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A dissonant violin in the international orchestra? Discount rate policy in Italy (1894-1913)*

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Abstract

Based on a new series and applying econometric techniques, this paper investigates the discount rate policy implemented by the main Italian bank of issue of the time, the Banca d'Italia. We focus on two interrelated aspects of the problem. Firstly, anchoring our analysis to the Bank's annual reports, we enquiry into the general determinants of its discount rate variations. Secondly, we study the reaction of the Italian rate to exogenous changes in leading international official rates. We show that discount rate variations responded to short-term fluctuations of official rates in the UK and France but, simultaneously, to deviations from long-term equilibrium relations involving two pairs of variables. On the one hand, a relationship between the Italian discount rate and the French open market rate; on the other hand, a link between the Bank's reserve ratio and its exposure to the national credit market. We also show that reactions to variations in foreign official rates were of a very limited magnitude. This "sterilisation" policy came with little repercussions in terms of exchange rate fluctuations or loss of international reserves, somehow in contrast with the results of the recent literature.

Keywords: Bank of Italy, discount rate policy, international gold standard, sterilization

JEL classification: N13, N23, E58, F33

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1 Introduction

The analysis of discount rate policy during the so-called "classical" gold standard is an evergreen in economic history. In the conventional version of the functioning of the system, countries are supposed to increase (decrease) interest rates to help the automatic mechanisms predicted by Hume's price-specie-flow model to re-equilibrate deficits (surpluses) in the trade balance. This stereotyped description of the "rules of the game", however, has been questioned since Keynes's intuition that London, as the leading global financial center, was in fact the "conductor of the international orchestra" and set the tempo and the tune to which all other countries had to play, independently from their surplus or deficit position in the international trade. A few decades later, Bloomfield (1959) reconsidered the matter arguing that also this mechanical view had to be qualified. Indeed, many countries tried to insulate themselves from the pressure coming from Britain, but the capacity to operate in autonomy varied from case to case: in the international orchestra there were leading violins and background percussions, as well as highly-skilled pianists allowed long solos. In fact, probably there was more than one international orchestra, and authorities in Vienna might have preferred the music played in Berlin and in Italy the one in Paris, both international centers being relatively independent from London (Flandreau and Jobst, 2005).

The awareness of such complex reality led to the emergence of two subsequent waves of research. The first, mainly in the 1980s and 1990s, delivered various country-specific studies where discount rate policies were analyzed in relation to factors such as liquidity ratios, exchange rates, and international discount rates (Eichengreen, 1987; Davutyan and Parke, 1995; Tullio and Wolters, 1996; Tullio and Wolters, 2007). The second, more recent, approach is part of an emerging literature aiming at refining the understanding of central banking during the years of the international gold standard, focusing in particular on the wide use of "gold devices"' and direct interventions in exchange rate markets (Reis, 2007; Jobst, 2009). Starting from the idea that "focusing solely on interest rates to study domestic policy and international adjustment provides an incomplete picture of central banking under the gold standard" (Bazot, Bordo and Monnet, 2016; p. 89), discount rate policy is seen as the mirror image of these other types of operations, and hence the attention is shifted mainly on when and why the discount rate lever was actually not activated (Øksendal, 2009). The natural background for this line of research has been set out by Morys's (2013) comparative study on the different approach to discount rates policies across peripheral and core countries. Along those lines, referring to the concept of "sterilization" (Officer, 2018), i.e. the attempt to limit the pass-through to the domestic economy of exogenous increases of international discount rates, Bazot, Bordo and Monnet (2016) looked at the case of France while Bazot, Monnet and Morys (2022) expanded the analysis to twenty-one countries offering an empirical test of the original Bloomfield hypothesis.

In this debate the case of Italy is understudied. Qualitative work such as the seminal contribution by Ciocca (1973), the comprehensive historical account by Fratianni and Spinelli (1997), and the subsequent articles by Bonelli and Cerrito (1999, 2000) provide valuable information but no empirical test. On the other hand, the only available econometric exercise, run in the spirit of the "first wave" of research described above (Spinelli and Trecroci, 2012), suffers from various limitations in terms of the number and nature of the determinants of the Italian discount rate, as well as in the definition and measure of the rate itself.

The aim of the present paper is to fill this gap in the literature under two respects. First, focusing on the main Italian bank of issue of the time, the Bank of Italy,[1] we discuss the different measures of the discount rate used in Italian studies so far, and we contribute by providing a new data series. Second, anchoring our analysis to the Bank of Italy's annual reports and other archival evidence, we carry out an econometric analysis to investigate two interrelated aspects of the Italian discount rate policy: the general determinants of discount rate variations and, following the approach of Bazot, Monnet and Morys (2022), the reaction of the Italian discount rate to international exogenous shocks.

The paper is organized as follows. Section 2 describes the institutional features that are relevant for the appropriate definition of the discount rate in Italy, reviews the available statistical series and presents our new measure. The following two sections focus on the determinants of the Italian discount rate. Section 3 considers the coeval view to identify what the Bank of Italy held as the most relevant factors influencing its discount rate policy. In the following Section 4 we turn these factors into explanatory variables and specify an econometric model for Italian discount rate changes over the 1896-1913 period and relevant sub-samples. Section 5 investigates the response of the Italian monetary authorities to external shocks, and Section 6 offers some concluding remarks.

[1] Among others, Ciocca (1973) claims that the discount rate set by the Bank of Italy dominated all others.

2 Discount rate policy in Italy: institutional features and empirical implications

Peculiar institutional settings make the analysis of the discount rate in Italy far from straightforward, and a preliminary discussion of this aspect is in order before approaching the econometric analysis.

Since its establishment in 1893 the Bank of Italy was *de jure* deprived from the power to set the official discount rate which, instead, was decided by the Treasury (although, at some stages, in consultation with the Bank). Over time, however, the Bank of Italy (and the other three Italian banks of issues) were allowed to use also other preferential discount rates, still decided upon by the Treasury. At the beginning of its activity in 1894, the Bank of Italy was given the right to apply a lower, "favourable" rate, called "*tasso di favore*", to discount bills coming from savings and loans institutions, cooperative banks as well as ordinary commercial banks. The use of this rate was only a possibility and the Bank was under no obligation to apply it. This rate, still managed by the Treasury, took the form of a percentage reduction over the official rate in place. In October 1895 (*Regio Decreto 25 Ottobre 1895*), the spectrum of the applicable rates was further broadened by the introduction of a "reduced rate", called "*tasso ridotto*". This rate was a lower bound defined by the Treasury that the Bank of Italy could apply to generically-defined "prime" bills, where such qualitative assessment was up to the Bank itself.

The availability of preferential rates meant that Italian banks of issue retained much more freedom than usually believed. First, because preferential and official discount rates were established as the minimum and the maximum, but the banks could also use any rate in between. In practice this meant that the Bank of Italy could decide, within these bounds, how many rates to use, and the overall evidence coming from the Bank's official Annual Reports shows that such policy was implemented in a very active way. Indeed, the actual number of rates used by the Bank of Italy varied substantially across the years: in general the number spanned from five to seven, but while in 1905 the Bank used eleven different rates, it made recourse to only four in 1912.

Even more importantly, the Bank of Italy could also determine the amount of bills to be discounted at each rate, although abiding by the institutional rules mentioned above. Likewise the number of rates applied, the relative quantities of bills discounted at different rates show remarkable variations. This is evident even when we limit our attention to the aggregate total share of bills discounted at any preferential rate, as shown in Figure 1. Apart from a few instances where no bills were discounted at any preferential rate, the share varied from a minimum of 1% to a maximum of 69%, with an average of 32%. The Figure also reveals that this share could change significantly from month to month, suggesting a degree of activism impossible to detect by looking only at the official discount rate. Variations in the number of rates used, and in the relative allocation of quantities of bills to various rates, thus appear as the main levers of the actual discount rate policy implemented by the Bank of Italy. This policy was the result of three complementary sub-strategies: putting pressure on the Treasury to modify the official rates if deemed necessary; defining the share of bills to be discounted at the official rate and the one allocated to preferential ones; and, within the latter share, deciding which rates to use and the relative amount of bills discounted at each rate. In general, the Bank saw the official rate as the one to apply to tendentially illiquid businesses as a form of self-insurance, and hence putting pressure on the Treasury to vary its level was the reflection of the "macroeconomic" risk as perceived by the Bank. On the other hand, the use of preferential rates, both in terms of the total amount of bills discounted at those rates, as well as the number and levels of the rates, was tuned to the actual needs of the "legitimate" commerce in order to expand or restrain it. In commenting its policy during 1889, the Bank of Italy explained rather clearly how these strategies were combined together: "We ... believed that it was not appropriate to suggest raising the official discount rate being enough, if needed, to increase the reduced rate ... later, as demand was turning more pressing [the Bank] raised its rate as to ... apply the official one to all businesses."[2] These considerations imply that the focus on the official rate, only changed on ten occasions between 1893 and 1913, is bound to provide a distorted perspective on the actual discount rate policy implemented by the Bank of Italy.

This issue did not escape the attention of Italian scholars who tried to deal with the empirical implications of these institutional features. For instance, Spinelli and Trecroci (2012), in their econometric exercise, used as the dependent variable the monthly unweighted average of the official discount rate and the minimum rate, relying on the statistics collected by De Mattia (1967). This approach implicitly assumes that various rates could be ordered in a continuum way and that each rate was used to discount the same amount of bills, which, as we have shown in the previous Section, stands at odds with the available evidence. Moreover, as shown below, this variable displays a very limited number of monthly non-zero variations.

A more ingenious way to deal with the problem was pioneered by Ciocca (1973) who exploited coeval data to construct a series based on an average of the various rates weighted with the relative amount of bills discounted at each rate. Although the methodological details remain unclear, the author claims that the average was weighted using not the total stock of bills discounted, but the flows of newly created discounts. As such, the series thus looks at variations applied to the "marginal" component of the stock, thereby not taking into account the price at which the existing stock has been discounted in previous months.

Given the uncertainties of this reconstruction, the present study is based instead on a

[2] Bank of Italy, *Annual Report*, 1889, p. 24-25 (authors' translation). For the use of the reduced rate as a corporate device, see Bonelli and Cerrito (2000). For the general relevance of the reduced rate vis-à-vis the official one, see Fratianni and Spinelli (1997).

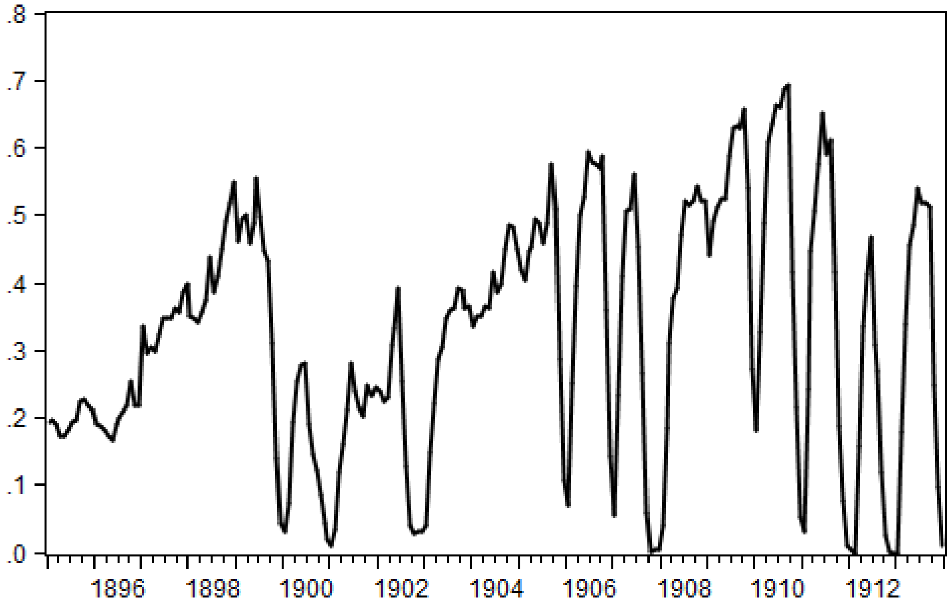
new series obtained as an average of the rates used by the Bank of Italy weighted with the quantities of bills discounted at each rate.[3] The resulting "actual" discount rate series is plotted in Figure 2 (both in levels and monthly changes), compared with the unweighted average of the official discount rate and the lowest preferential rate based on De Mattia (1967). It is clear from the figure that the "actual" measure is able to capture high-frequency changes in the overall discount conditions much more than the unweighted series, which displays unfrequent step-wise adjustments of mostly 25 or 50 basis points. Only in the final years of the sample (1911-1913) the two series show a more similar behavior, as a result of of the deliberate choice by the Bank of Italy of limiting the use of preferential rates. The remarkable difference between the two series is enhanced by looking at the distributions of their monthly changes shown in Figure 3. The unweighted measure largely resembles a dummy variable, characterized by a vast majority of zero changes, while the "actual" rate presents a much more spread out distribution. This suggests that the latter series is more likely to capture the response of the Bank of Italy to factors displaying frequent monthly changes, such as the size of the domestic credit portfolio, the liquidity ratio, and international open market interest rates.

Based on this evidence, we consider the "actual" discount rate measure much more informative on the overall discount rate policy of the Bank of Italy, and use that series in the empirical analysis implemented in Section 4 below.[4] Appendix A presents the results of a robustness check employing alternative discount rate measures, including the unweighted series shown in Figures 2 and 3.

[3] The source is: Ministero del Tesoro, *Bollettino dell'Ufficio centrale di ispezione per la vigilanza sugli istituti di emissione e sui servizi del Tesoro*, Rome, Tipografia dell'Unione Editrice, 1895-1913. Whenever possible, we used the actual monthly information on the quantities of bills discounted at each rate; otherwise, we applied the yearly quantities obtained from the Bank of Italy's Annual Reports.

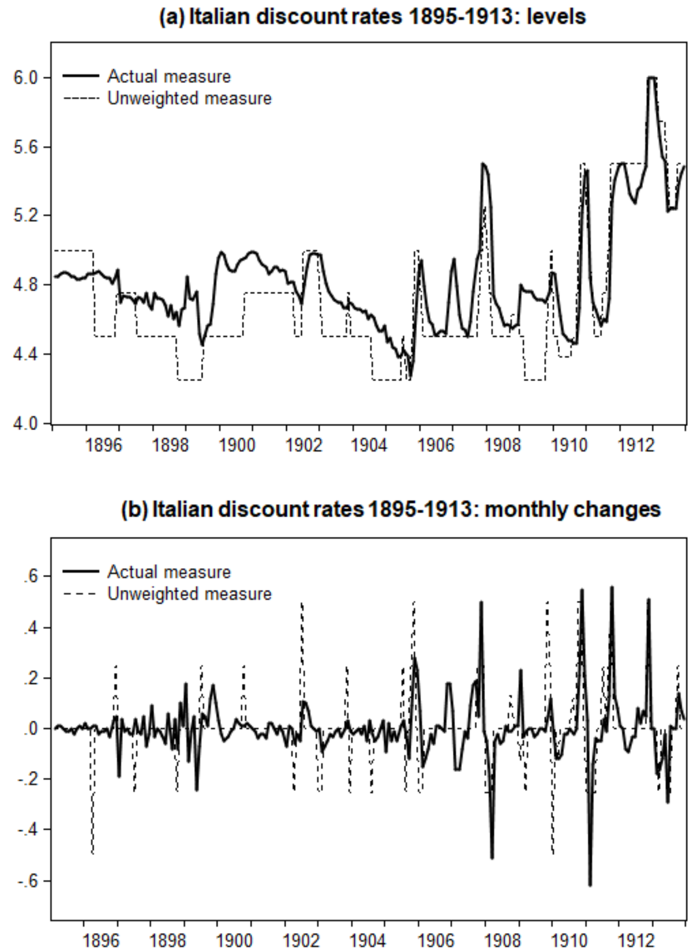
[4] The official discount rate is even less informative than the unweighted series, since it was set at 5% from 1895 to November 1907, and changed only seven times thereafter until December 1913, all changes measuring either 25 or 50 basis points.

Figure 1. Share of bills discounted at preferential rates (1895-1913)



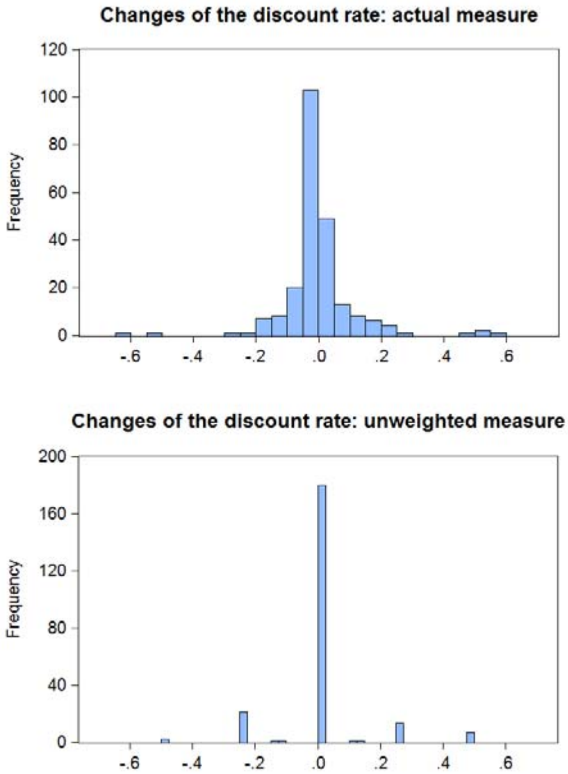
The Figure displays the fraction of bills discounted by the Bank of Italy at preferential ("reduced" and "favourable") rates. Source: Ministero del Tesoro, *Bollettino dell'Ufficio centrale di ispezione per la vigilanza sugli istituti di emissione e sui servizi del Tesoro*, Rome, Tipografia dell'Unione Editrice, 1895-1913

Figure 2. Actual and unweighted measures of Italian discount rates (1895-1913)



The Figure shows levels and monthy changes of the actual discount rate, constructed as described in the text (solid lines), and of the unweighted measure of the discount rate (dashed lines) over the 1896-1913 period. Source: Ministero del Tesoro,*Bollettino dell'Ufficio centrale di ispezione per la vigilanza sugli istituti di emissione e sui servizi del Tesoro*, Rome, Tipografia dell'Unione Editrice, 1895-1913.

Figure 3. Distributions of monthly changes of the discount rate (1895-1913)



The Figure displays histograms of the distributions of monthly changes of the actual measure of the discount rate (upper plot) and of the unweighted discount rate (lower plot) on the 1895-1913 period. Source: Ministero del Tesoro, *Bollettino dell'Ufficio centrale di ispezione per la vigilanza sugli istituti di emissione e sui servizi del Tesoro*, Rome, Tipografia dell'Unione Editrice, 1895-1913.

3 Objectives of the discount rate policy: the coeval perspective

Having derived a new measure of the Bank of Italy's actual discount rate, our next step is to test its quantitative determinants, in line with the approach of the "first wave" of the international literature. Previous research on the topic (Ciocca 1973; Fratianni and Spinelli, 1997; Bonelli and Cerrito, 1999 and 2000; Spinelli and Trecroci, 2012) suggests that four main considerations inspired the discount rate policy adopted by the Bank of Italy: the conditions of the international monetary and financial markets, the exchange rate, the state of the domestic economy (and the domestic demand for credit), and the Bank's own exposure measured by the reserves coverage, as well as the legal ceilings to money printing imposed by the government.[5]

If a general consensus exists on the main determinants of the Italian discount rate policy, it is far from straightforward to translate them into precise quantitative measures and/or to specify the type of relationship that these variables held with the discount rate. In order to make our study historically meaningful, we base our analysis on the information available in the Bank's annual reports to the shareholders.

In the case of the exchange rate, the identification of the relevant variable to use is uncontroversial. In the annual reports, the foreign currency of reference is the fully-convertible French franc rather than the British pound, given the strength of the commercial and financial links between Italy and France.

Matters, however, become more complicated for the other determining factors: international monetary conditions, the state of the domestic economy, and the Bank of Italy's exposure. References to these issues are indeed constantly made in the annual reports, but often in a rather vague way as regards to both their quantification as well as their actual role in the Bank's discount rate policy.

The conditions of the international monetary markets were indeed closely monitored by looking at foreign rates, but it is hard to tell whether the Bank used one specific rate as its main guidance. Depending on the year, reference is made to different primary European financial markets (Britain, France, Germany), and the reports' focus similarly switches from official discount rates to open market rates. It is also mostly unclear whether the Italian authorities reacted to levels (or given thresholds) and/or variations of international rates. Therefore, in the following empirical analysis, we make use of several foreign interest rates, namely the official British and French discount rates, and the commercial, open market, French interest rate. Those rates are portrayed in Figure 4 together with the Bank of Italy's actual discount rate. The Figure clearly shows that the Italian rate was constantly above all other rates

[5] According to Fratianni and Spinelli (1997), the Bank of Italy took a countercyclical attitude towards the state of the domestic economy, but the Bank's own exposure represented its main priority.

during the whole 1896-1913 period, in line with the established view that countries at the periphery of the system had to keep a positive spread vis-à-vis the rates prevailing in core economies. Again not surprisingly, in France the official discount rate worked as the ceiling for the commercial rate, the latter showing much more variability in the face of changing market conditions. Finally, although syncronized, the Italian rate never fully followed the spikes of the British official rate, suggesting a limited pass-through and a substantial degree of sterilization that will be further investigated in Section 5.

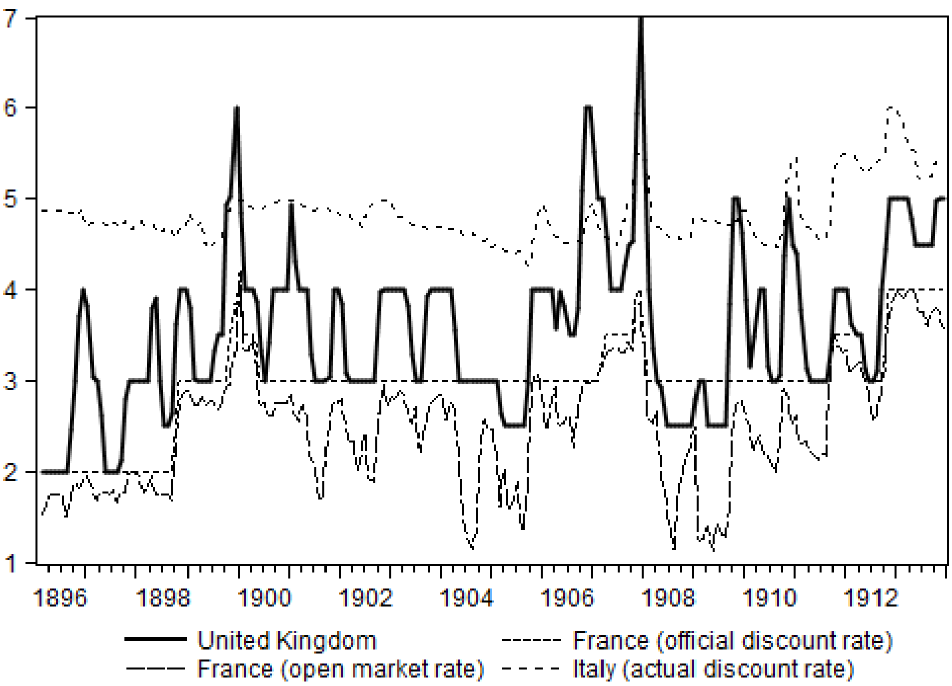
In depicting the conditions of the domestic credit market, the demand for discounts (and advances) appears rather consistently over the years as the main indicator,[6] although its precise relation to the discount rate is vague. The Bank of Italy certainly reacted to situations defined as "excessive expansions" or "speculation", but what exactly this meant, as well as what precise change in the discount rate could be expected, remains unclear.

Finally, as for the Bank's own exposure, most references concern the maximum amount of circulation allowed by law, rather than the reserve coverage, the latter being the standard variable used in the literature (for the case of Italy, see Spinelli and Trecroci 2012). In fact, given the institutional settings governing money issuing, the two aspects can be seen to some extent as two sides of the same coin. Under Italian laws the Bank of Italy could, in principle, expand its circulation above the theoretical maximum, at the cost of facing punitive conditions. Those conditions varied over the years but, in general, implied larger (and growing) reserve coverage if the upper limits set by law were exceeded.[7] Even in this case, however, the sources do not allow us to establish a precise relation between a given change in this variable and the level of the discount rate. To capture the role played by domestic credit market conditions and the Bank of Italy's position in shaping the Bank's discount rate policy, we rely on two variables from the Bank of Italy's balance sheet: the domestic asset portfolio (comprising discounts and advances), and the reserve coverage ratio (i.e. the ratio of international reserves to domestic money in circulation), plotted in Figure 5. The Figure tells a rather well-known story: the position of the Bank in terms of reserve coverage rapidly improved since the turn of the century, and this was paralleled by a similar upward trend in the amount of the domestic portfolio. Overall, the evolution of the two variables suggests a common long-run comovement, whereby the domestic portfolio and the reserve coverage ratio share an increasing trend over the decades, although with even lengthy periods of divergent behaviour. The idea of a long-run equilibrium relation between the two variable, coupled with short-run deviations, will be used to interpret some features of the Bank of Italy's discount rate policy in the empirical analysis of the following Section.

[6] Ciocca (1973) argued that since 1905 also the conditions of the stock market partly determined the actions of the Bank of Italy.

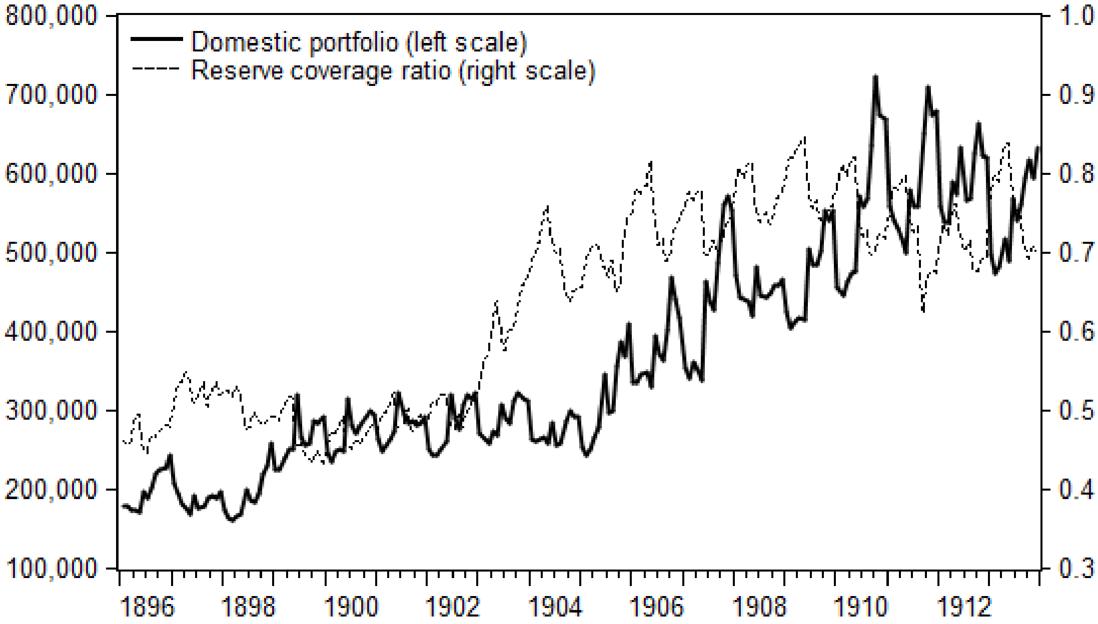
[7] The legal provisions were originally established by the 1893 law and subsequently changed in 1907 and 1913.

Figure 4. International discount rates (1896-1913)



Sources: Italian actual discount rate: Ministero del Tesoro, *Bollettino dell'Ufficio centrale di ispezione per la vigilanza sugli istituti di emissione e sui servizi del Tesoro*, Rome, Tipografia dell'Unione Editrice, 1895-1913; French official discount rate: Banca d'Italia, *Tassi ufficiali di sconto dei principali paesi esteri industrializzati 1800-1932* (available at *www.bancaditalia.it/statistiche/tematiche/stat-storiche/stat-storiche-esterna)*; French open market rate and UK discount rate: *NBER Macrohistory database (* available at *www.nber.org/research/data/nber-macrohistory-database).*

Figure 5. Bank of Italy's domestic portfolio and reserve coverage ratio (1896-1913)



The Figure shows the domestic portfolio of the Bank of Italy (thousands of Italian Lira; left scale) and the Bank of Italy's reserve coverage ratio (i.e. the ratio of international reserves to money in circulation; right scale). Source: Ministero del Tesoro, *Bollettino dell'Ufficio centrale di ispezione per la vigilanza sugli istituti di emissione e sui servizi del Tesoro*, Rome, Tipografia dell'Unione Editrice, 1895-1913.

4 The determinants of discount rate policy in Italy: an econometric analysis

This Section presents an econometric model of the Bank of Italy's discount rate policy focused on the main determinants of the Bank's decisions highlighted in the forgoing discussion: changes in leading international rates, fluctuations in the exchange rate, and the dynamics of the Bank's domestic portfolio and international reserves. Historians are in agreement on the fact that the period under study in this paper is marked by a net discontinuity around the end of 1902, when most macroeconomic variables, particularly the exchange rate, began to display remarkable stability after the long liquidation of the 1893 banking crisis.[8] For this reason we present results for the whole period under investigation (1986-1913), as well as for the later part of the sample (1903-1913).

We model monthly changes of the Italian actual discount rate (ΔR^{IT}) starting from general dynamic specifications including monthly changes and lagged levels of all the main variables likely affecting the Bank of Italy's discount rate policy: foreign (British and French) official discount rates (R^{UK} and R^{FR}), the open market French rate (R^{FR}_{omr}), the French franc/Italian lira exchange rate (EXR), the Bank of Italy's domestic portfolio (DOM, in logarithms), and reserve coverage ratio ($RCOV$). Introducing both first differences and lagged levels of the regressors allows us to capture any potential long-term relationship between the level of R^{IT} and its determinants together with short-run responses of the Italian rate to changes in foreign rates, the exchange rate, and the Bank's position in terms of domestic and international assets.

Table 1 displays results for three specifications of the model estimated on the full sample (1986-1913) and on the last decade (1903-1913). Columns (a) and (d) present estimates of a "basic" dynamic model including contemporaneous changes and lagged levels of the British and French discount rates, the open market French rate, and the French franc/Italian lira exchange rate. The "extended" specifications in columns (b) and (e) add lagged differences and levels of the Bank of Italy's domestic portfolio and of the reserve coverage ratio. Columns (c) and (f) present our preferred "final" specifications, where only statistically strongly significant variables are retained. In all specifications, also the lagged change of the Italian actual discount rate (ΔR^{IT}_{t-1}) is included, in order to capture persistence in the response of R^{IT} to changes in its determining factors. For each equation, the p-values of mis-specification tests for residual autocorrelation ($LM(6)$) and autoregressive conditional heteroskedasticity ($ARCH(6)$) up to the sixth order are reported.

Looking at the whole period 1896-1913, several results clearly stand out. First, variations of both the British and the French official discount rates trigger a positive response of the

[8] Ciocca (1973) suggests that a structural break in terms of discount rate policy occurred after 1905. We use this alternative periodization as a robustness check on our results, replicating the analysis on the 1906-1913 sample.

Bank of Italy's rate, although of a limited size. In particular, in the face of a 100-basis point rise in the Bank of England discount rate, R^{IT} increases by only around 3-4 basis points, whereas the reaction to a rise in the French official discount rate of the same magnitude is estimated in the 16-18 basis points range. No statistically significant response to changes of the open market French interest rate (ΔR^{FR}_{omr}) is detected. As for the lagged level terms, beside the Italian discount rate (R^{IT}_{t-1}), only the French open market rate ($R^{FR}_{omr,t-1}$) displays a strong statistical significance, hinting at a potential long-run relationship between the two rates, an issue that we will address below.

The lack of a contemporaneous response to variations of foreign commercial rates, as well as the very limited reaction to changes of leading international official discount rates, deserve further investigation. In fact, this finding might hide a more complex story, whereby Italian monetary authorities adjusted the domestic discount rate only to "moderate" changes in international rates, not reacting to changes of a larger size.[9] Thus, the lack of, or limited, response of the Italian rate might be the result of two very different types of behaviour: a strong reaction in the face of limited changes in the international rates, and a weak (or no) response to larger variations. Two considerations justify this hypothesis. First, in general the Bank of Italy had limited trust in the discount rate as an effective tool to influence international capital flows,[10] particularly during international crises. Hence, the Italian central bank was not at ease to follow substantial increases of foreign rates when coinciding with international financial shocks, preferring direct interventions in credit and exchange rate markets instead.[11] Second, the Bank of Italy was also very concerned about the absolute size that the discount rate was supposed to be raised to in such circumstances. Indeed, the Bank expressed this view adamantly in 1899 stating that "even under the arguable hypothesis that an increase in the discount rate could have attracted money to Italy from abroad, we should have raised it by various points above six and seven percent, the money price on the main foreign markets, that is to say to levels absolutely unsustainable for the national commerce and industry."[12] A problem we encounter in testing the hypothesis of a possible nonlinear reaction to changes in international rates, is that the Bank of Italy did not specify any precise threshold above which its response was to be more limited. Moreover, variations of international discount rates that can be seen as abnormal were very rare, making the results of statistical tests difficult to interpret. With these caveats in mind, we limit our analysis to the more volatile

[9] The existence of different "regimes" of reaction to international rates has been argued for by Bazot et al. (2016) in the case of France, although in an opposite direction. In fact, the Bank of France followed increases in the British discount rate (i.e. did not "sterilize") "when gold losses and exchange rate variations were too extreme " (p. 102).

[10] Bank of Italy, *Annual Report 1899* (p. 26), as reported by Spinelli and Trecroci (2012, p. 52). This was a common feeling among central bankers at the periphery; see, for instance, the position of the central bank in Portugal (Reis, 2007) and Austria (Morys, 2003).

[11] See, in particular, the documents collected in De Cecco (1990) and referring to the international crises occurred in 1885 and 1889 (document 139), and February 1904 (documents 190, 195, and 198).

[12] Bank of Italy, *Annual Report 1899*, p. 27 (authors' translation).

French commercial open market rate (ΔR^{FR}_{omr}), distinguishing between changes smaller and larger than 30 basis points (corresponding to one standard deviation of monthly variations in this rate over the full sample). When our "extended" model in Table 1 is modified in this way, estimation results do not support the hypothesis of a differential reaction of the Italian discount rate to small and large changes in the French open market rate.[13]

A second important finding from the model in Table 1 is that no statistically significant reaction of the Italian discount rate to movements in the exchange rate is detected, apparently in contrast with the attention devoted to this variable by coeval commentaries. Only in the later part of the sample there is evidence of a very weak positive response to depreciations of the Italian lira vis-à-vis the French franc: the estimated coefficient on $\Delta\, EXR$ (6.954, with an associated p-value of 0.21) implies that a 0.17% monthly depreciation of the lira (equal to the standard deviation of $\Delta\ EXR$ over the 1903-1913 period), triggers an increase of the actual discount rate of only slightly more than one basis point. To investigate further, similarly to what we did in the case of international discount rates, we test for a possible non-linear resoinse. Specifically, we isolated the episodes of depreciation (i.e. $\Delta\ EXR > 0$) larger than one standard deviation of $\Delta\ EXR$, allowing for a different volatility of the exchange rate over the sample. In particular, in the first part of the sample (1986-1902), we selected 8 episodes (out of 84 monthly observations) where depreciations larger than 0.55% occurred, whereas 14 monthly depreciations (out of 132 observations) larger than 0.17% were detected in the 1903-1913 decade. We then tested the hypothesis that the discount rate reacted only to relatively large depreciations of the lira by including only those episodes into the "extended" specifications of the model, in place of the $\Delta\, EXR$ variable constructed over the whole sample. The results confirmed the substantial lack of reaction of the discount rate to (even large) exchange rate movements.[14] On this basis, we omitted exchange rate variables from our final model specification.

A final key finding to highlight about the "extended" models in Table 1 concerns the block of explanatory variables capturing the effects of domestic credit and international reserve conditions on the Italian discount rate. Here an expansion of the Bank of Italy' domestic portfolio (captured by $\Delta\, DOM_{t-1}$) triggers a large positive response of the discount rate in the following month. Also the lagged levels of both domestic credit (DOM_{t-1}) and the reserve coverage ratio ($RCOV_{t-1}$) display strongly statistically significant coefficients of opposite sign. Overall, these results seem to confirm the coeval consensus about the internal determinants of the discount rate policy, according to which the Bank of Italy raised the discount rate

[13] In particular, over the full sample the estimated response of the Italian rate to "small" and "large" changes in the French open market rate are 0.014 and 0.037, respectively (with p-values for the hypothesis of no reaction of 0.69 and 0.37). For the later sub-sample (1903-1913) the corresponding values are 0.047 and 0.021 (with associetd p-values 0.31 and 0.71).

[14] The estimated coefficients were 5.44 for the full sample and 11.45 for the 1903-1913 period, with associated p-values of 0.17 and 0.27, respectively

reacting to both a worsening of its reserve position (i.e. a decrease in the reserve coverage ratio) and an increase in the demand for domestic credit.

In order to provide a more insightful account for the results discussed above, we reparameterize the "final" models in columns (c) and (f) of Table 1, where only strongly statistically significant regressors are retained, in equilibrium-correction form, shown in Table 2.[15] The estimated model is now the following:

$$\begin{aligned}\Delta R_t^{IT} = c + \rho\,\Delta R_{t-1}^{IT} + \beta_{UK}\,\Delta R_t^{UK} + \beta_{FR}\,\Delta R_t^{FR} + \gamma_R\,(R_{t-1}^{IT} - \kappa_R\,R_{om,\,t-1}^{FR}) \\ +\gamma_P\,(DOM_{t-1} - \kappa_P\,RCOV_{t-1}) + \delta_P\,\Delta\,DOM_{t-1} + \varepsilon_t\end{aligned} \tag{1}$$

where ρ captures the persistence of the response of R^{IT} to its determinants, β_{UK} and β_{FR} measure the contemporaneous reaction of the Italian rate to the British and French discount rates, and δ_P estimates the response to past expansions of the Bank of Italy's domestic asset portfolio. The terms in brackets describe two additional factors causing fluctuations in the the Italian discount rate. The first is a reaction of R^{IT} (measured by the negative coefficient γ_R) to deviations from its long-run relationship with the level of the French open market rate: the Bank of Italy decreases the discount rate whenever a positive deviation from the long-run equilibrium with R_{omr}^{FR} occurred in the previous month $(R_{t-1}^{IT} - \kappa_R\,R_{om,\,t-1}^{FR})$. Although, as shown in Table 1, there is no detectable contemporaneous reaction of R^{IT} to R_{omr}^{FR}, the Bank of Italy strongly responded to past misalignments between the two rates, trying to re-establish an equilibrium relation (measured by the coefficient κ_R) in the long-run. Overall, our interpretation of the Bank of Italy's reaction to international rates is that while the Bank responded contemporaneously (although rather mildly) to changes in the official discount rates of both Britain and France, it did not do so in case of variations of the French market rate; rather, it smoothed out its reaction over time to maintain a long-term equilibrium relationship between R^{IT} and R_{omr}^{FR}.

Finally, the results in Table 2 suggest that the Bank of Italy managed the discount rate also in response to misalignments between two important items of its balance sheet: the domestic asset portfolio and the reserve coverage ratio. An expansion of the domestic portfolio beyond its long-run desired relationship with the reserve coverage ratio (measured by the coefficient κ_P) entails an equilibrating increase of the discount rate in the following month (captured by the positive coefficient γ_P). This result strongly suggests that, in making decisions about the discount rate, the Bank of Italy did not take separately into account the domestic portfolio and the international reserves; rather it had in mind an equilibrium between those two quantities and used variations of the discount rate to try and correct past deviations from such a

[15] The mis-specification tests reported in Table 1 show that our "final" model does not show any sign of residual autocorrelation and autoregressive conditional heterosckedasticity, supporting the statistical adequacy of the chosen specification on both the whole sample and the later sub-period. Our results are also robust when the model is estimated on the 1906-1013 sub-sample, following Ciocca (1973).

relationship.[16]

On the whole, the econometric model for changes of the Bank of Italy's actual discount rate presented in Table 2 is able to capture all the main determinants of the Bank's policy, namely the role of leading international rates both in the short and the long run, and the effort of this institution to maintain a desired balance between domestic credit expansion and international reserves. Figure 6, showing the realized discount rate and the fitted values from estimation of (1) both in levels and monthly changes, also documents the fairly good predictive power of the model, which is able to track closely the wide fluctuations of the rate especially in the last decade of the sample.

[16] The non-stationary statistical feature of the domestic portfolio and reserve coverage ratio series (together with the stationarity of the Italian discount rate) suggest to investigate further their relationship with R^{IT} in the context of a VAR system allowing explicitly for a long-run relation between DOM and $RCOV$, interpreted as a cointegrating vector. This analysis is performed in Section B of the Appendix, and fully supports the results of Table 2 on both the whole sample and on the later sub-period.

Table 1. The econometric model for Italian actual discount rate changes

Dependent variable:	$\Delta\, R_t^{IT}$					
Sample:	1896(1)-1913(12)			1903(1)-1913(12)		
	(a) Basic	(b) Extended	(c) Final	(d) Basic	(e) Extended	(f) Final
$\Delta\, R_{t-1}^{IT}$	0.333*** (0.061)	0.262*** (0.059)	0.266*** (0.056)	0.389*** (0.077)	0.247*** (0.074)	0.262*** (0.067)
$\Delta\, R_t^{UK}$	0.044** (0.019)	0.029* (0.017)	0.033** (0.015)	0.053* (0.028)	0.028 (0.025)	0.033 (0.022)
$\Delta\, R_t^{FR}$	0.180*** (0.067)	0.163*** (0.061)	0.177*** (0.056)	0.287*** (0.105)	0.330*** (0.093)	0.300*** (0.085)
$\Delta\, R_{om,\,t}^{FR}$	0.057* (0.030)	0.007 (0.029)		0.071* (0.041)	−0.021 (0.039)	
R_{t-1}^{IT}	−0.128*** (0.027)	−0.149*** (0.028)	−0.146*** (0.025)	−0.176*** (0.044)	−0.243*** (0.047)	−0.186*** (0.036)
R_{t-1}^{UK}	−0.014 (0.013)	−0.008 (0.012)		−0.009 (0.019)	−0.009 (0.018)	
R_{t-1}^{FR}	−0.012 (0.025)	−0.045* (0.025)		0.029 (0.057)	−0.082 (0.054)	
$R_{om,\,t-1}^{FR}$	0.070*** (0.022)	0.055*** (0.021)	0.027** (0.012)	0.067** (0.029)	0.014 (0.024)	0.048*** (0.016)
$\Delta\, EXR_t$	−0.029 (1.975)	1.077 (1.849)		3.857 (6.291)	6.954 (5.610)	
EXR_{t-1}	−0.077 (0.303)	−0.148 (0.391)		1.846 (2.638)	1.544 (2.525)	
$\Delta\, DOM_{t-1}$		0.239** (0.093)	0.226*** (0.080)		0.316** (0.129)	0.263** (0.113)
DOM_{t-1}		0.168*** (0.036)	0.141*** (0.031)		0.230*** (0.048)	0.197*** (0.043)
$\Delta\, RCOV_{t-1}$		0.125 (0.330)			0.615 (0.424)	
$RCOV_{t-1}$		−0.380*** (0.105)	−0.362*** (0.085)		−0.712*** (0.199)	−0.507*** (0.162)
c	0.887 (1.418)	−0.458 (1.921)	−0.930*** (0.318)	−7.889 (12.020)	−0.739 (11.453)	−1.410*** (0.437)
T	216	216	216	132	132	132
R^2	0.34	0.46	0.45	0.44	0.58	0.56
$LM(6)$ (p-value)	0.26	0.21	0.16	0.48	0.45	0.20
$ARCH(6)$ (p-value)	0.01**	0.19	0.08	0.01**	0.24	0.28

For all specifications, estimated coefficients with standard errors in parentheses are reported. *,** and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. R^{IT} is the actual Italian discount rate (constructed as detailed in the main text); R^{UK} and R^{FR} are the official British and French discount rates; R_{om}^{FR} is the French open market interest rate; EXC is the (logarithm of) the French franc/Italian lira exchange rate; DOM is the (logarithm of) the Bank of Italy's domestic portfolio; $RCOV$ is the Bank of Italy's reserve coverage ratio (defined as the ratio of international reserves to money in circulation). T denotes the number of observations used in estimation. $LM(6)$ and $ARCH(6)$ are the Lagrange multiplier tests for residual serial correlation and autoregressive conditional heteroskedasticity up to the sixth order, respectively. For both tests, p-values are reported.

Table 2. Modelling actual discount rate changes

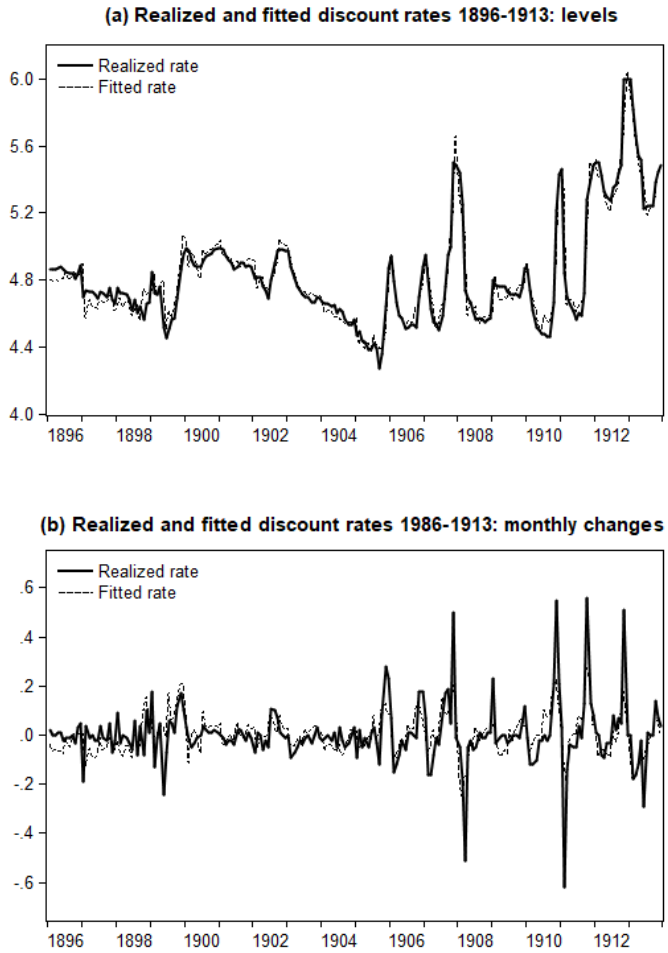
Dependent variable:	ΔR_t^{IT}	
Sample:	1896(1)-1913(12)	1903(1)-1913(12)
ρ_{IT}	0.266*** (0.056)	0.262*** (0.067)
β_{UK}	0.033** (0.015)	0.033 (0.022)
β_{FR}	0.177*** (0.056)	0.300*** (0.085)
γ_R	−0.146*** (0.025)	−0.186*** (0.036)
κ_R	0.186** (0.074)	0.256*** (0.072)
γ_P	0.141*** (0.031)	0.197*** (0.043)
κ_P	2.565*** (0.361)	2.576*** (0.737)
δ_P	0.226*** (0.080)	0.263** (0.113)
c	−0.930*** (0.318)	−1.410*** (0.437)
T	216	132
R^2	0.45	0.56
$LM(6)$ (p-value)	0.16	0.20
$ARCH(6)$ (p-value)	0.08	0.28

For both samples, estimated coefficients with standard errors in parentheses are reported. *, ** and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. The estimated model is of the following form:

$$\Delta R_t^{IT} = c + \rho \, \Delta R_{t-1}^{IT} + \beta_{UK} \, \Delta R_t^{UK} + \beta_{FR} \, \Delta R_t^{FR} + \gamma_R \, (R_{t-1}^{IT} - \kappa_R \, R_{om,\,t-1}^{FR})$$
$$+ \gamma_P \, (DOM_{t-1} - \kappa_P \, RCOV_{t-1}) + \delta_P \, \Delta \, DOM_{t-1} + \varepsilon_t$$

where R^{IT} is the actual Italian discount rate; R^{UK} and R^{FR} are the official British and French discount rates; R_{om}^{FR} is the French open market interest rate; DOM is the (logarithm of) the Bank of Italy's domestic portfolio; $RCOV$ is the Bank of Italy's reserve coverage ratio (defined as the ratio of international reserves to money in circulation). T denotes the number of observations used in estimation. $LM(6)$ and $ARCH(6)$ are the Lagrange multiplier tests for residual serial correlation and autoregressive conditional heteroskedasticity up to the sixth order, respectively. For both tests, p-values are reported

Figure 6. Realized and fitted discount rates (1896-1913)



The Figure displays the levels (panel (a)) and the monthly differences (panel (b)) of the realized values of the actual Italian discount rate (solid lines) and of the fitted values obtained from the estimated model in equation (1) (dashed lines) over the 1896-1913 period.

5 Reactions to shocks and "sterilization"

The finding of a limited reaction of the Italian discount rate to variations of international official rates, in line with what suggested by coeval qualitative evidence, reveals that Italy too embraced quite openly what in modern terminology we refer to as "sterilization" policy (Officer 2018). In the spirit of the "second wave" of the international literature mentioned in the introduction, Bazot, Monet and Morys (2022) have recently argued that these strategies, aiming at insulating domestic economies from exogenous increases in leading international rates, were very commonly adopted during the gold standard age. The specific case of Italy in this narrative can only partly be derived from their study, which considers a pool of 21 countries. In the model of "sterilization" used by Bazot, Monet and Morys (2022), countries which decided not to pass through to the domestic economy the entire increase of the (exogenous) British discount rate, had to face an increase in the domestic demand for discounts. They also had to deal with an exchange rate depreciation, caused by international capital mobility, unless international reserves were committed to defend currency stability. Between 1903 and 1911 Italy was part of a group of countries which managed to partly sterilize the impact of increases in the British discount rate by expanding the domestic portfolio and spending international reserves to limit the impact of sterilization on exchange rate fluctuations. In the years before and after this phase, Italy is considered instead among economies on a floating exchange rate regime, which let this variable to fully absorb the effects of the limited response to external shocks.

The aim of this Section is to explore the Italian case on its own, using a new measure of the discount rate. In so doing, we take less a draconian view on the difference between the two regimes described above, and implement our main empirical investigation on the whole 1896-1913 sample. However, we perform the analysis also on the post-1902 sub-period as a robustness check.

To assess the reaction of the Italian discount rate, the Bank of Italy's domestic and international portfolios and the French franc/Italian lira exchange rate to an unexpected exogenous variation in the British discount rate, we set up a 5-variable VAR model including the British discount rate (R^{UK}), the domestic portfolio and international reserves of the Bank of Italy (DOM and INT, both in logarithms), the French franc/Italian lira exchange rate (EXR, in logarithms), and the actual Italian discount rate (R^{IT}). The VAR is specified over the 1896(1)-1913(12) period with two lags of all endogenous variables, and the impulse responses of all series to an innovation in R^{UK} are obtained. Following the insight of Bazot *et al.* (2022), a simple Choleski identification scheme is used, with R^{UK} placed first in the ordering. Note that the ordering chosen for the remaining variables does not affect their impulse responses to an innovation in R^{UK}.

Figure 7 shows the responses up to 36 months of all series to a one-standard deviation exogenous innovation in the British discount rate, corresponding to 40 basis points. On two dimensions the results for Italy are in line with the predictions of the model. First, a very limited pass-through to the domestic actual discount rate is detected. In the face of a 40-basis point rise in the British discount rate, the increase of the Italian actual rate is less than 2 basis points on impact (5%), and reaches around 5 basis points after two months (13%), before declining rapidly thereafter. Second, the domestic portfolio is expanded by 2% on impact: this reaction is fairly limited in size, since only a relatively small share of Italian firms could choose whether to re-discount their bills abroad or domestically. However, on another key aspect Italy actually looks like a "dissonant violin": sterilization took place without any decline in international reserves or an exchange rate depreciation. Indeed, what emerges is a phenomenon that we can define as "free sterilization". To make sense of this apparent anomaly it is necessary to start from the consideration that, in the case of Italy, the specific type of capital outflows that most directly impacted on exchange rate fluctuations took the form of international investors selling back gold-denominated Italian bonds floated in international markets. The ensuing decline in bond prices opened a gap vis-à-vis the price of the Lira-denominated public bonds (called "*Rendita*") quoted in the Italian market, as this price tended to remain more stable thanks to the action of institutional investors. This gap made it convenient to buy gold against Lire in Italy to purchase gold-denominated bonds abroad and sell them back in Italy at a profit. The rise of the price of gold in Lire (*de facto* equivalent to an exchange rate depreciation against gold-based currencies) eventually tended to close the window for arbitrage, re-establishing the equilibrium between the two prices. Although opinions diverged on the actual deeper cause of the changes of the Italian bonds prices in international markets, this mechanism was considered by all coeval observers as the main proximate determinant of exchange rate fluctuations. More recent econometric evidence also supports this view (Tattara, 2003).

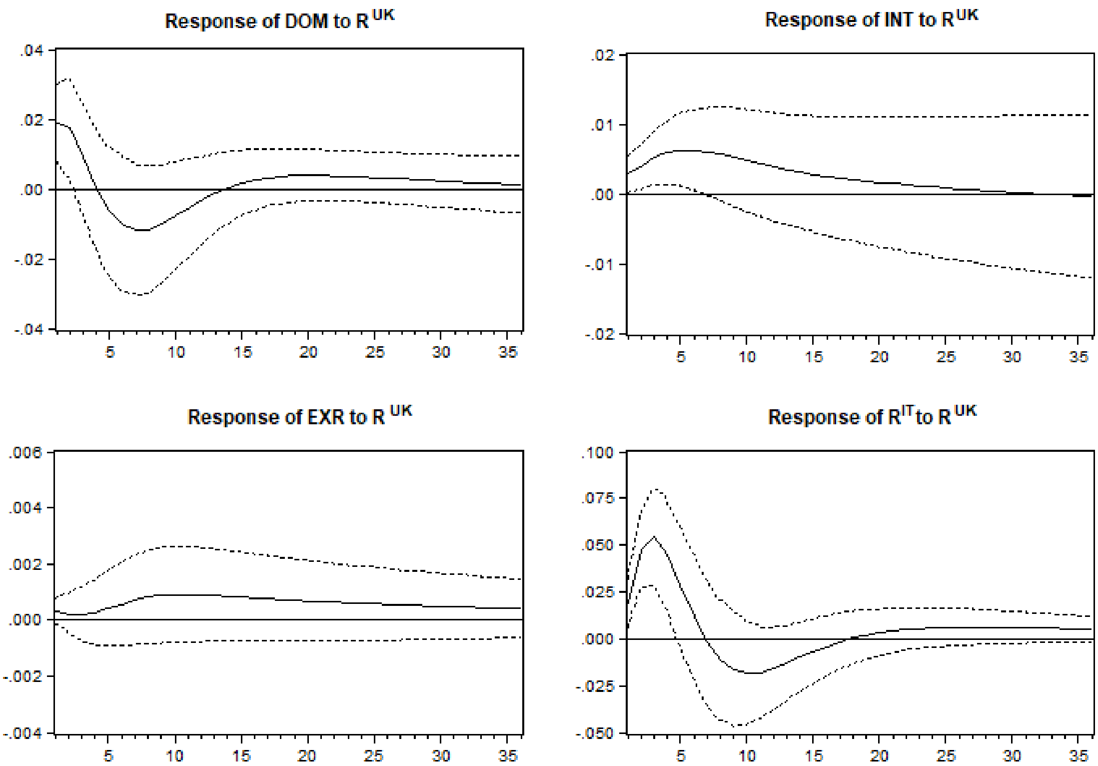
Given the existence of this mechanism, the model of sterilization proposed by Bazot *et al.* (2022) can apply to Italy, and be supported by econometric evidence, only assuming that the attitude of international investors towards Italian public bonds (determining their price, the gap vis-à-vis their quotation on the Italian market, and exchange rate variations) was sensitive to any innovation in the spread between the British and the Italian discount rates. Thus, as a further investigation, we estimated a VAR model with the price of the Italian *Rendita* (quoted on the Paris financial market) in the place of the exchange rate. The results, reported in Section C of the Appendix, confirm the pattern of responses of all variables to an innovation in the British rate: a limited pass through to the Italian discount rate, a moderate and short-lived expansion of the Bank of Italy's domestic portfolio, and no effect on the Italian bond price and on the exchange rate.

Overall, our findings point towards the lack of full integration with the British financial market, probably due to the existence of transaction costs. At first glance, narrative evidence supports this hypothesis; for good and for bad, international investors were likely to make decisions on Italian bonds according to their perception of the state of "fundamentals", such as the conditions of public finance, fiscal revenues, and money supply. A case in point is the lack of reaction of the *Rendita*'s price following the decision, occurred in 1906, to replace a stock of bonds bearing a nominal interest of 5% with equivalent assets yielding a 3.5% nominal return instead. In this respect, it is likely that the opening of a gap between Italian and international rates *per se* made little, if any, difference to investors' decisions.

Finally, we investigated whether the pattern of responses changes when the exogenous impulse comes from an innovation in the French discount rate, since our findings in the previous Section show a larger response of the Italian actual discount rate to the French rate rather than to the British one. To this aim, we estimated the same five-variable VAR system with the French official discount rate placed first in the ordering in the place of the British rate. Figure 8 displays the impulse responses of the endogenous variables to a one-standard deviation innovation in the French rate, corresponding to 10 basis points. The pass through to the Italian discount rate is still limited (going from 2.5 basis points on impact to 4.5 basis points after two months), though larger than in the case of innovations in the British rate. The response of the Bank of Italy's domestic asset portfolio is positive (between 1% and 2%) but hardly statistically significant, and no significant responses are detected for the Bank's international portfolio and for the exchange rate. Here our interpretation is similar as for the case of the British official rate. Despite a higher degree of financial integration between the Italian and the French financial markets, still the existence of frictions made it possible a form of "free sterilization": a limited discount rate pass-through was compatible with almost no change in the domestic portfolio and with no consequences on the exchange rate, and hence with no need to spend foreign reserves. Again, this pattern of responses is confirmed when the Italian *Rendita*'s price replaces the exchange rate in the estimated system, as shown in Section C of the Appendix.

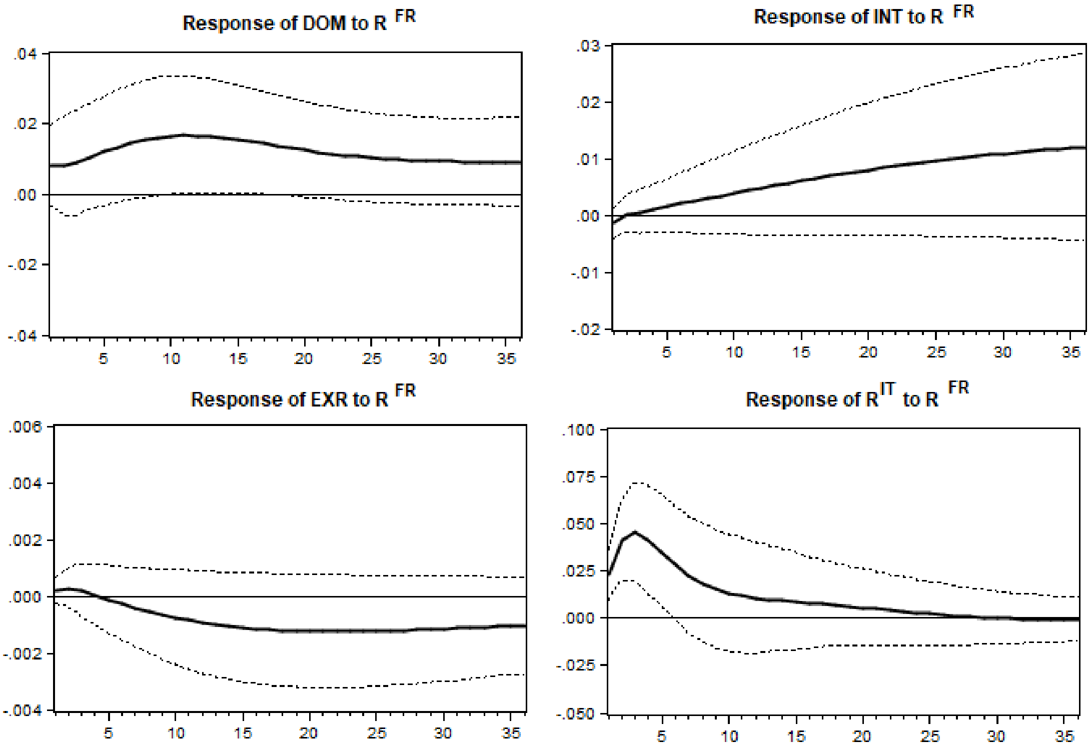
Very similar results are obtained when the estimation sample is limited to the post-1902 period and when innovations to the French open market interest rate are considered as an exogenous source of shocks in the place of unexpected changes in the official discount rate.

Figure 7. Responses to an innovation in the British discount rate



The Figure displays the impulse response functions to a 0.40% innovation in the British discount rate of the Bank of Italy's domestic portfolio and international reserves (DOM and INT, in logarithms), the French franc/Italian lira exchange rate (EXC, in logarithm) and the actual Italian discount rate (R^{IT}). The responses, obtained using a Choleski identification scheme with the British discount rate ordered first, are shown up to 36 months with 95% confidence intervals. The estimation sample is 1896(1)-1913(12).

Figure 8. Responses to an innovation in the French discount rate



The Figure displays the impulse response functions to a 0.10% innovation in the French official discount rate of the Bank of Italy's domestic portfolio and international reserves (DOM and INT, in logarithms), the French franc/Italian lira exchange rate (EXC, in logarithm), and the actual Italian discount rate (R^{IT}). The responses, obtained using a Choleski identification scheme with the French official discount rate ordered first, are shown up to 36 months with 95% confidence intervals. The estimation sample is 1896(1)-1913(12).

6 Conclusions

Little is still known about the discount rate policy implemented in Italy during the international gold standard period. Using a novel series of its discount rate, the paper fills this gap analyzing the action of the main Italian bank of issue, the Bank of Italy, from its establishment to the eve of World War I. Given the dominant position of this institution in the panorama of Italian banks of issue, our results acquire a systemic character.

To what extent can we actually conclude that Italy was a "dissonant violin" in the international orchestra? In accordance with the results of the most recent literature, it is probably fair to argue that if international central banking during the gold standard can be seen through a music metaphor, the music scene of late 19th-early 20th century resembled more a dodecaphonic concert than a classic symphony with instruments paying more or less in tune with the director's guidance. Digging into the Italian case shows, nonetheless, some interesting (maybe unique) peculiarities.

In terms of discount rate setting, in fact the Bank od Italy was not dissimilar from other contemporary institutions, and corporate aims (arising from the impact of the liquidity ratio and of the domestic portfolio) together with reactions to international rates explain most of the policy. Our empirical investigation confirms that the available literature was right in indicating deep changes in the discount rate policy since about the end of the century. Interestingly, over the whole period considered, no statistically significant effect of the exchange rate on the discount rate is detected, despite some rather clear indication of the relevance of this variable in the official reports published by the Bank. Even considering different "regimes" of response to exchange rate variations (i.e. above or below a given threshold), no clear relation emerges.

If the variables that the Bank of Italy took into account in its decisions about the discount rate are relatively standard, our analysis reveals how they are part of an interesting and complex decision-making process, with the Bank simultaneously paying attention to short-term responses and to long-term relationships. The Bank reacted contemporaneously to changes in leading international discount rates, albeit with a limited pass-through. However, this response occurred together with the Bank's effort to try and correct past deviations from the equilibrium relation of the Italian rate with the French open market rate, and past excessive expansions of the domestic portfolio as regards to the level of international reserves.

If there is an area where Italy might look like a "dissonant violin" this concerns the policy of "sterilization" of international discount rates. As compared to the general categories identified by Bazot, Monnet and Morys (2022), Italy seems a story on its own. Autonomous changes in the British rate were almost completely sterilized with little implications: apart from a moderate increase in the domestic portfolio, no effect was visible on the exchange rate. A similar situation took place in case of variations of the French official discount rate, although in this case it seems that a wider degree of pass-through was necessary in order to protect the economy form fluctuations of the exchange rate.

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Appendix

This Appendix presents results from the estimation of the econometric model for monthly changes in alternative measures of the Italian discount rate (Section A), on the relationships between the actual Bank of Italy discount rate, the domestic portfolio, and the ratio of international reserves to domestic money in circulation (Section B), and additional evidence on the effects of an innovation in the British and French discount rates on the Bank of Italy's domestic and international portfolios, on the price of the Italian "Rendita", and on the Italian actual discount rate (Section C).

A. Results for alternative discount rate measures

For comparison, we applied our final model specification to the data for two alternative measures of the Italian discount rate: the (unweighted) average measure R^{IT}_{unw} computed by De Mattia (1967), and a measure of the discount rate weighted with the flows of new discounts, R^{IT}_{w} (Ciocca, 1973). Figure A1 displays R^{IT}_{unw} and R^{IT}_{w} together with the "actual" measure of the discount rate (R^{IT}) described and used in our empirical analysis in Section 4. The three discount rate measures show clear long-run comovements but they also deviate for prolonged periods as in 1897-1899 and in 1908-1910. Correlations of levels and monthly changes are reported in Table A1 for the full 1896-1913 sample and for two sub-periods (1896-1902 and 1903-1913). Whereas correlations of the discount rate levels are fairly high, those among monthly changes are lower, especially in the first sub-period. In particular, the correlation between changes in the actual measure (ΔR^{IT}) and in the commonly used unweighted discount rate (ΔR^{IT}_{unw}), are the lowest both in the overall sample (0.54) and in each sub-period, being as low as 0.20 in 1896-1902.

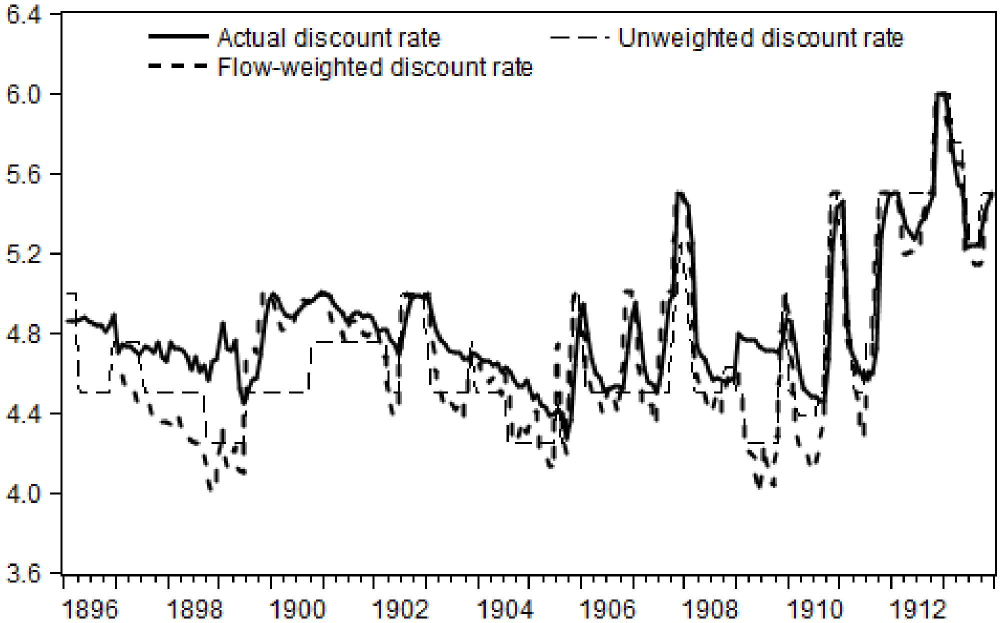
The estimated model is the following ($i = unw$, w):

$$\Delta R^{IT}_{i\,t} = c + \rho\,\Delta R^{IT}_{i\,t-1} + \beta_{UK}\,\Delta R^{UK}_{t} + \beta_{FR}\,\Delta R^{FR}_{t} + \gamma_R\,(R^{IT}_{i\,t-1} - \kappa_R\,R^{FR}_{om,\,t-1})$$
$$+\gamma_P\,(DOM_{t-1} - \kappa_P\,RCOV_{t-1}) + \delta_P\,\Delta\,DOM_{t-1} + \varepsilon_{i\,t}$$

The results, displayed in Table A2, confirm the ability of the model to capture important determinants of monthly changes related to both international and domestic factors also for the alternative measures of the discount rate. However, compared with the full-sample results obtained for the actual discount rate measure (R^{IT}), the model for R^{IT}_{unw} delivers a weaker long-run relationship between the Italian rate and the open market French rate (the estimate of κ_R is not statistically significant), and a substantially lower predictive power ($R^2 = 0.29$). Not surprisingly, given the higher correlation between the actual and the two alternative discount rate measures over the last decade (documented in Table A1), both models fare better over the 1903-1913 sample: the estimated coefficients capturing the long-run relationships among the variables (κ_R and κ_P) and the adjustment dynamics of R^{IT}_{unw} and

R_w^{IT} (γ_R and γ_P) are strongly statistically significant and in line with the values delivered by the model for the actual discount rate.

Figure A1. Actual and alternative discount rate measures



The Figure displays the actual discount rate measure (R^{IT}), constructed as detailed in the text and used in the econometric model presented in Section 5, the unweighted discount rate (R_{unw}^{IT}) in De Mattia (1967), and the flow-weighted discount rate (R_w^{IT}) in Ciocca (1973). The sample is 1986(1)-1913(12) for R^{IT} and R_{unw}^{IT}, and 1897(2)-1913(12) for R_w^{IT}.

Table A1. Correlations between actual and alternative discount rate measures

Whole sample: 1896-1913							
	R^{IT}	R^{IT}_{unw}	R^{IT}_{w}		ΔR^{IT}	ΔR^{IT}_{unw}	ΔR^{IT}_{w}
R^{IT}	0.321			ΔR^{IT}	0.120		
R^{IT}_{unw}	**0.878**	0.408		ΔR^{IT}_{unw}	**0.541**	0.144	
R^{IT}_{w}	**0.894**	**0.897**	0.437	ΔR^{IT}_{w}	**0.706**	**0.698**	0.183

Sub-sample: 1896-1902							
	R^{IT}	R^{IT}_{unw}	R^{IT}_{w}		ΔR^{IT}	ΔR^{IT}_{unw}	ΔR^{IT}_{w}
R^{IT}	0.130			ΔR^{IT}	0.062		
R^{IT}_{unw}	**0.525**	0.206		ΔR^{IT}_{unw}	**0.198**	0.103	
R^{IT}_{w}	**0.804**	**0.695**	0.309	ΔR^{IT}_{w}	**0.544**	**0.688**	0.120

Sub-sample: 1903-1913							
	R^{IT}	R^{IT}_{unw}	R^{IT}_{w}		ΔR^{IT}	ΔR^{IT}_{unw}	ΔR^{IT}_{w}
R^{IT}	0.396			ΔR^{IT}	0.145		
R^{IT}_{unw}	**0.914**	0.487		ΔR^{IT}_{unw}	**0.605**	0.165	
R^{IT}_{w}	**0.921**	**0.933**	0.487	ΔR^{IT}_{w}	**0.731**	**0.700**	0.208

The table reports correlation coefficients (in bold) between the levels (R^{IT}, R^{IT}_{unw} and R^{IT}_{w}) and the first differences (ΔR^{IT}, ΔR^{IT}_{unw} and ΔR^{IT}_{w}) of the actual discount rate (constructed as detailed in the text), the unweighted measure of the discount rate (De Mattia, 1967), and the measure of the discount rate weighted with the flows of new discounts (Ciocca, 1973) respectively, for the whole sample (1896-1913) and for two sub-samples: 1896-1902 and 1903-1913. When R^{IT}_{w} and ΔR^{IT}_{w} are involved, the sample begins in 1897(2). Standard deviations of the discount rate series are shown on the main diagonal of the table.

Table A2. Results for alternative discount rate measures

Dependent variable:	$\Delta R^{IT}_{unw,t}$		$\Delta R^{IT}_{w,t}$	
Sample:	1896(1)-1913(12)	1903(1)-1913(12)	1897(4)-1913(12)	1903(1)-1913(12)
ρ_{IT}	0.149** (0.062)	0.141** (0.073)	0.255*** (0.051)	0.222*** (0.060)
β_{UK}	0.041* (0.021)	0.057* (0.030)	0.068** (0.021)	0.067** (0.030)
β_{FR}	0.138** (0.077)	0.341*** (0.110)	−0.012 (0.077)	0.189 (0.112)
γ_R	−0.130*** (0.028)	−0.189*** (0.042)	−0.171*** (0.033)	−0.202*** (0.046)
κ_R	0.164 (0.115)	0.297*** (0.093)	0.268*** (0.088)	0.325*** (0.088)
γ_P	0.163*** (0.043)	0.227*** (0.059)	0.215*** (0.046)	0.243*** (0.058)
κ_P	2.078*** (0.418)	1.924** (0.802)	2.301*** (0.331)	2.992*** (0.790)
δ_P	0.249** (0.106)	0.247* (0.140)	0.864*** (0.118)	0.890*** (0.156)
c	−1.300*** (0.437)	−1.872*** (0.602)	−1.739*** (0.454)	−1.838*** (0.587)
T	216	132	201	132
R^2	0.29	0.39	0.58	0.64
$LM(6)$ (p-value)	0.47	0.44	0.15	0.11
$ARCH(6)$ (p-value)	0.27	0.69	0.39	0.88

Estimated coefficients with standard errors in parentheses are reported. *, ** and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. The estimated models are of the following form ($i = unw,\ w$):

$$\Delta R^{IT}_{i\,t} = c + \rho\,\Delta R^{IT}_{i\,t-1} + \beta_{UK}\,\Delta R^{UK}_{t} + \beta_{FR}\,\Delta R^{FR}_{t} + \gamma_R\,(R^{IT}_{i\,t-1} - \kappa_R\,R^{FR}_{om,\,t-1})$$
$$+\gamma_P\,(DOM_{t-1} - \kappa_P\,RCOV_{t-1}) + \delta_P\,\Delta\,DOM_{t-1} + \varepsilon_{i\,t}$$

where R^{IT}_{unw} and R^{IT}_{w} are, respctively, the unweighted Italian discount rate (De Mattia, 1967), and the measure of the discount rate weighted with the flows of new discounts (Ciocca, 1973); R^{UK} and R^{FR} are the official British and French discount rates; R^{FR}_{om} is the French open market interest rate; DOM is the (logarithm of) the Bank of Italy's domestic portfolio; $RCOV$ is the Bank of Italy's reserve coverage ratio (defined as the ratio of international reserves to money in circulation). T denotes the number of observations used in estimation. $LM(6)$ and $ARCH(6)$ are the Lagrange multiplier tests for residual serial correlation and autoregressive conditional heteroskedasticity up to the sixth order, respectively. For both tests, p-values are reported.

B. Discount rate, domestic portfolio and international reserves

To investigate the relationships between the actual Bank of Italy discount rate, the domestic portfolio, and the ratio of international reserves to domestic money in circulation, a three-variable VAR model is estimated over the whole sample period 1896(1)-1913(12), including R^{IT}, DOM and $RCOV$. This formulation allows for a sharper test of the long-run relationship between the domestic portfolio and the reserve situation (the latter captured by the reserve coverage ratio), deviations from which determine an equilibrating response of the discount rate, as shown in the main text.

Preliminary univariate analysis shows that R^{IT} is stationary (the ADF unit root test yields a p-value of 0.004), whereas DOM and $RCOV$ contain a unit root (ADF p-values being 0.61 and 0.60, respectively). The VAR is specified in levels with two lags of the endogenous variables and the contemporaneous monthly changes of the relevant international discount rates (ΔR_t^{UK}, ΔR_t^{FR} and $\Delta R_{om\,t}^{FR}$) added as exogenous series. The vector-equilibrium-correction mechanism ($VECM$) form of the system is estimated as (constants omitted):

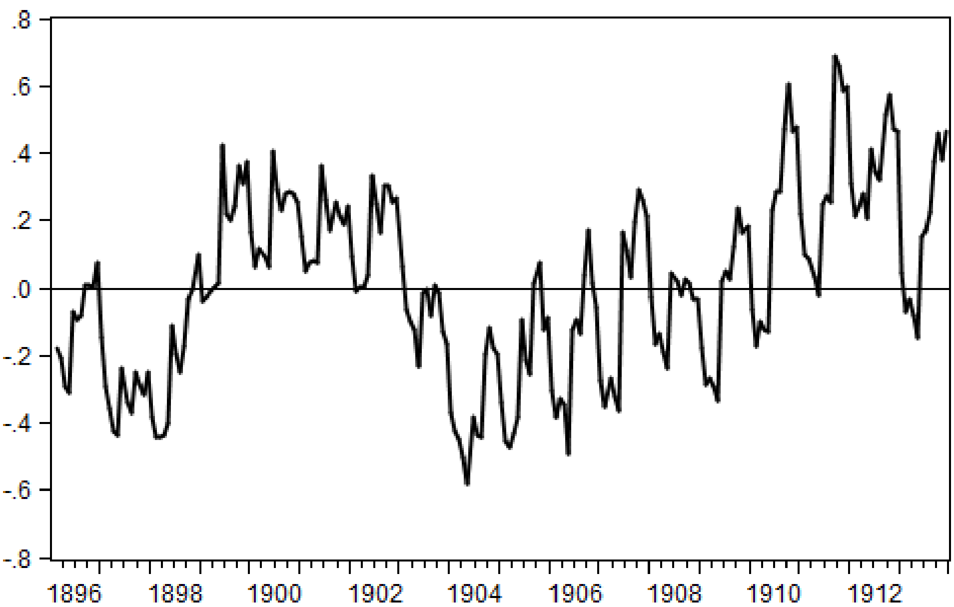
$$\begin{pmatrix} \Delta R_t^{IT} \\ \Delta DOM_t \\ \Delta RCOV_t \end{pmatrix} = \begin{pmatrix} \pi_{11} & \pi_{12} & \pi_{13} \\ \pi_{21} & \pi_{22} & \pi_{23} \\ \pi_{31} & \pi_{32} & \pi_{33} \end{pmatrix} \begin{pmatrix} R_{t-1}^{IT} \\ DOM_{t-1} \\ RCOV_{t-1} \end{pmatrix} + \begin{pmatrix} \phi_{11} & \phi_{12} & \phi_{13} \\ \phi_{21} & \phi_{22} & \phi_{23} \\ \phi_{31} & \phi_{32} & \phi_{33} \end{pmatrix} \begin{pmatrix} \Delta R_{t-1}^{IT} \\ \Delta DOM_{t-1} \\ \Delta RCOV_{t-1} \end{pmatrix}$$
$$+ \begin{pmatrix} \theta_{11} & \theta_{12} & \theta_{13} \\ \theta_{21} & \theta_{22} & \theta_{23} \\ \theta_{31} & \theta_{32} & \theta_{33} \end{pmatrix} \begin{pmatrix} \Delta R_t^{UK} \\ \Delta R_t^{FR} \\ \Delta R_{om\,t}^{FR} \end{pmatrix} + \begin{pmatrix} u_t^R \\ u_t^{DOM} \\ u_t^{RCOV} \end{pmatrix}$$

Johansen's maximum likelihood procedure is applied to matrix $\mathbf{\Pi}$, collecting the π_{ij} $(i,j = 1,2,3)$ coefficients on the lagged levels of the endogenous variables, in order to test for the number of valid cointegrating (stationary) relations among the series. Both the trace (λ_{TR}) and maximum eigenvalue (λ_{MAX}) tests point to the existence of 2 valid cointegrating vectors (for the null hypothesis of at most 1 cointegrating vector, λ_{TR} ans λ_{MAX} display p-values of 0.032 and 0.028, respectively). One cointegrating vector should capture the stationarity of the discount rate R^{IT}, whereas the other could describe a long-run relation between the size of the domestic portfolio and a measure of the adequacy of international reserves (i.e. the reserve coverage ratio). When cointegration is present, matrix $\mathbf{\Pi}$ can be expressed as the product of a matrix of loadings ($\boldsymbol{\alpha}$), capturing the adjustment towards the long-run equilibrium of the endogenous variables, and a matrix containing the cointegrating vectors ($\boldsymbol{\beta}$): $\mathbf{\Pi} = \boldsymbol{\alpha}\,\boldsymbol{\beta}'$. Estimation of the $VECM$ system with the restrictions on the number and the shape of the cointegrating vector imposed delivers the following estimates of the loadings in $\boldsymbol{\alpha}$ and of the unrestricted coefficients of the long-run relationships in $\boldsymbol{\beta}$:

$$\hat{\mathbf{\Pi}} = \hat{\boldsymbol{\alpha}}\,\hat{\boldsymbol{\beta}}' = \begin{pmatrix} \underset{(0.025)}{-0.125^{***}} & \underset{(0.031)}{0.168^{***}} \\ \underset{(0.022)}{-0.027} & \underset{(0.027)}{-0.060^{**}} \\ \underset{(0.007)}{0.004} & \underset{(0.008)}{0.017^{**}} \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & \underset{(0.279)}{-2.583^{***}} \end{pmatrix}$$

The likelihood ratio tests of the identifying restrictions imposed on the cointegrating vectors yields a $\chi^2(1)$ statistics of 2.60, with an associated p-value of 0.11, fully supporting the interpretation of the long-run relations proposed above. Moreover, the estimated coefficient on the reserve coverage ratio (−2.583) is extremely close to the estimate obtained from the single-equation dynamic model in the main text ($\kappa_P = 2.565$, with the opposite sign due to the chosen formulation of equation (1) in the main text. Also the reaction of the discount rate to misalignments in the relation between the domestic portfolio and the reserve coverage ratio, portrayed in Figure A2, is estimated at 0.168, close to $\gamma_P = 0.141$ yielded by the single-equation specification.

Figure A2. Deviations from the domestic portfolio/reserve coverage long-run equilibrium



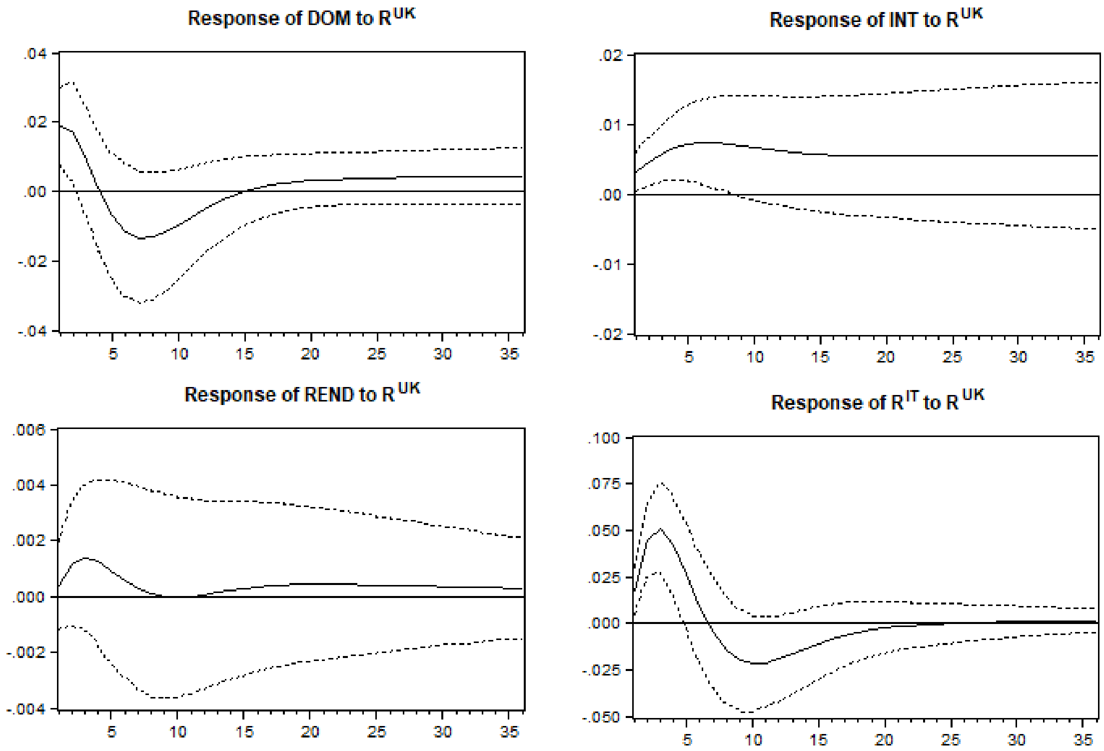
The Figure displays (demeaned) deviations from the detected long-run relation between the domestic portfolio and the reserve coverage ratio, measured by $DOM_t - 2.583\ RCOV_t$.

C. Additional evidence on sterilization

This Section shows the results obtained from a five-variable VAR system designed to estimate the response of the Italian discount rate, the Bank of Italy's domestic and international asset portfolios and the price of the Italian *Rendita* quoted on the Paris financial market, in the face of exogenous innovations in leading international (British and French) official discount rates. The VAR models include the foreign official discount rate (either R^{UK} or R^{FR}), the domestic portfolio and international reserves of the Bank of Italy (DOM and INT, both in logarithms), the price of the Italian *Rendita* ($REND$, in logarithm), and the actual Italian discount rate (R^{IT}). Estimation is carried out over the 1896(1)-1913(12) period with two lags of all endogenous variables, and impulse responses to an innovation in R^{UK} and R^{FR} (placed first in the ordering) are obtained.

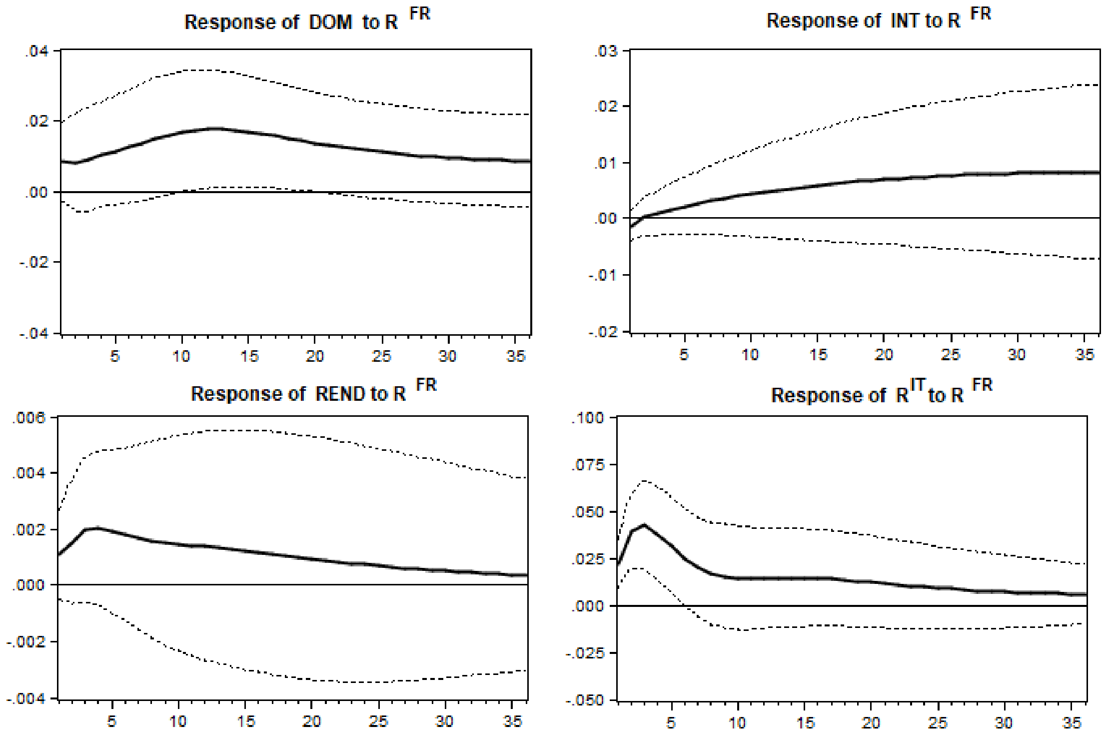
Figures A3 and A4 show the impulse responses to a 40 basis point innovation in the British discount rate and to a 10 basis points innovation in the French rate, respectively, and are directly comparable to Figures 7 and 8 in Section 5. In both cases a limited pass-through to the Italian rate and small (positive) reactions of the domestic portfolio are detected. Moreover, the price of the *Rendita* bond does not show any reaction to foreign discount rate innovations. On the whole, the patterns of responses are very similar to those obtained with the exchange rate in the system and discussed in Section 5.

Figure A3. Responses to an innovation in the British discount rate (VAR with the price of the Italian "Rendita")



The Figure displays the impulse response functions to a 0.40% innovation in the British discount rate of the Bank of Italy's domestic portfolio and international reserves (DOM and INT, both in logarithms), the price of the Italian "Rendita" ($REND$, in logarithms) and the actual Italian discount rate (R^{IT}). The responses, obtained using a Choleski identification scheme with the British discount rate ordered first, are shown up to 36 months with 95% confidence intervals. The estimation sample is 1896(1)-1913(12).

Figure A4. Responses to an innovation in the French discount rate (VAR with the price of the Italian "Rendita")



The Figure displays the impulse response functions to a 0.10% innovation in the French official discount rate of the Bank of Italy's domestic portfolio and international reserves (DOM and INT, both in logarithms), the price of the Italian "Rendita" ($REND$, in logarithms) and the actual Italian discount rate (R^{IT}). The responses, obtained using a Choleski identification scheme with the French discount rate ordered first, are shown up to 36 months with 95% confidence intervals. The estimation sample is 1896(1)-1913(12).