE and the fact that the BoE changed its rate much more often than the BdF over the period. In Section 5, we present narrative evidence that the few changes in the BdF rate actually followed the BoE rate. We also show that no evidence suggests that the BoE looked at the monthly changes in the balance sheet of the BdF when setting its rate.[11]

Formally, our identification procedure means that the international shock, ϵ_t, is defined such that the BoE rate at time t, B_t, is the following function:

$$B_t = f(Y_{t-n}) + \epsilon_t$$

where Y are all variables in the VAR (including past values of the BoE rate):

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_n Y_{t-n} + C\eta_t$$

and C is the contemporaneous impact matrix of the η_t mutually uncorrelated disturbances. Ai and C are (n X n) matrices of coefficients (where n is the number of variables included in the VAR) and Yt-1 and ηi are ($n \times 1$) vectors of n variables. Our identification assumption means that the international shock ϵ_t is the first element of η_t (which is ordered first in the VAR). Thus, an increase in B_t due to an increase

[7] The following document highlights this concern: Archives of the Bank of France (ABF), "Procès-verbal du Conseil Général, séance du 14 Mars 1895".

[8] Based on various sources, White (1933, p.186) also documents two other gold devices the BdF used. It could raise the gold export point by requiring the banks demanding gold for export to discount long-term bills in excess of the amount of gold demanded. It could lower the gold import point by crediting importers of specie from the date of shipment rather than the date of receipt or accepting gold at branches in seaports rather than in Paris in order to decrease shipment costs. Based on our reading of the archives of the BdF, we follow H.D White in saying that no evidence shows frequent use of these devices or that they had major quantitative consequences.

[9] Jeanne (1995) has shown the usefulness of VARs to study English gold flows under the gold standard.

[10] The reverse causality between English and French macroeconomic variables, renders it misleading to compute the impact of the English rate on the French economy by looking at the value of the correlation between them.

[11] This assumption is questionable regarding the total excess of specie imports and the exchange rate, since massive gold flows from France to England may affect the BoE rate. But these variables are not our main variable of interest – contrary to the balance sheet of the BdF – and the conclusions of the paper are similar if the VAR does not include them.

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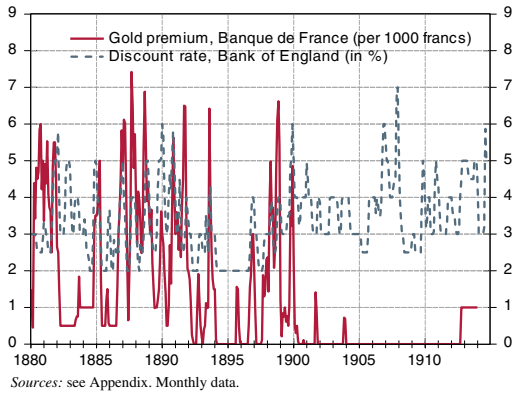

Sources: see Appendix. Monthly data.

Fig. 2. Gold premium in Paris and Bank of England discount rate (1880–1914). *Sources:* see Appendix. Monthly data.

in ϵ_t is a policy decision of the BoE which past French variables do not explain. It is interpreted as a short-term international shock to the French economy. The ordering of the other variables in the VAR does not matter in the following estimations because we only simulate the impact of a shock to the BoE rate.

We use monthly data in order to include a sufficient number of variables in the VAR, to keep the recursive identification relevant and, most of all, to be able to observe short-term adjustments. The variables in the estimation are the BoE discount rate (hereafter "Bank rate"), the exchange rate between London and Paris, the BdF discount rate (hereafter "Banque rate"), and the BdF gold premium in Paris. These variables are supposed to determine gold and money flows. In addition, we include the liquidity ratio (or cover ratio). The gold standard literature uses this ratio since the (formal or informal) objective of the central bank was to maintain a stable proportion between metallic reserves and notes in circulation (Goodhart, 1972; Tullio and Wolters, 2003; Morys, 2013).[12] We define it as *liquidity ratio = (gold stock + silver stock) / notes in circulation*. Last, we include some general indicators of French economic activity. There is no monthly or quarterly series of the French money supply and gold circulation, but we have the excess of specie imports available from trade statistics and published in White (1933).[13] Sicsic (1989) states that the trade statistics of metal imports and exports are not reliable and miss important flows (especially from coins brought by travelers). These flows were certainly too important to propose a reliable estimation of the French outstanding gold circulation, but trade statistics may provide interesting information to estimate the response of gold flows to a change in foreign discount rates. We express this variable, which excludes silver bullion, in millions francs. We also control for the French business cycle. A common practice is to use discounts of commercial paper as a proxy for aggregate demand (Baubeau, 2004). But total French discounts are available only annually, and the discounts of the BdF are a policy variable rather than a simple proxy for business activity, as Section 4 will show. Thus we use monthly imports as a proxy for French aggregate demand (as in Bordo and MacDonald, 2005). However, foreign supply affects this series, which does not fully reflect domestic demand, although we control for the exchange rate in our estimations. In order to check the robustness of our results, we have constructed a new index of French economic activity based on railway revenues available for the whole period (1880–1913).[14] The Appendix describes how we constructed this series and presents the sources of the data. We will show below that using imports or railway revenues does not modify the main results of the estimations and our interpretation of the BdF policy. No monthly or quarterly price index is available for France before 1900. In that year, the economic newspaper *La Réforme économique* started to publish a wholesale price index including only a few commodities. For this reason, we only use the price index (expressed as a growth rate) in the VAR as a robustness check (estimated over 1900–1913). Finally, the VAR has to be estimated with stationary data; hence all series with a unit root (credit, prices, imports, revenues) were differenced, whereas we kept stationary series (interest rates, exchange rate, liquidity ratio, gold premium, spread) in levels.[15]

3.2. The role of gold reserves and the gold premium

We first estimate a VAR with the following set of variables: Bank rate, liquidity ratio (in %), gold premium, Banque rate, exchange rate, difference of the logarithm of imports, and excess of specie imports. The VAR can be estimated over the sample August 1884–December 1913, when we include the excess of specie imports, or over the sample January 1881–December 1913 when it is estimated with the six other variables.[16] Since the results are very similar (see Fig. 4 and Fig. 9 for results with the 1881–1913 sample), we present the estimation here, including the excess of specie imports. The VAR includes two lags of each variable.[17] Fig. 3 shows the response of the variables to a one-standard deviation shock to the discount rate of the BoE. A one-standard deviation shock increases the Bank rate by 0.4 percentage point. Such an increase has strong effects on the BdF liquidity ratio and gold premium. The former falls immediately and is decreased by 1.5 percentage points after four months while the latter increases immediately by 0.3 percentage point (in a rather similar magnitude to the Bank rate, as already observed in Fig. 2).[18] The response of the official discount rate of the BdF is extremely moderate compared to the BoE rate and only weakly significant; this is not surprising since the BdF's rate reacted to the BoE's only 30 times out of 194 (see Section 5 for discussion). Therefore, because the BdF rate barely adjusts to the shock, the franc is immediately depreciated by 0.016 and goes back to its initial value after five months (the central parity was 25.25). The shock does

[12] The Banque de France did not have a formal reserve ratio target but this does not mean that the BdF liked to see gold outflows. In fact, absence of such target could even be worse for the BdF's credibility as this could make its credible commitment uncertain. This is why the BdF frequently used the gold premium before 1900. And, as shown in Section 5 of the paper, the changes in the gold stock explained the infrequent changes in the discount rate of the BdF. The absence of a formal target gave flexibility to the BdF. But as shown in the next section, such flexibility could have been hampered by the increase in the interbank market rate (because of free capital flows). An increase in central bank liquidity was then necessary to offset gold outflows.

[13] Based on a careful study of French trade and gold circulation, H.D White found that "the Bank of France was virtually the sole depository of the specie reserve of all the French banks; specie imported into France went either into vaults of the Bank of France or into hand to hand circulation. Throughout the period under survey specie imports were in excess of specie exports (White, 1933, p. 172)."

[14] Several analyses studying the gold standard in the UK and Germany have used railway revenues as an indicator of economic activity, including Goodhart (1972); Jeanne (1995) and Bordo and MacDonald (2005). Our series of railway revenues shows a strong correlation with annual series of French activity. The correlation coefficient between annual railway revenues and annual GPD is 0.94. The correlation coefficient between annual railway revenues and annual industrial production is 0.85. For imports, these numbers are 0.74 (GDP), 0.84 (Ind. prod.) and 0.82 (Agr. prod.) respectively. The correlation between deflated GDP and industrial (agricultural) production is 0.79 (0.82) only. Annual data is from Saint-Marc (1983).

[15] We present in parenthesis the *P*-values of the Augmented Dickey-Fuller unit root test for the variables of the VAR (the null hypothesis is that the variable has a unit root). Stationary variables: BdF rate (0.00), BoE rate (0.00), exchange rate (0.00), liquidity ratio (0.01), gold premium (0.00), spread (0.00), excess of specie imports (0.00). Non stationary variables: gold stock (0.96 in level; 0.00 in 1st difference), imports (0.99 in level; 0.00 in 1st difference), BdF credit (0.98 in level; 0.00 in 1st difference), price index (0.84 in level; 0.00 in 1st difference), railway revenues (0.76 in level; 0.00 in 1st difference).

[16] The liquidity ratio series starts in November 1880, so the estimation starts in January 1881 because we include two lags in the VAR.

[17] We use two lags following the Hannan-Quinn information criterion. The use of more or less lags does not affect our main conclusion.

[18] In a separate estimation (available on demand), we have checked that the decrease in the liquidity ratio reflects a decrease in gold that the BdF holds. For example, in 1900, from a gold stock of 2000 million francs, 26 million would have flowed out of the BdF four months after a 0.4 percentage points increase in the English rate. In other words, in 1900, the BdF gold stock decreases by 65 million after four months if the BoE raises its discount rate by 1%. This change is not too large precisely due to the influence of the gold device and to the informal objective of avoiding losing too much gold.

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not affect the variation of the logarithm of imports. Finally, as expected, the increasing spread between French and British rates and the depreciation of the Franc coincide with a fall of French excess of specie imports.[19]

Our results confirm previous knowledge about the mechanisms at work during the gold standard and provide a complete quantification of these mechanisms. A rise in the BoE rate depreciates the franc and gold flows out of the vaults of the BdF. This implies that the higher the gold reserves, the less it is necessary to increase the discount rate since gold outflows would finally stabilize the exchange rate. The impulse response functions estimated from the VAR also make clear that the BdF used gold devices rather than its discount rate to mitigate gold exports. Our estimations also offer important conclusions as to the timing of adjustment to international shocks. The total time of the adjustment is robust across specifications and is always shorter than a year. Twelve months after the shock, its effects on the exchange rate, liquidity ratio, and gold premium are all non-significantly different from zero. The persistence of the effect of a monetary shock on the French economy during the gold standard is shorter than the one observed in subsequent periods where the effect could be felt 20 or even 25 months after a shock (Mojon, 1998; Monnet, 2014). Markets and central banks all adjusted very quickly during the gold standard. Consequently, previous studies using annual data could not observe and account for short-term (less than a year) adjustments in response to international shocks (White, 1933; Bloomfield, 1959; Baubeau, 2004).

3.3. Robustness checks: quarterly data and price index

In order to provide evidence of the robustness of our previous results, we now check that they hold with quarterly data when using railway revenues as a proxy for aggregate demand. The quarterly variables used in the VAR are the following: Bank rate, liquidity ratio, gold premium, Banque rate, exchange rate, and the variation of the logarithm of railway revenues. The ordering and transformation of variables are similar to the previous section and we still estimate the VAR with two lags. Fig. 4 shows that the pattern and magnitude of the impulse response functions resemble those observed in Fig. 3.[20] The effect on the liquidity ratio is more persistent, however. Interestingly, the response of railway revenues to the English rate is negligible (lower than −0.002%): it provides further evidence that an increase in the English Bank rate did not have a negative effect on the French business cycle, despite large gold outflows and a fall in the liquidity ratio. Such a conclusion is important, as the absence of short-term effects of foreign monetary policy on domestic activity despite the fixed exchange rate may contribute to explain why the gold standard lasted 35 years without losing public support. Finally, the absence of a price index in the model might also affect our previous findings. We have checked that the results previously described do not change when we use the monthly price index (available after 1900) in the estimations. The absence of a role for prices is consistent with the principles of the gold standard, according to which the difference of price levels between countries remained fixed and inflation was low and stable.

3.4. From gold devices to the foreign assets portfolio

In 1900, gold reserves of the Banque de France were high enough to stop using the controversial gold premium. In fact, members of the General Council, including its most prominent member, the Baron Alphonse de Rothschild, emphasized the perverse effect of the gold premium as equivalent to capital controls (Contamin, 2003). One of the consequences of the end of gold devices at the turn of the century was the development of infrequent BdF interventions in foreign markets, though they had already been used several times in the previous decades during financial crises (Bloomfield, 1959, p.56; Flandreau, 1997; Bordo and Schwartz, 1999; Rodgers and Payne, 2014). As Governor Magnin explained in 1890, the rationale of the policy was straightforward:

> *We avoided the threat of a monetary crisis in England, which would have affected the French market and thereby obliged the Banque de France to increase its discount rate.* (*quoted in* Ramon, 1932, p.400).[21]

Beginning in 1906, the BdF started to officially manage a portfolio of foreign assets for this purpose. Exceptional interventions on the foreign markets (mainly on the London market) became more common from this date (Gallarotti, 1995, p.80–85, 130–131, 140; Contamin, 2003). They followed increases in the BoE discount rate, usually with a one month lag (Fig. 5). This portfolio was notably used during the US financial crisis of 1907 (Rodgers and Payne, 2014). Because the discount portfolio was not used before 1906, it has not been included in previous VAR estimations.[22] We argue that the role of the foreign portfolio to stabilize foreign market rates – and then the domestic discount rate – is better understood if we know how the BdF used its domestic portfolio to stabilize the domestic rate.[23] Surprisingly, these domestic operations and their effects, although at the core of the operations of the BdF, have received very little attention in previous studies (and much less than the international portfolio). The next section attempts to fill this gap.

4. How the Banque de France sterilized gold outflows

The consequences of the stable discount rate policy of the BdF on its provision of credit to the French economy can be viewed in Fig. 6, which displays the BdF domestic asset portfolio (discounts and advances) and the BoE discount rate. Although the correlation between these two variables is not perfect since demand for BdF discounts also had domestic causes, it is noteworthy that all the increases in the BoE rate correlate with an increase in the domestic asset portfolio of the BdF. The next section investigates the causes and meaning of this correlation.

4.1. The link between international reserves and domestic assets

Since an increase in the English rate drained gold out of the BdF, Fig. 6 is consistent with an overall negative co-movement between domestic and international assets, as observed by Emanoil (1932) and White (1933, p.198), and interpreted by Bloomfield (1959) as a "violation of the rules of the game." Such a negative co-movement was actually well known at the BdF since Governor Pallain replied to Senator Aldrich in the following way:

> Aldrich: Does the export of gold reduce the volume of notes?Pallain: Not necessarily. It may happen that among our assets a certain fraction of the gold is replaced by an equal amount of bills in our

[19] Note that the depreciation of the franc may contribute to a gold outflow since it causes the exchange rate to cross the gold point in the short run. Excess of specie imports are not in logarithms in the VAR but in millions (because they can take negative values). Thus, the reaction function of this variable in Fig. 3 is not cumulative.

[20] To save degrees of freedom, we do not include the excess of specie imports. Thus, the estimation starts in 1881. Results are similar with the excess of specie imports (as in Fig. 8). The choice of two lags is based on the Hannan – Quinn criterion.

[21] Quote translated from French by the authors. This 1890 operation was actually initiated and mostly organized by the Baron Alphonse de Rothschild. He played the intermediary and managed to convince the Conseil Général that cooperation was needed (ABF, Procès-verbal du Comité des Livres et Portefeuilles, 10 November 1890).

[22] The foreign portfolio responds positively but insignificantly to an increase in the BoE discount rate (the fact that the discount portfolio is set to zero until 1906 obviously biases significance).

[23] In addition to the reference quoted above, Flandreau and Gallice (2007) highlighted the impact of this policy from the perspective of a private bank: there was a "negative correlation existing from 1906 to 1913 between variations in the Paribas portfolio of bills and the portfolio of the BdF: when Paribas sold, the BdF bought. … Thus, paradoxically, the variations in the French bank of issue's bills stock were much more consistent with British interest rate changes than were those in our private bank's bills portfolio" (p.99). Section 4 shows that the paradox Flandreau and Gallice identified about the portfolio of foreign assets provides a good characterization of the BdF portfolio of domestic assets during the whole period.

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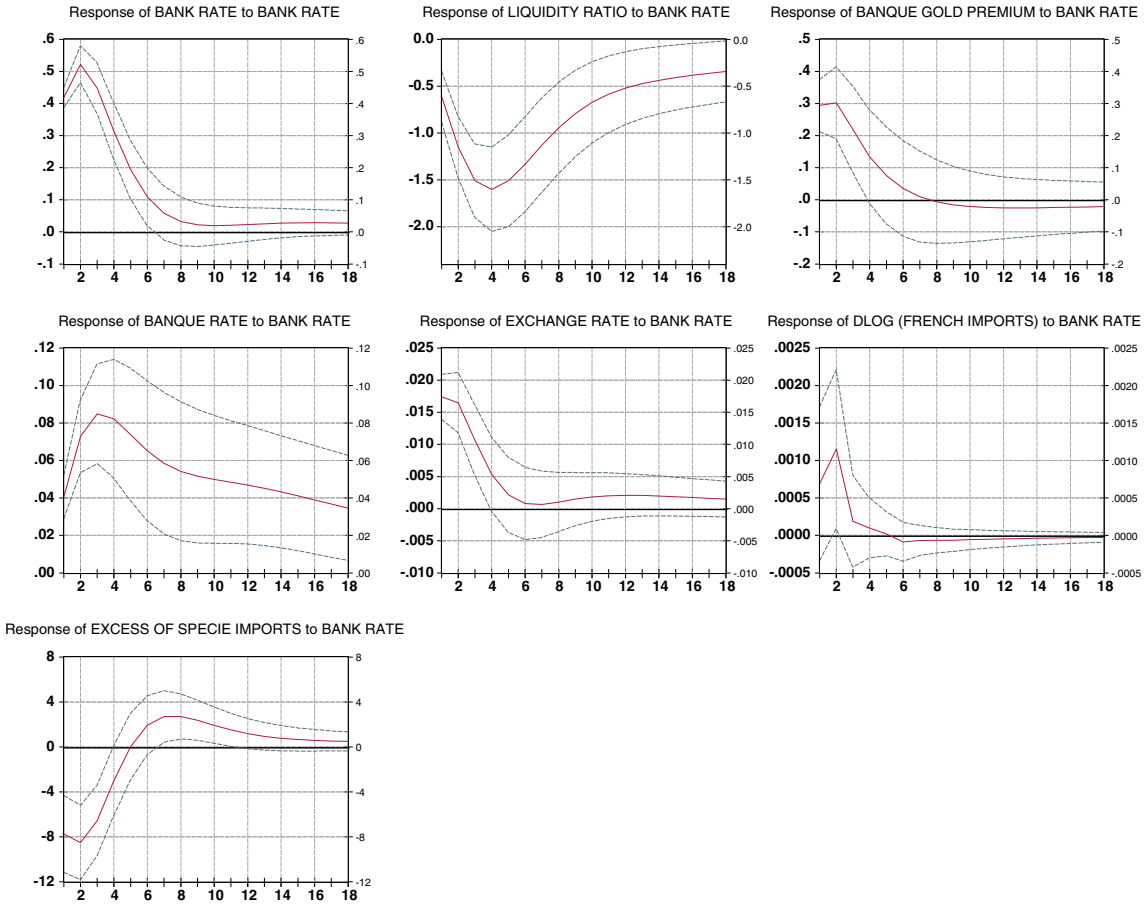

Fig. 3. Response to a shock in the Bank of England discount rate (monthly data). *Notes:* the impulse response functions are based on OLS-VAR results using a Cholesky decomposition where variables are set in the following order: 1) Bank of England discount rate 2) liquidity ratio 3) Gold premium 4) Banque de France discount rate 5) £/F exchange rate 6) 1st difference of the log of imports 7) excess of specie imports. Two lags of each variable are included in the VAR. Estimation sample: August 1884–December 1913. X-axis displays months after the shock. The shock occurs in period 1. Dotted lines denote two standard error bands. *Sources:* see Appendix.

> portfolio, and that without changing the total of notes in circulation. (Pallain, 1908, p.212)

However, the negative correlation between domestic and international assets is not obvious in the data. According to White (1933) and Bloomfield (1959), it was mostly visible at an annual frequency. We find, however, that the correlation is in fact not statistically significant with annual data. With monthly data, the correlation between the logarithms of central bank credit and of the gold stock is even significantly positive (0.053). The correlation between the percentage changes of these two variables – still with monthly data – is also non-significant. Hence, previous studies which have documented a negative co-movement relied on very limited evidence based on simple graphs.

Moreover, Bloomfield's view that this negative correlation reflects "violations of the rule of the game" has not remained unchallenged. As the proponents of the monetary theory of the balance of payments have suggested, we might interpret this negative relationship differently (Johnson, 1973; McCloskey and Zecher, 1976; Sommariva and Tullio, 1987, 1988). Contrary to Bloomfield's assumption, the direction of causation can run from changes in domestic assets to endogenously determined changes in foreign assets. If the domestic production deviates from trend in a positive way, the demand for credit at the central bank increases. In the short-term, such an increase puts pressure on the interbank money market rate and, then, the spread between the interbank rate and the official discount rate decreases. In order to ease the market, the central bank provides more credit and thereby pushes down the interbank rate, leading to gold outflows. Sommariva and Tullio (1987, chp. 2) found some evidence of such a mechanism in Germany during the gold standard (1880–1913). In order to control for this potential effect, we include a proxy for French domestic economic activity in the VAR. Furthermore, the influence of domestic demand on the BdF supply of credit can be important without implying a balance of payments effect and, thus, can be related to domestic assets of the central bank but not to the English rate and the gold stock. However, given the observed correlation between the English rate and the BdF portfolio (Fig. 6), it seems unlikely that the monetary theory of the balance of payments explains all variations in BdF discounts, except if the French business cycle had a direct and systematic influence on the English interbank market.

Did the BdF use its balance sheet (discount and advances) to sterilize gold outflows in response to international shocks? Setting an interest rate is not enough to maintain rate stability. The only way to avoid a too narrow spread between the central bank and the interbank rates, and thus keep the BdF rate effective is to provide domestic credit.[24] The BdF was able to do so because it could let gold flow out without jeopardizing its credibility. The alternative theory (monetary theory of the balance of payments) states that the BdF would not have been involved in this kind of activity and that domestic aggregate demand

[24] Tullio and Wolters (2004) provided evidence of a positive correlation between, on the one hand, the liquidity ratio of the BdF (defined as the ratio of gold and silver holdings to banknotes outstanding) and, on the other hand, the differential between the money market rate in Paris and the official discount rate of the BdF. However, their analysis does not account for the role of the domestic portfolio, does not investigate why the official discount rate stayed stable most of the time, and does not offer a comprehensive picture of the short-term mechanisms at play in the balance sheet of the central bank and in the money market in response to changes in the English rate.

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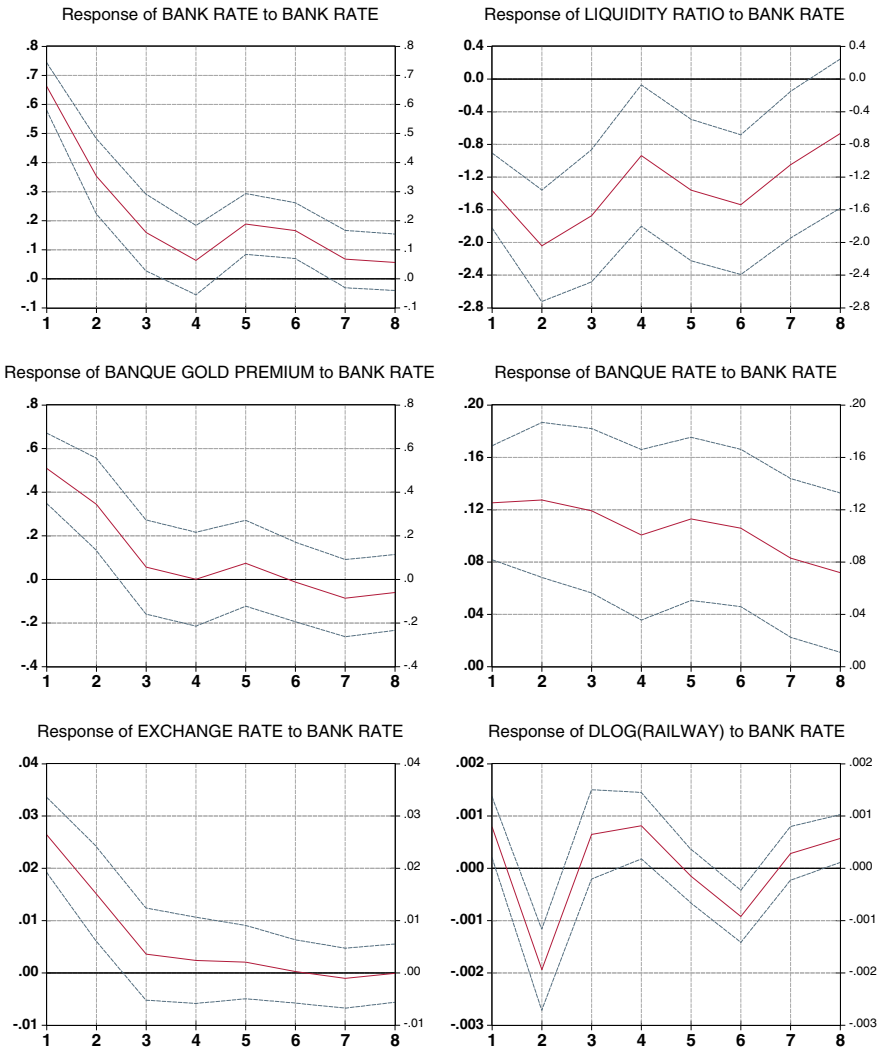
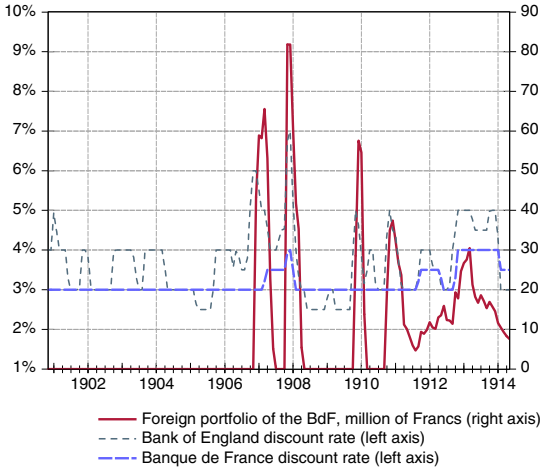


Fig. 4. Response to a shock in the Bank of England discount rate (quarterly data). *Notes:* the impulse response functions are based on OLS-VAR results using a Cholesky decomposition where variables are set in the following order: 1) Bank of England discount rate 2) liquidity ratio 3) Gold premium 4) Banque de France discount rate 5) £/F exchange rate 6) 1st difference of the log of railway revenues. Two lags of each variable are included in the VAR. Estimation sample: 1881 Q1-1913 Q4. X-axis displays quarters after the shock. The shock occurs in period 1. Dotted lines denote two standard error bands. *Sources:* see Appendix.

largely explains the movements in central bank assets and liabilities. Before attempting to test alternative theories using VAR estimations, it is useful to explain in greater detail the data on the money market rate and the domestic portfolio of the BdF.

4.2. The portfolio of the Banque de France and the French money market

As Roulleau (1914, chp. 8) and White (1933, chp. 9) explain, the Parisian money market rate that the *Economist* published was a composite of the rates at which the largest merchant and commercial banks bought some of the highest-quality paper in the Parisian interbank market. Most discounting in France was done at the BdF discount rate or slightly below, but a small part of commercial paper (traded by the most well-known banks) was discounted at a much lower interest rate. This market was relatively small although we do not have any precise evaluation of its size. And the spread between the market rate and the BdF rate was usually low compared to the English spread (0.5 percentage point on average over the period). Thus, this Parisian money market rate was deemed a good indicator of credit conditions in France by contemporaries such as Roulleau (1914), as well as by the



Sources: see Appendix. Monthly data.

Fig. 5. Banque de France's foreign portfolio and discount rate, Bank of England discount rate (1900–1914). *Sources:* see Appendix. Monthly data.

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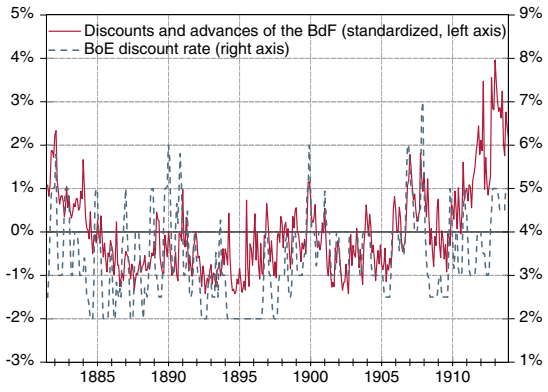
board members of the BdF.[25] Research by Flandreau and Sicsic (2003) and Ungaro (2016) on the *reports* (repurchase agreement) market has also shown that the rate the *Economist* published was a reliable indicator. The BdF was a true pillar of the French banking system as most banks depended on its liquidity provision for their usual business: thanks to the large network of BdF branches, any bank in the country could have access to the central bank discount window (Bazot, 2014).[26] The Parisian money market rate was the lower bound of French interest rates since only the main Parisian banks could trade on this market. Thus, when this interbank rate was very close to the official discount rate of the central bank, it meant that most French banks would actually obtain cheaper loans at the central bank discount window than on the market. Responding to the banks' demand, the BdF increased the provision of domestic liquidity. Then, the spread between the central bank rate and the money market rate decreased. An increase in the BoE rate would first push up the Parisian money market rate (lowering the difference with the official discount rate), as Fig. 7 reflects. Then, the money market rate would go back to normal if the BdF responded to demand at the discount window.

Although the money market rate is mostly a Parisian discount rate, we think it is necessary to consider all domestic assets in order to investigate the extent of the possible BdF sterilization. As France was financially integrated during the gold standard and the BdF had a large network of branches within the country, the Parisian rate is a reliable proxy for credit conditions in France and BdF credits could affect these conditions. However, the conclusions discussed in the next section are similar if we use only advances and discounts in Paris, since Parisian and provincial discounts followed the same path (Bazot et al., 2014).[27]

4.3. VAR estimations: the extent of sterilization

We now turn to the results of VAR estimations. Identification assumptions, data, and specifications are similar to the ones in Section 3. We add the spread between the BdF discount rate and the money market rate (the spread – expressed in percentage points – falls when the money market rate increases and the BdF rate remains constant) as well as a variable named "BDF CREDIT" (in logarithm first-differences) that is the sum of all discounts and advances of the BdF (domestic portfolio). As described previously, we investigate the responses of the French economy and BdF policy to a shock to the BoE discount rate. The variables are set in the following order: Bank rate, liquidity ratio, gold premium, spread between Banque rate and interbank market rate, variation of the logarithm of BdF credit (discounts and advances), Banque rate, exchange rate, variation of the logarithm of imports, and excess of specie imports. The results in Fig. 8 first show that adding two variables does not modify the conclusions of the previous section: the exchange rate and the liquidity ratio react in the same way. Most of all, after a positive shock to the English Bank rate, the spread decreases immediately and the BdF increases its loans to the French economy. BdF domestic credit increases by almost 2% in the month after the shock. After four months, the cumulative response of BdF credit is around 4% while the cumulative response of the liquidity ratio is around

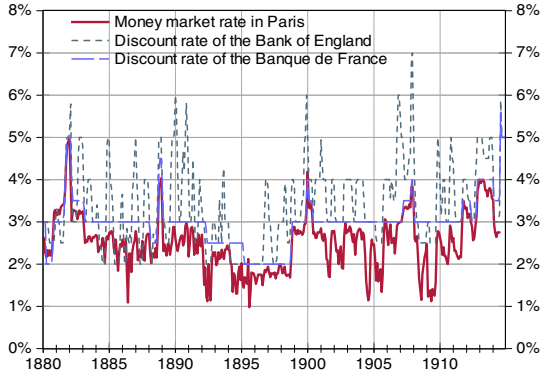


Notes: the series of Banque de France (BdF) domestic assets has been standardized to have zero mean and unit variance.
Sources: see Appendix. Monthly data.

Fig. 6. Banque de France domestic portfolio and Bank of England discount rate (1880–1914). *Notes:* the series of Banque de France (BdF) domestic assets has been standardized to have zero mean and unit variance. *Sources:* see Appendix. Monthly data.

– 6 percentage points. Given the gold stock was on average 1.5 times bigger than the asset portfolio, the BdF was almost completely sterilizing the gold outflows. Additional VAR estimations whose results are not reported here include the yield of six-month French Treasury bonds. Adding such a variable would illuminate whether the BdF recognized that increase in the BoE rate posed a need to decrease the cost of government financing and therefore expand its credit to the economy, as Ramon (1932) suggests. The six-month bond rate increases by a single percentage point after an international shock – though not immediately – and goes back to normal after eight months (see Bazot et al., 2014 for detailed results). Thus, BdF credit provision eased both private and public credit conditions.

One may wonder whether the coefficients of the VAR are stable over the whole period and, then, whether impulse response functions show a similar pattern when the VAR is estimated over several subsamples. Fig. 9 shows the responses of the three main variables of interest (spread, BdF credit, and liquidity ratio) as well as the response of the BoE rate (to check that the shocks have the same magnitude across subsamples). We compare the responses of the VAR estimated over the full sample (January 1881–December 1913) to responses of the VAR estimated over three shorter subsamples: 1881–1900 (when the BdF was using gold devices), 1900–1913 (when gold devices were no longer used), 1906–1913 (when the BdF also used a foreign assets portfolio). To avoid displaying too many graphs, Fig. 9 only shows the impulse response functions of the four main variables. We estimate the VAR with



Sources: see Appendix. Monthly data.

Fig. 7. The French money market rate compared to the Bank of England and Banque de France discount rates (1880–1914). *Sources:* see Appendix. Monthly data.

[25] A 1895 discussion – which led to a decrease in the Banque discount rate – makes clear that if the volume of discounts decreased and the spread between the money market rate in Paris (*le taux du marché libre*) increased too much (i.e. the market rate being way below the official rate) the BdF had to decrease its rate. See ABF, "Procès-verbal du Conseil Général, 14 Mars 1895."

[26] Advances on securities played a similar role to rediscounting even though they entail higher interest rates (usually 1% higher than the discount rate).

[27] The increase in outstanding circulation largely financed the expansion of the asset side: the liquidity ratio thus remained stable over time, around 85%. Contrary to England, France had no law requiring notes to be covered by a certain proportion of gold. But the government set a ceiling on the outstanding notes in circulation.

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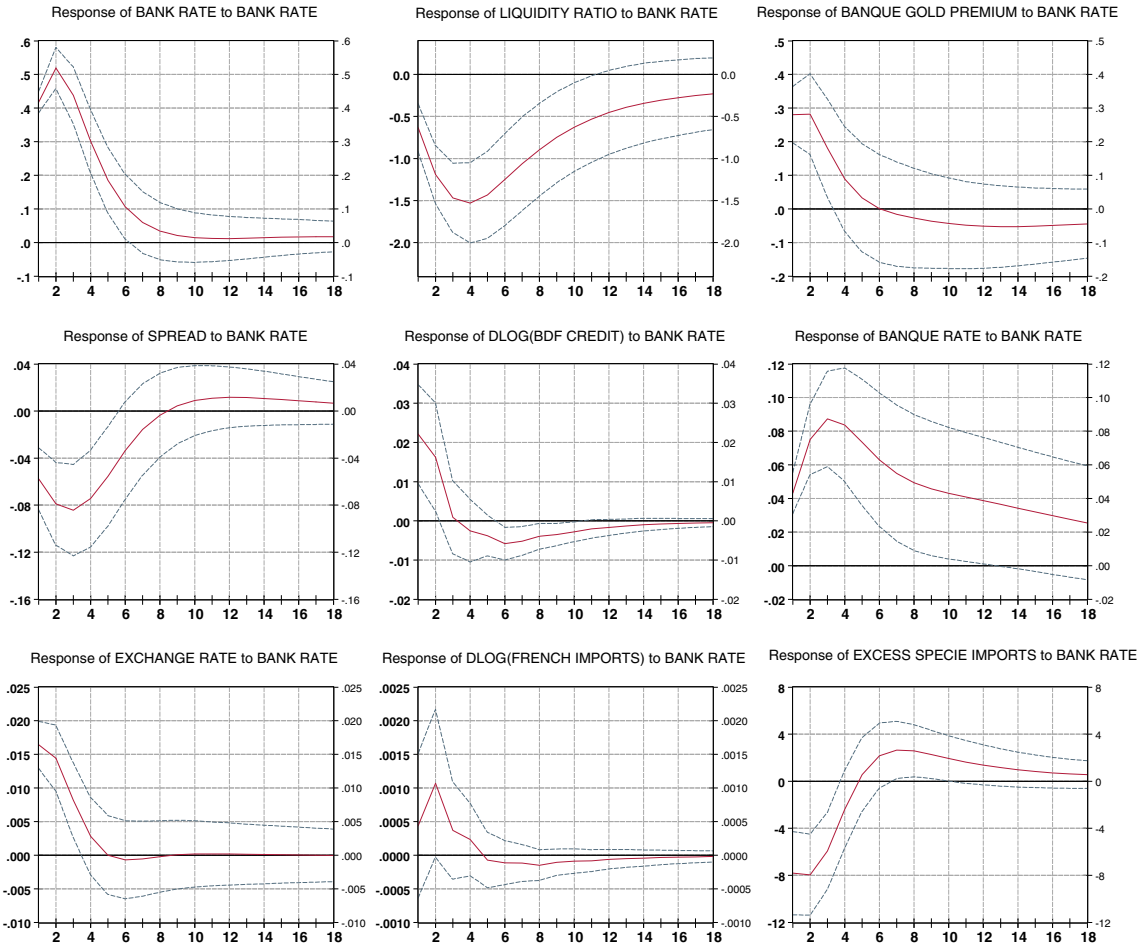

Fig. 8. Response to a shock in the Bank of England discount rate (monthly data). *Notes:* the impulse response functions are based on OLS-VAR results using a Cholesky decomposition where variables are set in the following order: 1) Bank of England discount rate 2) liquidity ratio 3) Gold premium 4) the spread between French money market and Banque de France discount rate 5) 1st difference of the log of Banque de France's domestic credit 6) Banque de France discount rate 7) £/F exchange rate 8) 1st difference of the log of imports 9) the excess of specie imports. Two lags of each variable are included in the VAR. Estimation sample: August 1884–December 1913. X-axis displays months after the shock. The shock occurs in period 1. Dotted lines denote two standard error bands. *Sources*: see Appendix.

eight variables (the excess of specie imports is excluded in order to start the sample in 1881).[28]

Fig. 9 shows that the impulse response functions are very similar across subsamples (1881–1913; 1881–1900; 1900–1913; 1906–1913): the shocks to the BoE rate are identical and the signs and the shapes of the responses to the shock are the same. We observe only two differences. First, the response of BdF domestic credit to a shock is slightly lower during the last period of the sample. This difference should not be overstated since the last period of estimation (1906–1913) is short; however, the fact that the BdF could also rely on its foreign portfolio during this period and thus accept foreign bills as collateral could easily explain this result. Second, the response of the spread is much lower during the first half of the sample (1881–1900). The difference in the average value of the spread across subsamples explains this difference in the response. Fig. 7 shows that the Parisian interbank market rate was much lower than the BdF discount rate after 1900. From 1881 to 1900, the mean of the spread is 0.41; from 1901 to 1913, it is 0.55. The difference (0.11 points) between the responses across the two subsamples almost equals the difference between the average values of the spread. Hence, in the second period, a higher increase in the spread was necessary to cause the same amount of BdF loans to the domestic economy.

4.4. Testing an alternative explanation: the monetary theory of the balance of payments

The results of the previous VAR estimations offer a consistent story of the behavior of the domestic assets of the Banque de France after a shock to the discount rate of the Bank of England. We have interpreted our findings as evidence of full sterilization by a central bank whose primary objective was to keep a stable domestic official discount rate. As we have explained, the monetary approach to the balance of payments may provide an alternative explanation. In order to prove that international shocks drive the negative correlation between the domestic assets and the international reserves of the central bank, we need to control for domestic activity. As in Section 3, we estimate a quarterly VAR that includes railway revenues as a reliable proxy for aggregate demand. If aggregate demand primarily determined the spread and gold flows, a shock to the BoE rate should have very little impact on these

[28] We have also checked that the results are similar if we estimate the VAR with Bayesian methods rather than with OLS. For Bayesian estimation, we follow standard practice and choose Minnesota (Litterman) priors with a prior mean of 0 on all coefficients except the first lag of the dependent variable in each equation, whose prior mean is set to 1. As with any Bayesian estimation, the median value of the distribution depends on the priors. Shapes of impulse response functions are however identical. Responses are similar when we estimate the VAR only with the four variables of interest. Results are available upon request.

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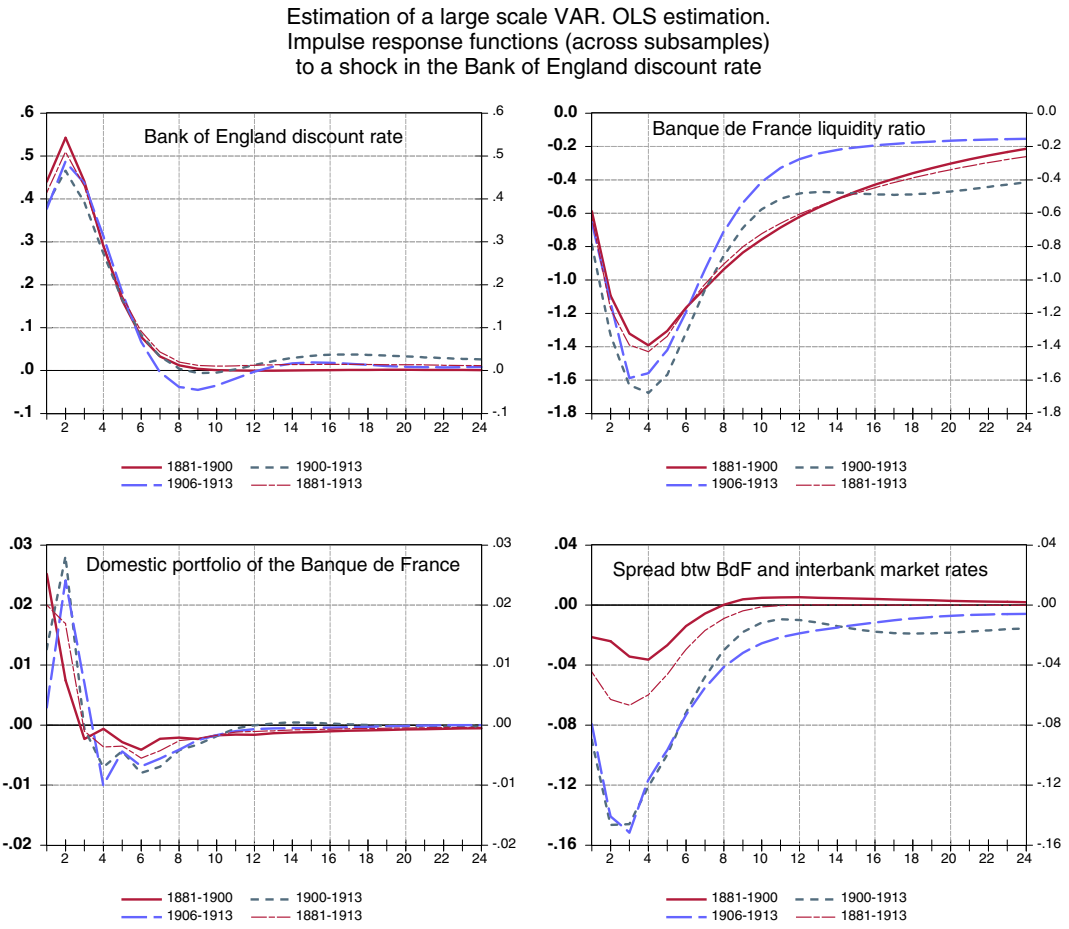

Fig. 9. Response to a shock in the Bank of England discount rate. Four sub-samples (monthly data). *Notes:* the impulse response functions are from a 8 variables OLS VAR, estimated with 2-month lags, and based on a Cholesky decomposition where variables are set in the following order: 1) BoE discount rate 2) liquidity ratio 3) Gold premium 4) the spread between French money market and Banque de France discount rate 5) 1st difference of the log of Banque de France's domestic credit 6) Banque de France discount rate 7) £/F exchange rate 8) 1st difference of the log of imports. Estimation sample: January 1881–December 1913. X-axis displays months after the shock. The shock occurs in period 1. Dotted lines denote two standard error bands. *Sources:* see Appendix.

variables. This is not what we find in Fig. 10: the impact of a shock on the liquidity ratio, the spread, and BdF credit resembles previous results. Thus, the results of VAR estimations with quarterly data and railway revenues are entirely consistent with previous conclusions and interpretations.

4.5. Summary of results

The rise in domestic BdF credit after a shock to the English Bank rate should be interpreted as full sterilization of international shocks by the BdF rather than as a consequence of the monetary theory of the balance of payments. These results cast new light on how the objective of stable and low rates constrained BdF policy. Because of full capital mobility, a shock to the English Bank rate transmitted immediately to the French interbank market. As a result, the spread between the interbank rate and the official discount rate increased, putting pressure on the BdF to increase its rate or to discount more commercial paper. We have shown that policymakers used the second solution much more than the first one. Use of the discount portfolio in reaction to international shocks was key to achieve the objective of a stable discount rate. The VAR estimations show that the gold stock and gold devices were necessary but not sufficient to avoid a further increase in the discount rate. The objective of a stable discount rate forced the BdF to use its balance sheet extensively to sterilize international shocks. Emanoil (1932) more than any other analyst of BdF policy understood the link between the BdF discount policy and the functioning of the classical gold standard. He wrote:

> The BdF must be in a strong monetary position for its portfolio to increase and its reserves of gold to decrease without causing concern. This is how the BdF could keep a low discount rate, at least for a short period of time, in spite of the upward pressure of the money market rate. Applied in other countries this policy proved to be far less successful. […] We can see that, even though gold reserves decrease, outstanding notes and BdF's credit increase. However, this does not mean that gold outflows have no impact on the money market rate but that the BdF has more than offset these outflows by increasing its credit operations (Emanoil, 1932, p.101–104).[29]

5. How the Banque set the official discount rate

As previous sections have emphasized, the BdF was willing to keep a stable discount rate. Nevertheless, the BdF increased or decreased its discount occasionally between 1880 and 1914. What motivated these infrequent changes? If the story we have told so far is correct, increases in the discount rate may be extreme cases when the Banque recognized that the gold flows and domestic portfolio adjustments were insufficient to maintain the credibility of the exchange rate band. Thus, an

[29] Translated from French to English by the authors.

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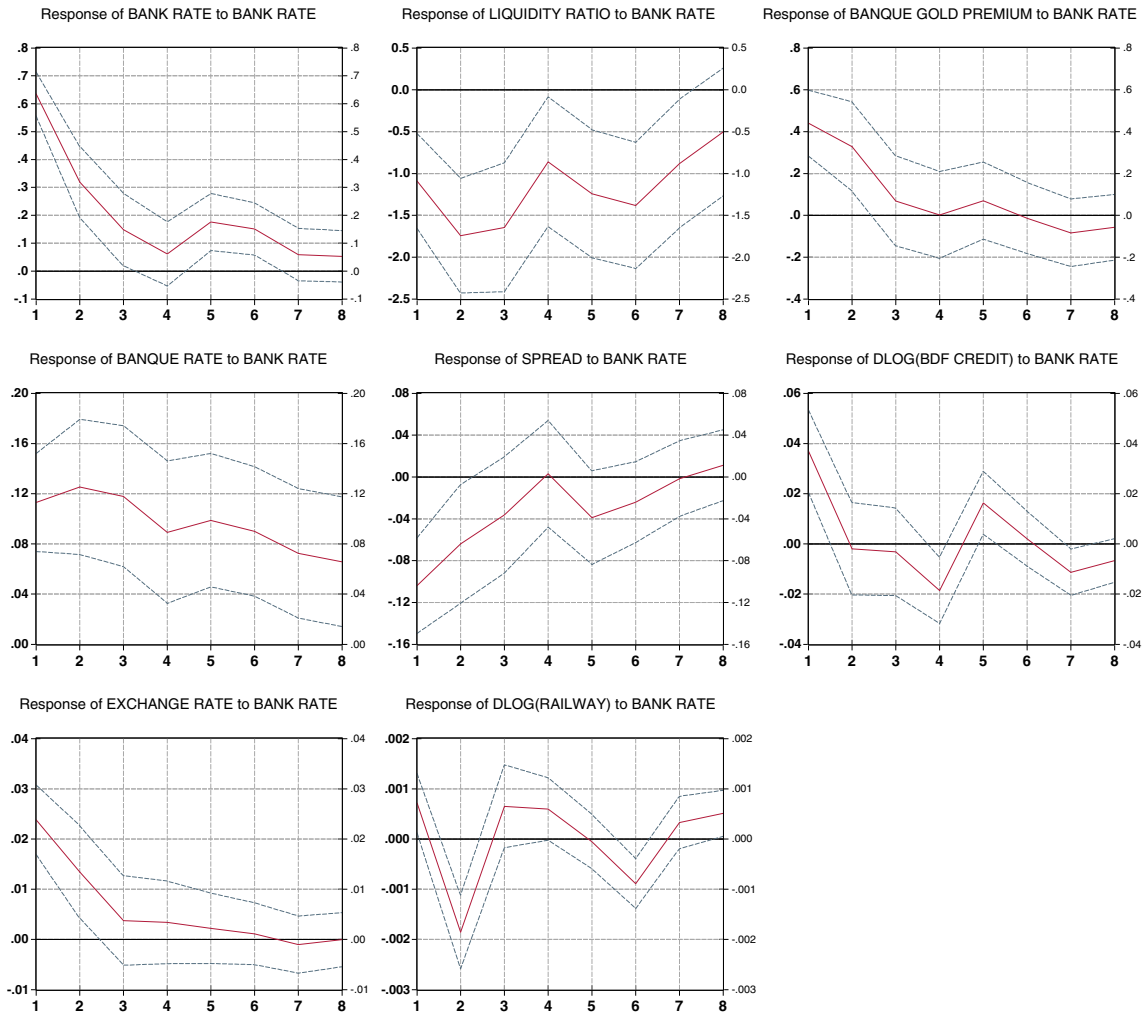

Fig. 10. Response to a shock in the Bank of England discount rate (quarterly data). *Notes:* the impulse response functions are based on OLS-VAR results using a Cholesky decomposition where variables are set in the following order: 1) Bank of England discount rate 2) liquidity ratio 3) Gold premium 4) the spread between French money market and Banque de France discount rate 5) 1st difference of the log of Banque de France's credit provision 6) Banque de France discount rate 7) £/F exchange rate 8) 1st difference of the log of railway revenues. Two lags of each variable are included in the VAR. Estimation sample: 1881 Q3–1913 Q4. X-axis displays quarters after the shock. The shock occurs in period 1. Dotted lines denote two standard error bands. *Sources:* see Appendix.

increase in the BdF discount rate was like a devaluation coming after months of defending the parity. While traditional views of the central bank's discount rate policies consider the interest rate as the core of international adjustments, we argue that the determination of the discount rate of the central bank is highly nonlinear. Most of the time, a rise in the English discount rate and gold outflows would not affect the level of the BdF discount rate. Exceptional cases, by contrast, call for an adjustment. Fig. 7 suggests this conjecture is accurate. An increase in the BdF discount rate is always associated with an increase in the English discount rate as well as with a smaller spread between the interbank rate and the official rate. The reverse is not true, however.

5.1. Archival evidence

Between 1880 and 1913, the BdF changed its discount rate the same day or the next day after a BoE change nineteen times, and within a month after a BoE's change eight times, always in the same direction but usually not by the same amount.[30] Only three incidents of a change to the BdF – twice in 1880 and once in 1907 – did not follow an increase by the BoE. The board of the Bank of England usually met Wednesdays and announced the official discount rate on Thursday mornings, and the BdF meetings took place on Thursday afternoon. The Banque sometimes announced its decision the same day, and sometimes announced it Friday. Thus, decisions of the BoE to change rates were announced at the beginning of each BdF Thursday meeting. Most of the time, the governor asked whether the BdF should maintain the *status quo* or follow the BoE. Unfortunately, the transcripts of meetings contain very few details about the content of the discussion motivating such decisions. Most of the time, no justification appears in the transcripts; the few exceptions occur when the Banque changed the discount rate and never when it kept the discount rate fixed despite a change in the BoE discount rate. These exceptions consist of one or two sentences in which the Governor or a board member justifies the decision. On October 14, 1880, one of the few times when the BdF increased its discount rate when the BoE rate had stayed the same, the Governor stated it was because of a "persisting" diminution in the BdF gold stock. On September 13, 1888, after the announcement of an increase in the BoE rate, M. de Rothschild explained the "current state of the exchange rate reveals a dangerous situation for the country" as a justification for the increase in the BdF rate. On October 4, 1898, the Governor reported that the Ministry of Finance had asked him to defend the

[30] We use the dates of change published in Roulleau (1914).

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gold stock of the central bank and then to increase the discount rate. On March 21, 1907, when the BdF increased its discount rate without an increase in the BoE rate in the previous month, it again cited the sharp decrease of the BdF's gold stock – by 400 million – compared to its previous year level. It also cited the fact that the discount rate of the BdF had been much lower than the rates of other central banks for a long period.[31]

5.2. Econometric evidence

Archival evidence supports our argument that the BdF normally did not need to follow the BoE. It was only necessary when gold losses and exchange rate variations were too extreme. However, no formal or informal targets for the gold stock or the exchange rate specifically triggered the BdF decision to modify the discount rate. Several factors combined in every case of a change in the discount rate of the BdF, and the decision did not depend linearly on the values of these factors. Thus, we need to take into account a "switch" in the BdF decision. A proper way to do this is to estimate a Markov switching model with two regimes. In the first regime, the discount rate is very likely to remain stable because no variable affects it (since the BdF defended its stability through gold sales and expansion of domestic credit). The second regime predicts that the BdF will change its discount rate under the pressure of international variables and changes in the composition of its balance sheet. This approach is similar to the one researchers have used to analyze and estimate the determinants of devaluations (currency crises) that occur after central banks attempt to defend their parities (Jeanne and Masson, 2000; Chen, 2006). What distinguishes the current paper is that we seek to uncover the variables that may have affected the BdF decision to change its discount rate in each regime.

The estimation endogenously selects two regimes and provides the probabilities of being in either one. The dependent variable is the change in the BdF discount rate. The explanatory variables that we include in the equation are values at the end of each month: the spread (between the Paris money market rate and the BdF rate), the BoE rate in levels and in variations, the growth rate (first difference of the logarithm) of the BdF gold stock, and the deviation from the upper gold point.[32] The latter variable is denoted "Point" and takes small values when the exchange rate approaches the gold export point. For the definition of gold points, we use the values Morgenstern (1959) gives but the conclusions are the same if we use time-varying gold points, as others have (Officer, 1996; Bordo and MacDonald, 2005).[33] We conduct the estimation by trying several models in order to obtain the best fit: that is, when the probability of being in a particular regime accurately predicts the change in the BdF discount rate. Fig. 11 shows the probability of being in "regime 2" together with the discount rates of the BoE and BdF. The probability of being in "regime 2" equals one when the BdF changed its discount rate and approaches zero otherwise. Next, we investigate how the independent variables explain changes in the BdF rate in each regime. Table 1 reports our estimation results. By construction, the probability of being in "regime 1" is near one when the Banque keeps its discount rate stable. By contrast, we have selected "regime 2" so that it predicts the probability that the Banque changes its rate with accuracy. In this regime, it turns out that all variables affect the change in the BdF discount rate significantly. According to this estimation, the BdF increased its discount rate when the spread was low, when the exchange rate was close to the gold export point, when the Bank rate was high and increasing and when the BdF gold stock was decreasing. As expected, the values of the coefficients are large: a 1 percentage point increase in the Banque rate is associated with a decrease in the spread by −0.23 percentage point and an 8% decrease in the gold stock.

Comparing the results of the Markov switching model to a standard OLS (ordinary least squares) regression illuminates them (Table 2). As described above, the studies that have used OLS have obtained less robust results. We find the same problem when we run an OLS regression with the same variables as in the Markov switching equation. Moreover, the OLS equation naturally predicts many changes in the Banque de France discount rate that actually did not happen (and the values of the coefficients are lower). Most important, in the specification reported in Table 2, the variations of the gold stock have no effect. The limitations of OLS cause the absence of effects by making the assumption that an increase in the Bank rate would always imply a similar increase in the BdF rate, whereas the observation of the pattern of the two discount rates has suggested that this assumption does not hold. This is not because of a threshold value of the Bank rate. The non-linearity mainly reflects the fact that increases in the BdF rate depend on many factors coming together. A rise in the BdF rate occurred only in a particular regime. The main objective of the Banque was to make it unlikely it would be in this regime. Results obtained with a switching model show evidence that the second regime augments the explanatory power of the independent variables. They concur with the narrative evidence that negative changes in the BdF gold reserves explain the few changes in the BdF discount rate. A change in the BoE discount rate was not a sufficient condition for a change in the BdF's discount rate. The very nature of the BdF's balance sheet policy determines the switch to change the official discount rate: sterilization required a large gold stock and, when its gold reserves fell too far, the BdF had to increase the official discount rate. Central banks cannot forever escape the constraint of international finance.

6. Conclusion

This paper attempts to explain and quantify how the BdF managed to insulate its discount rate from changes in the BoE discount rate through the use of its balance sheet. It has revealed that the BdF's policy is the product of a dual constraint (or a double objective): maintaining the stability of the domestic discount rate and maintaining the fixed parity of the exchange rate. The Banque used its balance sheet to achieve both objectives. When necessary, in a few extreme cases, the BdF always preferred to change the discount rate rather than modifying the exchange rate parity. Yet these changes in the discount rate were seldom and temporary. Frequent changes would have threatened the domestic legitimacy of the exchange-rate regime, in the same way that a permanent suspension of convertibility would have threatened French international credibility. As a consequence, the Banque's ability to sterilize international shocks is probably a key element, in political economy terms, in the long lasting adherence of the country to the gold standard.[34]

Indeed, the BdF's policy under the gold standard was at the extreme of the spectrum, and the BoE was at the other extreme (Reis, 2007). Several central banks fell in between, with values of the liquidity ratio and number of interest rate changes closer to that of France than England's (Morys, 2013). Our study of France under the gold standard leads to at least three conclusions that could not be drawn from the English case. They should be useful for the study of other countries: international adjustments could work through the balance sheets of central banks

[31] Archives of the Banque de France (ABF): "Procès-verbal de la séance du Conseil Général du Jeudi 14 Octobre 1880"; "Procès-verbal de la séance du Conseil Général du Jeudi 13 Septembre 1898"; "Comité des Livres et Portefeuilles du 4 Octobre 1898"; "Procès-verbal de la séance du Conseil Général du Jeudi 21 Mars 1907." The authors have translated all quotes from the French.

[32] We include the BoE discount rate both in level and in variation because we think that the marginal effects matter. A negative change in the BoE rate would probably be perceived as unimportant if it is already high.

[33] See Bazot et al. (2014) for more details.

[34] Foreign exchange interventions were another usual tool – in addition to gold devices – which was mainly used by small central banks – as well as by the US Treasury – to stabilize the exchange rate and to insulate partly open economies from international shocks (Bloomfield, 1959; Reis, 2007; Esteves et al., 2009; Jobst, 2009; Ugolini, 2012; Bordo et al., 2015, chp. 2).

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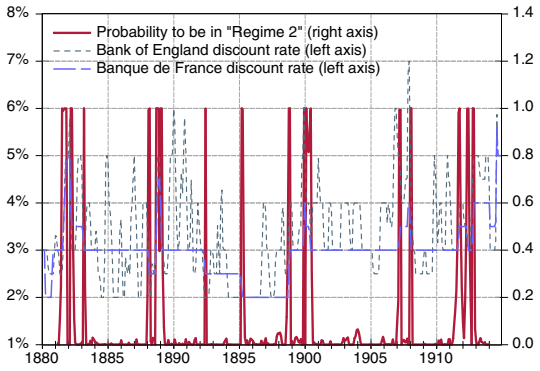

Sources: see Appendix and authors' calculations based on the equation presented in Table 1. Monthly data.

Fig. 11. Probability to be in regime 2 according to the Markov switching equation. *Sources*: see Appendix and authors' calculations based on the equation presented in Table 1. Monthly data.

rather than through interest rates (and the former is thus as important to look at as the latter), the objective of a stable discount rate forced the central bank to rapidly change the composition of its balance sheet, and finally, the setting of the official discount rate was highly nonlinear. The remarkable stability of the BdF discount rate over the period, as well as its large gold stock, suggests that the extent of sterilization in France was exceptional. Nothing prevented other countries from using this mechanism as long as the stock of gold central banks held exceeded the value legal reserve ratios require. Based on Bloomfield's (1959) observation of frequent negative correlations between the foreign and domestic portfolios of central banks, a similar phenomenon occurred elsewhere (e.g. Sweden (Jonung, 1984); e.g. Germany (McGouldrick, 1984; Giovannini, 1993; Bordo and Eschweiler, 1994)); however, the extent of sterilization in these countries was less. Discussing the BdF sterilization policy, Emanoil claimed that "applied in other countries, this policy proved to be far less successful" (Emanoil, 1932, p.101). Further research should be devoted to investigate and understand why.

A more general conclusion of this study is that the key forces of the gold standard were at work even though the banks did not exactly follow the rules of the game. The central bank kept a close eye on exchange-rate deviations while the exchange-rates adjusted through gold movements. Notwithstanding very different central banking practices, domestic objectives and interpretations of the so-called "rules of the game," the gold standard still worked as a credible rule.

Table 1
Determinants of Banque de France discount rate changes (Markov switching estimation). *Sources:* see Appendix.

Variable	Coefficient	Std. Error	*P*-value
Regime 1			
Δ(bank rate)	0.010	0.006	0.105
Bank rate(−1)	0.002	0.001	0.060
Spread(−1)	−0.005	0.006	0.409
Δlog(BDF gold stock(−1))	0.085	0.034	0.012
Distance gold point(−1)	−0.044	0.042	0.294
Regime 2			
Δ(bank rate)	0.538	0.012	0.000
Bank rate(−1)	0.062	0.003	0.000
Spread(−1)	−0.233	0.025	0.000
Δlog(BDF gold stock(−1))	−0.083	0.044	0.059
Distance gold point(−1)	−1.404	0.158	0.000
Common			
Log(sigma)	−2.914	0.036	0.000
Transition matrix			
P11-C	0.309	0.383	0.419
P21-C	−2.951	0.271	0.000

Notes: Markov Switching Regression (Quadratic hill climbing/EViews Legacy), initial probabilities obtained from ergodic solution; ordinary standard errors & covariance using numeric Hessian. Δ denotes the first difference of a series. Log denotes the logarithm. The sample includes 395 observations (from February 1881 to December 1913). The definition of variables is described in the text.

Table 2
Determinants of Banque de France discount rate changes (OLS estimation). *Sources:* see Appendix.

Variable	Coefficient	Std. Error	*P*-value
Δ(bank rate)	0.127	0.013	0.000
Bank rate(−1)	0.012	0.003	0.000
Spread(−1)	−0.022	0.014	0.137
Δlog(BDF gold stock(−1))	0.018	0.063	0.766
Distance gold point(−1)	−0.310	0.093	0.001
Adjusted R-squared	0.199		

Notes: the sample includes 395 observations (from February 1881 to December 1913). Δ denotes the first difference of a series. Log denotes the logarithm. The definition of variables is described in the text.

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Appendix A. Data appendix

All data are monthly except railway revenues which are quarterly. Weekly data on the balance sheet of the Bank of France from 1898 were collected by Patrice Baubeau and are available online (http://www.BdF-france.fr/la-BdF-de-france/histoire/annuaire-historique.html). Bank of France data from 1881 to 1898 were collected by the authors of this paper. Data on prices (1900–1913), railway revenues (1880–1913), and trade (from 1880 to 1885) are also new series collected for this paper. Other sources are listed below. All series start in 1880, unless specified otherwise.

- **Imports and exports**

From 1880 to 1885, *Statistiques mensuelles du commerce extérieur de la France* (Direction générale des douanes et droits indirects).
From 1886 to 1914, *Bulletin de statistique et législation comparée* (available in NBER MacroHistory database, series m07027 and m07032)

- **Excess of specie imports**

White (1933). Starts in 1884.

- **BdF discount rate**

NBER MacroHistory database, series m13014

- **Bank of England discount rate**

NBER MacroHistory database, series m13013

- **Reichsbank discount rate**

NBER MacroHistory database, series m13015

- **Money market rate in Paris**

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The Economist, available in NBER MacroHistory database, series m13017

- **Exchange rate Paris-London**

NBER MacroHistory database, series m14107

- **Foreign portfolio**

Archives of the Banque de France (ABF), Situation hebdomadaire de la BdF.

- **Gold premium in Paris**

White (1933)

- **French 6-month interest rate on government bonds**

Arbulu (2006)

- **Gold and silver reserves of the BdF**

ABF, Situation hebdomadaire de la BdF

- **Advances and discounts of the BdF**

ABF, Situation hebdomadaire de la BdF

- **Notes in circulation**

White (1933)

- **Stock market index**

Le Bris and Hautcoeur (2010). This an index of the forty largest firms listed in the official stock market.

- **Monthly price index (1900–1913)**

La *Réforme économique* (20 commodities).

- **Railway revenues**

Revenues of the General network (*réseau d'intérêt general*) which was divided in 7 large networks (*Paris-Lyon-Méditerranée; Rhône au Mont-Cenis; Nord; Ouest; Orléans; Est; Midi*). Published revenues are from passengers and freight, not from other sources (state subsidies, financial investments etc.).

From 1880 to 1886, *Bulletin du Ministère des travaux publics*. Statistics are available for each network. We add the revenues of the 7 networks. Data are quarterly.

From 1887 to 1899, *Bulletin de statistique et législation comparée*. Data are quarterly. The Bulletin publishes the sum of the revenues of the 7 networks.

From 1900 to 1913, *Bulletin de statistique et législation comparée*. Data are monthly; we sum the revenues for each quarter. The Bulletin publishes the sum of the revenues of the 7 networks.

Appendix B. Supplementary data

Supplementary data to this article can be found online (Bazot et al.,2016) http://dx.doi.org/10.1016/j.eeh.2016.07.006.

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