The Objectives of British Monetary Policy during the Classical Gold Standard, 1876-1913: An econometric analysis of domestic and foreign determinants of Bank Rate[1]

by

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Introduction

This paper analyses the factors which influenced the Bank of England's decisions to change the official discount rate during the period from 1876 to 1913. Goodhart (1972) used regression analysis to study the link between the discount rate of the Bank of England (also called "Bank Rate") and the Bank of England's liquidity ratio (also called the "Proportion"). He regressed the level of Bank Rate on the Proportion using monthly data from 1891 to 1914 and found that changes in the discount rate were significantly influenced by changes in the liquidity ratio with a lag. His explanation was that as the Proportion was falling the Bank became more concerned about maintaining convertibility of banknotes into gold and would thus increase Bank Rate to attract gold from internal circulation and from abroad. He also showed that the Proportion was moving anti-cyclically, as the demand for gold and banknotes increased as the business cycle was improving, and that an increase in Bank Rate would raise the whole structure of interest rates in London, so as to cause sufficient capital inflows. The presumption that the conclusions reached by Goodhart (1972) for Great Britain are valid also for other gold standard countries is suggested by the common institutional/legal framework and by the negative correlation between the discount rate and the liquidity ratio found by Bloomfield (1959) for all gold standard countries.

[1] This paper is based on a Laurea dissertation presented by Piera Bignetti on July 7 1997 at the University of Brescia entitled "Le determinanati del tasso di sconto inglese durante il tallone aureo (1876-1913): un'analisi econometrica" and written under the supervision of the first author. We thank Hannah Nielsen for research assistance.

In an econometric study on Germany Sommariva and Tullio (1987) analysed the determinants of changes in the Reichsbanks' discount rate and its liquidity ratios for the period from 1876 to 1913. They used data which refer to each discount rate change enacted by the Reichsbank and contained in a rather rare volume published in 1925 in Berlin by the German Imperial Printing Office entitled Vergleichende Notenbankstatistik (1925) (henceforth VN). This data, which had never been used before, exists for four gold standard countries (Germany, the United Kingdom, France and Austria-Hungary), is compiled using the same criteria for all four countries and contains, besides discount rates and liquidity ratios, also data on exchange rates and private discount rates. Like Goodhart (1972) for the Bank of England, Sommariva and Tullio (1987) found that the Reichsbank reacted negatively, systematically and with a lag to changes in the liquidity ratio. This implies that the main objective of its actions was to maintain internal convertibility of outstanding banknotes into gold. More recently Contamin and Denise (1999) arrived at the same conclusion.

The results found by Bloomfield (1959), Goodhart (1959), Sommariva and Tullio (1987) and Contamin and Denise (1999) that the Bank of England and the Reichsbank were changing the discount rate in order to keep internal convertibility should not come as such a big surprise: if the Reichsbank managed to keep internal convertibility of its notes for over 38 years, and the Bank of England for even longer, it is rather obvious that this objective must have been very important for them.

In this paper on the Bank of England we go several steps further. *First*, using the data from VN we estimate a more complete reaction function of the Bank of England which includes, in addition to the liquidity ratio, also foreign discount rates and deviations of the market exchange rate from gold parity. This will tell us how important was for the Bank the objective of keeping the market exchange rate within the gold points. Moreover it will tell us which were the most important gold standard countries influencing the Bank of England and how high was the degree of financial market integration at that time.

Second, instead of using annual or monthly data we use the data published in VN. The main advantages of using this data are that they are available for the whole period from 1876 to 1913 and that problems of reverse causation are avoided because of the way the data are defined[2].

Third, we study the stability of the reaction function. This will tell us how stable the behaviour of the Bank of England was over time, how the degree of financial market integra-

[2]Since we have the same data for four gold standard countries we can also make meaningful comparisons across countries and study the mutual financial linkages.

tion changed from 1876 to 1913 and if there were periods during which the use of gold devices[3] by the Bank of England or other major Central Banks significantly changed the coefficients of the estimated reaction function, for instance by reducing the coefficient of foreign discount rates. From the beginning of the period to the end many factors changed significantly, like the communication technology, the world availability of gold, the relative gold stocks of the main Central Banks, the relative economic weight of the main countries and the intensity of the use of gold devices.

Fourth, we address the question of whether the Bank of England reacted asymmetrically to changes in the liquidity ratios, in foreign discount rates and in deviations of the Pound from gold parity in tranquil and turbulent periods. The idea being that the more the Bank was interested in accumulating gold, the more promptly she would react to decreases in reserves and the more reluctant she would be to reduce the discount rate when reserves were increasing. Despite the short run nature of our model, tests of asymmetry of this type allow us to say something about the potential undermining of the long run stability of the system on the part of those Central Banks which were more aggressive in accumulating gold, a question of central importance to the understanding of the working of the gold standard.

The paper is structured as follows: Section 1 presents the model explaining Bank Rate, taking into account foreign official discount rates and the state of the foreign exchange market. Section 2 describes the data used. Section 3 presents estimates and the stability tests. Section 4 presents separately the estimates of the model for the period 1876-1895 and for the period 1896-1913. This split is suggested by the end of the long period of declining prices and by the fact that the Bank of England stopped using gold devices intensively around 1892/93. Section 5 presents the asymmetry tests and Section 6 concludes.

1 The model

Following Bloomfield (1959), Goodhart (1972) and Sommariva and Tullio (1987) we present in this section the reaction function of the Bank of England explaining changes in Bank Rate, which are assumed to depend on changes of her liquidity ratio. However, in order to test the assumption of multipolarity of the gold standard and to measure the degree of international financial market integration, a set of variables capturing international influences (exchange rates and foreign official discount rates) was added to the equation.

[3]Gold devices were used by Central Banks to avoid sales and exports of gold and/or to make these operations more costly to the private sector. They consisted in raising the sales price of gold, moving the delivery of gold to places distant from the border, delivering minted national coins instead of ingots and increase the interest rates on

Thus changes in Bank Rate (Δi^E) are assumed to depend on the level of the narrowly or broadly defined liquidity ratio (l_i), on its changes (Δl_i) (where $i = 1$ denotes the narrow and $i = 2$ the broad liquidity ratio), on changes in the official discount rates in Germany (Δi^D), France (Δi^F) and Austria-Hungary (Δi^A) and finally on the percentage deviation of the exchange rates of the British Pound with the Reichsmark, the French Franc and the currency of the Austro-Hungarian empire from their respective gold parity $w^j = (e_j - e_j^*) / e_j^*$, where $j = D, F, A$. The gold parity never changed during the whole period for the United Kingdom, France and Germany.

Hence the equation to be estimated is:

$$(1) \qquad \Delta i^E = a_1 + a_2 \Delta l_i + a_3 l_i + \sum{}_j a_{4,j} \Delta i^j + \sum{}_j a_{5j} w^j + u$$

where $i = 1,2$, $j = D, F, A$ and Δ stands for a change of the variable. In this case Δ does not denote the usual difference operator, since in our data set the changes refer to differently spaced time points.

In estimating equation (1) two different definitions of the liquidity ratio have been used, the first is the ratio of the gold and silver stock of the Bank of England to the banknotes issued (l_1), and the second has the same numerator but includes in the denominator sight liabilities in addition to banknotes issued (l_2). By comparing the goodness of the fit and the stability of the estimated regressions we will be able to make some inferences about which ratio may have been of greater importance to the Bank of England.

For the exact definition of the variables and the time span to which their changes refer see Section 2. Suffice to mention here that the series used are not equidistant time series but they refer to timely ordered episodes of all official discount rate changes enacted during the period. There were 221 discount rate changes for the Bank of England.

The expected signs of the coefficients of the explanatory variables are: positive for changes in foreign official discount rates, negative for the level of the liquidity ratio, negative for changes in the liquidity ratio and negative for deviations of the exchange rate of the Pound from gold parity. Note that the expected sign of the deviation is negative because the exchange rate of the Pound is defined, like today in the United Kingdom, as the number of

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lending to gold exporters in order to increase transaction costs. The Bank of France is known to have simply refused the sale of gold in some periods.

foreign currency units per Pound, such that an increase in e_j implies an appreciation of the Pound.

The level of the liquidity ratio has been introduced into the equation in order to verify whether, when things were turning for the worse (liquidity ratios were falling), the Bank of England had a tendency to increase the discount rate less at high levels of gold reserves than at low levels. This is admittedly a rather crude test of asymmetric behaviour.

Changes in foreign discount rates are measured over a similar interval chosen by the compilers of the tables of VN to measure changes in liquidity ratios. The exact definition of the intervals to which the changes in the foreign discount rates refer is discussed in Section 2.

Equation (1) can be considered a reaction function of the Bank of England distinguishing between three objectives of monetary policy: the objective of keeping internal convertibility of banknotes issued into gold, the objective of keeping exchange rates within the gold points and a third objective, not completely independent from the other two, of acting defensively to previous changes in foreign discount rates. Concerning the latter objective one should keep in mind that movements in opposite directions of the official discount rates within one month were rare during the period. There were 11 such changes between London and Berlin, 2 between London and Paris and 2 between Paris and Berlin[4].

Reaction functions of Central Banks estimated for the post World-War II period usually include inflation, unemployment or deviation of real GDP from trend or from potential GDP[5]. However, the classical gold standard was a different period characterized by the absence of national accounts, by the fact that unemployment was not a major issue and by a predominance of concerns about financial stability over those about the business cycle. As a result this difference in specification of the reaction functions of Central Banks between then and now seems perfectly justified by the different historical background of the two periods.

2 Description of the data used.

The VN data used in this paper are obtained from a 1925 volume entitled Vergleichende Notenbankstatistik: Organisation und Geschäftsverkehr Europäischer Notenbanken, 1876 – 1913. This two-volume publication contains monthly and annual financial data for seven European countries: Austria-Hungary, Belgium, France, Germany, Holland, the United Kingdom and Russia. For the four countries France, Germany, the United Kingdom, and Austria-Hungary there are more detailed tables containing a wealth of data relating to each official

[4]See Tullio and Wolters (1996).

[5] This approach has become popular as the so-called Taylor rule, especially since the work by Taylor (1993).

discount rate change. For the United Kingdom the relevant table is Table 135 (pages 248-255 of Vol. 2). Most of the columns of this table are reproduced below as Table 1 in order to facilitate the description of the data. The numeration of the columns is retained from the original table. We do not translate the headings from German because the explanation which follows should make the contents of the columns sufficiently clear.

The one and a half page long introduction to this set of tables contains the following sentence: “These tables represent an attempt to explain with a purely numerical methodology those factors taken into consideration in deciding changes in the discount rate at the time the changes were enacted. These factors were the balance sheet of the Central Bank on the days prior to the change, confronted with another balance sheet chosen on purpose *by the compilers of the table* (italic our addition), the foreign exchanges and some foreign discount rates” (VN, page 238). This sentence and the data description which follow go a long way in explaining what the German compilers were aiming at. They certainly knew very well, long before these concepts became current, what a reaction or an objective function of a central bank is.

The first four columns define each episode of change in the official discount rate:
Column 1 reports the year of the change,
column 2 reports the day and month of the change,
column 3 reports the discount rate before the change,
column 4 reports the discount rate after the change.

The official discount rates reported in column 4 minus the one reported in column 3 is the dependent variable of equation (1) (Δi^E).

Column 5 contains a date close to the discount rate change. It generally refers to one working day prior to the discount rate change[6],
column 6 contains a date preceding the discount rate change by two weeks to two months and on some occasions by more.

The items of the Bank of England’s balance sheet reported in columns 20 to 24 refer to these two dates. The choice of these two dates and hence of the interval between them, over which the changes in the liquidity ratios are measured, was made by the compilers of the tables and may have been based on the knowledge of the daily statements actually used by the Board of Directors to decide changes in the discount rate[7].

[6] In two (four) cases the date refers to one (two) day(s) after the discount rate change. These six out of 221 episodes represent 2.7 % of the observations.
[7] We hasten to add that this is our own supposition.

For the whole period the average interval between the two statements was 50 days. The interval fell from 58.7 days in the period 1876-1895 to 36.9 days in the period 1896-1913[8]. This significant reduction from the first to the second period may suggests, together with the results of the tests we will present in the next sections that the Bank of England reacted more rapidly in the second period to changes in the liquidity ratios.

The explanatory variables of equation (1) are obtained from Table 135 of VN as follows:

(a) Δl_1 is obtained from column 21. This liquidity ratio is defined as the ratio of the gold and silver stock to banknotes outstanding issued by the Bank of England. The change refers to the interval between the dates shown in columns 5 and 6.

(b) Δl_2 is obtained from column 24. This ratio is defined as the ratio of the gold and silver stock of the two departments of the Bank of England to their short term liabilities (banknotes issued plus sight liabilities). Again the change is measured between the two dates shown in columns 5 and 6.

(c) l_1 is obtained from column 20: it is the level of the first liquidity ratio with reference to the date reported in column 5.

(d) l_2 is obtained from column 23.

The percentage deviations of the market exchange rate (e_j) of the British Pound with the Reichsmark, the French Franc and the Austro-Hungarian currency $(w^j = (e_j - e_j^*)/e_j^*)$ with respect to gold parities (e_j^*) were obtained as follows: Table 135 reports the market exchange rates of the Pound with respect to the three currencies on the day preceding the change in the official discount rate:

(e) column 25 reports the number of Reichsmarks per Pound in Berlin,

(f) column 26 reports the number of French Francs per Pound in Paris,

(g) column 27 reports the number of units of the Austro-Hungarian currency per Pound in Vienna.

The explanatory variables used in the regressions are the differences between the market exchange rate and gold parity expressed in percent of gold parity[9].

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[8] These two sub-periods are the same considered by Sommariva and Tullio (1987) in their study of the Reichsbank.

[9] The values of the gold parities used are the following: Reichsmarks per Pound = 20.430, French Francs per Pound=25.225, Austro-Hungarian Kronen per Pound after 1895=24.018 (before 1896 there was no central parity). These parities are obtained from Gallarotti (1995).

Table 1-Partial reproduction of Table 135 from VN (1925)

Der Diskontsatz der Bank von England wurde verändert am: Jahr	am: Tag	von (Prozent)	auf (Prozent)	A. Hauptposten des Status der Bank von England — Ausweise wurden herangezogen: a. für die Beurteilung der Diskontveränderung maßgebend vom	b. zum Vergleich, um die Statusveränderung zu kennzeichnen vom	Deckungsverhältnisse — Deckung der Noten gegen Metall: nach Sp. 5 (Prozent)	Metall: + oder — gegen Spalte 6	Gold: nach Sp. 5	der täglich fälligen Verbindlichkeiten durch die Totalreserve[3]: nach Sp. 5	+ oder — gegen Spalte 6	B. Wechselkurse in London[4]) am Tage vor der Diskontveränderung: Berlin 3 Mte. (Mark für 1 £)	Paris 3 Mte. (Francs für 1 £)	Wien 3 Mte. (Gulden für 1 £)	Amsterdam 3 Mte. (Florin u. Stüber für 1 £)	C. Diskontsätze am Tage vor der Diskontveränderung (Prozent): Deutsche Reichsbank	Bank von Frankreich	Österreichisch-ungarische Bank	Privatdiskont an der Londoner Börse[5])	Spannung zwischen Spalte 32 und 34
1	2	3	4	5	6	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1876	6. Jan.	4	5	5. Jan.	20. Dez. 75	75,6	— 3,2	74,9	28,7	— 4,4	20,66	25,43	11,60	12.3 1/2	6	4	5	4 1/2	+ 1/2
	27. Jan.	5	4	26. Jan.	5. Jan.	83,1	+ 7,5	82,4	43,1	+ 14,3	20,59	25,43	11,75	12.3	5	4	5	3 1/2	— 1 1/2
	23. März	4	3 1/2	22. März	5. Jan.	94,2	+ 18,6	93,4	46,5	+ 17,7	20,70	25,50	11,83	12.4 1/2	4	4	4 1/2	3 3/4	— 3/4
	6. April	3 1/2	3	5. April	5. Jan.	92,6	+ 17,0	91,9	45,4	+ 16,6	20,71	25,48	11,94	12.4 1/2	4	4	4 1/2	2 3/4	— 3/4
	20. April	3	2	19. April	5. Jan.	94,1	+ 18,5	93,4	47,0	+ 19,1	20,68	25,46	12,30	12.4	4	4	4 1/2	1 1/2	1 1/2
1877	3. Mai	2	3	2. Mai	14. März	86,0	— 11,9	85,3	37,5	— 8,7	20,64	25,30	13,13	12.3	4	2	4 1/2	3	+ 1
	5. Juli	3	2 1/2	4. Juli	2. Mai	93,7	+ 7,7	93,0	42,6	+ 5,1	20,66	25,35	12,81	12.3 3/4	4	2	4 1/2	2	1
	12. Juli	2 1/2	2	11. Juli	4. Juli	96,2	+ 2,5	95,5	46,0	+ 3,4	20,63	25,30	12,84	12.3 3/4	4	2	4 1/2	1 1/2	— 1/2
	28. Aug.	2	3	29. Aug.	25. Juli	89,7	— 5,3	89,0	43,9	— 3,1	20,64	25,30	12,25	12.4	4	2	4 1/2	3	+ 1
	4. Okt.	3	4	3. Okt.	29. Aug.	81,6	— 8,1	80,9	37,1	— 6,8	20,68	25,30	11,98	12.4	5 1/2	2	4 1/2	3 1/2	+ 1/2
	11. Okt.	4	5	10. Okt.	29. Aug.	80,4	— 9,3	79,7	35,5	— 8,4	20,70	25,40	12,18	12.4 1/2	5 1/2	2	4 1/2	4 1/2	+ 1/2
	29. Nov.	5	4	28. Nov.	10. Okt.	87,1	+ 6,7	86,4	47,0	+ 11,5	20,70	25,35	12,16	12.4 1/2	5	2	4 1/2	3 1/2	— 1 1/2
1878	10. Jan.	4	3	9. Jan.	10. Okt. 77	88,8	+ 8,4	88,0	39,6	+ 4,1	20,63	25,35	12,20	12.4 1/2	4 1/2	2	4 1/2	2 3/4	— 1 1/4
	31. Jan.	3	2	30. Jan.	9. Jan.	92,5	+ 3,7	91,7	44,0	+ 5,0	20,57	25,33	12,50	12.4 1/2	4	2	4 1/2	2	— 1
	28. März	2	3	27. März	20. Febr.	88,6	— 5,3	87,9	33,2	— 14,1	20,56	25,33	12,26	12.4 1/2	4	2	4 1/2	3	+ 1
	30. Mai	3	2 1/2	29. Mai	27. März	86,5	— 2,1	85,8	40,1	+ 6,9	20,56	25,30	12,16	12.4 1/2	4	2	4 1/2	2 1/2	— 1/2
	27. Juni	2 1/2	3	26. Juni	20. Febr.	85,0	— 8,9	84,3	36,0	— 11,3	20,56	25,30	11,95	12.4 1/2	4	2	4 1/2	2 15/16	+ 7/16
	4. Juli	3	3 1/2	3. Juli	26. Juni	79,3	— 5,7	78,6	30,7	— 5,3	20,56	25,30	11,89	12.4	4	2	4 1/2	3 1/2	+ 1/2
	1. Aug.	3 1/2	4	31. Juli	26. Juni	78,3	— 6,7	77,6	34,4	— 1,6	20,58	25,33	11,75	12.3 1/2	4	2	4 1/2	4 1/2	+ 1
	12. Aug.	4	5	11. Aug.	26. Juni	78,1	— 6,9	77,4	35,8	— 0,2	20,66	25,38	11,89	12.4 1/2	4	2	4 1/2	5	+ 1
	14. Okt.	5	6	13. Okt.	11. Aug.	78,3	+ 0,2	77,6	27,7	— 8,1	20,78	25,53	12,18	12.5 1/2	5	2	4 1/2	6 1/2	+ 1 1/2
	21. Nov.	6	5	20. Nov.	13. Okt.	90,7	+ 12,4	90,1	40,9	+ 13,2	20,71	25,50	11,98	12.5	5	3	4 1/2	4 1/2	— 1 1/2
1879	16. Jan.	5	4	15. Jan.	24. Dez. 78	89,3	+ 6,4	88,7	30,7	+ 3,0	20,68	25,50	12,00	12.5	4	3	4 1/2	3 1/2	— 1 1/2
	30. Jan.	4	3	29. Jan.	15. Jan.	93,3	+ 4,0	92,7	36,6	+ 5,9	20,60	25,43	11,94	12.4 1/2	4	3	4 1/2	2 1/2	— 1 1/2
	13. März	3	2 1/2	12. März	29. Jan.	114,9	+ 21,6	114,2	50,3	+ 13,7	20,63	25,50	11,89	12.4 1/2	4	3	4 1/2	2 3/4	— 1/4
	10. April	2 1/2	2	9. April	29. Jan.	112,3	+ 19,0	111,6	49,1	+ 12,5	20,64	25,48	11,94	12.4	3	3	4 1/2	1 1/2	— 1/2
	6. Nov.	2	3	5. Nov.	24. Sept.	105,8	— 20,8	105,1	46,0	— 18,2	20,58	25,45	11,86	12.4	4 1/2	3	4	2 3/4	+ 3/4
1880	17. Juni	3	2 1/2	16. Juni	7. Jan.	109,1	+ 9,6	108,3	50,9	+ 11,9	20,67	25,51	11,95	12.4 1/2	4	2 1/2	4	2 3/4	— 1/4
	9. Dez.	2 1/2	3	8. Dez.	10. Nov.	96,1	— 3,7	96,3	45,3	— 5,4	20,61	25,54	11,98	12.4 1/2	4	3 1/2	4	3	+ 1/2
1881	13. Jan.	3	3 1/2	12. Jan.	10. Nov. 80	90,9	— 8,9	90,1	40,8	— 9,9	20,62	25,56	11,99	12.4 1/2	4	3 1/2	4	3 3/4	+ 3/4
	17. Febr.	3 1/2	3	16. Febr.	5. Jan.	106,2	+ 16,1	105,4	46,8	+ 10,6	20,63	25,60	11,99	12.5	4	3 1/2	4	2 15/16	— 9/16
	28. April	3	2 1/2	27. April	16. Febr.	100,5	— 5,7	99,8	49,3	+ 2,5	20,67	25,56	11,91	12.4 1/2	4	3 1/2	4	2 7/16	— 1/16
	18. Aug.	2 1/2	3	17. Aug.	27. April	90,9	— 9,6	90,1	43,4	— 5,9	20,69	25,50	11,93	12.4 1/2	4	3 1/2	4	3	+ 1/2
	25. Aug.	3	4	24. Aug.	27. April	89,4	— 11,1	88,6	41,6	— 7,7	20,73	25,55	11,91	12.5 1/2	4	3 1/2	4	3 15/16	+ 15/16
	6. Okt.	4	5	5. Okt.	24. Aug.	80,0	— 9,4	79,3	30,2	— 11,4	20,74	25,55	11,95	12.5 1/2	5 1/2	4	4	4 7/8	+ 7/8
1882	30. Jan.	5	6	1. Febr.	25. Jan.	74,1	— 7,0	73,3	31,1	— 7,9	20,73	25,51	12,15	12.6 1/2	5	5	4	6	+ 1
	23. Febr.	6	5	22. Febr.	1. Febr.	86,4	+ 12,3	85,6	38,6	+ 7,5	20,72	25,56	12,15	12.6	5	5	4	4 1/2	— 1 1/2
	9. März	5	4	8. März	1. Febr.	89,8	+ 15,7	89,0	40,2	+ 9,1	20,70	25,55	12,16	12.6 1/2	4 1/2	4	4	3 1/2	— 1 1/2
	23. März	4	3	22. März	8. März	97,4	+ 7,6	96,6	45,7	+ 5,5	20,69	25,53	12,18	12.5 1/2	4	4	4	2 1/2	— 1 1/2
	17. Aug.	3	4	16. Aug.	28. Juni	81,2	— 12,3	80,4	37,8	— 5,2	20,67	25,41	12,10	12.5	4	3 1/2	4	3 1/2	+ 1/2
	14. Sept.	4	5	13. Sept.	28. Juni	82,5	— 11,0	81,7	39,2	— 8,8	20,72	25,51	12,15	12.5 1/2	5	3 1/2	4	4 1/2	+ 1/2
1883	25. Jan.	5	4	24. Jan.	3. Jan.	86,6	+ 9,6	85,8	44,5	+ 14,7	20,60	25,46	12,15	12.5 1/2	4	3 1/2	5	3 3/4	— 1 1/4
	15. Febr.	4	3 1/2	14. Febr.	3. Jan.	90,2	+ 13,2	89,4	45,0	+ 15,2	20,65	25,46	12,13	12.5 1/2	4	3 1/2	4 1/2	3 1/2	— 1/2
	1. März	3 1/2	3	28. Febr.	14. Febr.	93,2	+ 3,0	92,4	43,0	— 2,0	20,64	25,44	12,11	12.4 1/2	4	3	4	2 1/2	— 1/2
	10. Mai	3	4	9. Mai	28. Febr.	79,1	— 14,1	78,3	33,4	— 9,6	20,66	25,44	12,13	12.4	4	3	4	4 1/2	+ 1 1/2
	13. Sept.	4	3 1/2	12. Sept.	4. Juli	95,0	+ 11,5	94,2	46,2	+ 11,0	20,70	25,54	12,15	12.5 1/2	4	3	4	3 1/2	— 1/2
	27. Sept.	3 1/2	3	26. Sept.	4. Juli	96,4	+ 12,9	95,6	47,3	+ 12,1	20,65	25,48	12,13	12.4 1/2	4	3	4	2 1/2	— 1/2

(h) Turning to the changes of the official discount rates in Germany (Δi^D), France (Δi^F) and Austria-Hungary (Δi^A), the information contained in Table 135 is not sufficient to construct these series. For its construction we used information contained in other tables of VN. For these three foreign countries VN contains daily figures of the official discount rate for the whole period 1876-1913. For each of the 221 episodes of changes in the Bank of England's discount rate we calculated the corresponding changes in the three foreign official discount rates with reference to the interval between the date given in column 6 and the day before the discount rate change (see columns 29 – 31 of Table 1). Thus same-day changes in foreign official discount rates are excluded by construction. In the case of same-day changes we do not know which Central Bank made the first move[10].

To summarize five observations are in order. *First*, the data presented in Table 1 can be divided into three main categories: (A) information on the balance sheet items of the Bank of England, in other words on her assets and liabilities, (B) the market exchange rates with reference to the three main foreign currencies on the day preceding the change in the discount rate and (C) the official discount rates in Germany, France and Austria-Hungary on the day preceding the change in the official discount rate.

Second, the series contained in each column are not equally spaced chronologically ordered data; hence the frequency of the data is variable depending on the time elapsed between one discount rate change and the next. *Third*, recalling that between 1876 and 1913 the Bank of England changed the official discount rate 221 times, varying from a minimum of zero in 1895 to a maximum of 12 times in 1893[11], it is clear that the use of annual data, as for example in Bloomfield (1959), hides a substantial amount of information and certainly entails problems of reverse causation between changes in the discount rate and changes in the liquidity ratio. This may hold also for monthly data, albeit to a much smaller degree. Our data are not subject to this criticism. *Fourth*, there is virtually no degree of discretion on our part in the way the series were constructed. How the variables were constructed follows logically from a careful analysis of Table 135 in VN.

Fifth, the compilers of the table were not just statisticians, they were economic historians writing a history of the gold standard in numbers. We presume that they must have had substantial inside information on how decisions were taken and on how the system was actually working. They may have written the book with some degree of longing for stability in international monetary matters which in 1925 was nowhere near in sight. They may have written it with the same spirit which guided Egyptian scholars in the third and second centuries BC to write down as much as they could about their disappearing culture[12].

By estimating equation (1) for Great Britain with the data presented in this section we make use of an incredible wealth of information which has never been used before by other

[10]However, from the minutes of the meetings of the Board of the Banque de France (Conseil Géneral) we know that on 5 or 6 occasions the Governor read a telegram from London, usually at the very beginning of the meeting, announcing a change in the Bank of England's discount rate and that a (same-day) change in the Banque de France's discount rate was decided. On one occasion (August 25 1881) the Governor even pointed out that an increase in the French discount rate was not justified by the observed changes in the balance sheet items of the Bank, a fact fully confirmed by our data. The Conseil Genéral decided nevertheless to go ahead with the increase. In cases like these the order of causality can be established.

[11]The average number of changes was 5.8 per year.

[12]Most of the written Egyptian documents concerning the Egyptian culture date from these last centuries.

authors. In addition the VN data allow to study the degree of financial market integration and of multi-polarity of the system and to make homogeneous comparisons for four gold standard countries.

3 The determinants of the Bank of England's official discount rate.

In this section we present estimates of equation (1) for the period 1876-1913 using the data described in Section 2 consisting of 221 observations. The estimation method used is ordinary least squares (OLS) and the programme is Eviews 4.0. As explained in Section 1 this equation can be considered a reaction (objective) function of the Bank of England.

Our "not equally spaced chronologically ordered data" exclude by construction all episodes on which the balance sheet of the Bank, the situation of foreign exchanges and recent changes in foreign discount rates were analysed and the decision was taken *not to change* the discount rate. This exclusion may lead some people to believe that the coefficients we estimate are biased. The question is: biased with respect to what? For instance in equation (1) the estimated coefficient of changes in the liquidity ratio is certainly higher in absolute value than in the case we had used equally spaced data. However, we simply do not have such data. On the other hand comparing the alleged bias in the coefficients estimated in this paper with coefficients estimated using for example monthly data is wrong first because our data is of a different nature and second because the coefficients estimated with monthly data may be strongly biased towards zero, especially if a large proportion of the changes in the discount rate occurred at the beginning of the month and if the gold stock of the Central Bank changed significantly within the month in the expected direction as a result of the change in discount rate itself.

Table 2 shows the OLS estimates of equation (1) separately for the two definitions of the liquidity ratio. The first two regressions use the narrow definition of the liquidity ratio (Δl_1) and the last one uses the broad definition (Δl_2). We started estimation by introducing all explanatory variables in the regressions and then eliminated successively all non significant variables. The levels of the liquidity ratios were never significant.

The explanatory power of the regressions is relatively high. The second regression using the narrow definition of the liquidity ratio, has an Adjusted R^2 of 0.62 and the third regression, using the broad definition, has an adjusted R^2 of 0.55. Both are quite high considering that the dependent variable measures changes. The difference in the Adjusted R^{2}'s suggests that for the Bank of England the narrow definition of the liquidity ratio was more important than the broad one. This is also confirmed by the AIC and SC measures.

Table 2: The determinants of Bank Rate

Period	1876 – 1913 (T = 221)		
	(1) Δi^E	(2) Δi^E	(3) Δi^E
c	0.086	0.085	0.116
	(2.7)	(2.7)	(3.3)
Δl_1	-0.039	-0.039	
	(16.3)	(16.2)	
Δl_2			-0.060
			(13.4)
Δi^D	0.172	0.202	0.129
	(3.4)	(4.2)	(2.3)
Δi^F	0.270		
	(1.9)		
$\overline{R}^2$	0.626	0.622	0.545
DW	1.82	1.77	1.62
AIC	1.307	1.313	1.499
SC	1.368	1.360	1.545
Q(10)	8.25	9.86	18.88
	[0.60]	[0.45]	[0.04]
HET	0.40	0.09	1.45
	[0.88]	[0.99]	[0.22]
JB	1.37	1.57	3.05
	[0.51]	[0.45]	[0.22]
RESET	11.63	13.55	21.55
	[0.00]	[0.00]	[0.00]

Notes:
Absolute values of the t-statistics are given in parantheses, p-values in brackets. DW denotes the Durbin-Watson statistic. Q(10) denotes the Box-Pierce Portmanteau statistic with 10 lags to test for white noise in the residuals. HET is the White test for heteroskedasticity in the residuals. The RESET test tests against specification errors. The Akaike (Schwarz) information criterium is denoted as AIC (SC).

In regressions (2) and (3) of Table 2 the two explanatory variables with statistically significant coefficients (at least at the 5% level) are changes in the liquidity ratio and changes in the German official discount rate. The coefficients of both explanatory variables have the expected signs. The liquidity ratio is by far the most significant variable. A fall of 1 percentage point in the liquidity ratio led to an increase in the discount rate of 4 to 6 basis points, depending on the definition of the liquidity ratio. An increase of 100 basis points in the German official discount rate led to a 13 to 20 basis points increase in Bank Rate, suggesting that Berlin played on average during the period an important role in determining the London rate[13]. There was also a weak influence of Paris on Bank Rate (see regression (1)).[14]

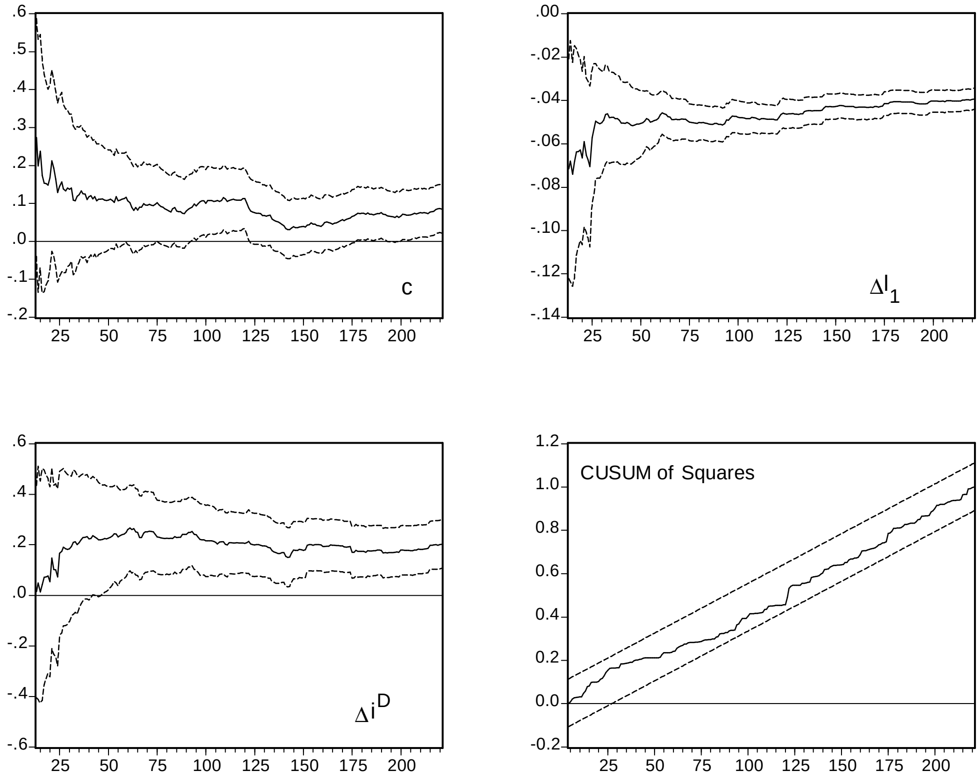
The fact that the constant terms are significantly positive is an indication that on average during the sample period there was an exogenous tendency for Bank Rate to rise which is not surprising given that after 1895 inflation started to go up throughout the gold standard world.

The residuals of the second regression indicate the absence of serial correlation (see the Durbin-Watson and Box-Pierce tests). The residuals also show absence of heteroskedasticity (as indicated by the White test) and no deviation from normality (as indicated by the Jarque-Bera test). However, the hypothesis of no functional form misspecification is rejected as indicated by the Ramsey Reset test.

Next we present stability tests for the second regression. Figure 1 presents the Cusum of Squares test. It confirms the stability of the estimated equation at the 5% confidence level (the statistic always remains within the 5% confidence interval). Figure 1 also presents the recursive parameter estimates which show the stability of individual parameters. These graphs enable to track the evolution of each coefficient as more observations are added to the sample. If a coefficient displays a significant variation as more data are added this is an indication of parameter instability. Both the coefficient of the German official discount rate and of the liquidity ratio show a fair degree of stability: apart from an initial rise in their value, a distortion caused by the initially small number of observations, the two coefficients do not show abrupt changes. However, the coefficient of the German discount rate shows a slightly declining trend after about the 80th observation up until about the 140th and the coefficient of the liquidity ratio is significantly smaller in absolute value in the second half of the period. We shall deal with the possible cause of the temporary decline of the coefficient of the German discount rate after the 80th observation in the next section. In addition we shall formally test the hypothesis that the coefficient of the liquidity ratio was significantly different after observation 133 which corresponds to the last discount rate change in 1894.

[13]This conclusion is reinforced by the fact that changes in the Bank of England's liquidity ratios were in turn significantly influenced by changes in the German discount rate and by the exchange rate of the Pound with the Reichsmark (see Tullio and Wolters, 2004).

Figure 1: Recursive coefficients and CUSUM of Squares test for regression (2) of Table 2



The overall stability of this regression and the fact that the residuals pass all standard tests is noteworthy in the light of the fact that the degree of financial market integration changed considerably during the period, that the Pound became a reserve currency, that there were periods of quite intensive use of gold devices on the part of the Bank of England, the Reichsbank and the Bank of France, that several financial crises occurred in England (notably in 1890, 1893 and 1907) and that around 1895 the general phase of declining prices came to an end as a result of the discovery of new gold mines and of a new process to extract gold (the cynide process).

As to the regression which uses the broad definition of the liquidity ratio the explanatory power is about 15% smaller (see regression 3 of Table 2). In addition at the 5% level of significance the residuals do not pass the test for the absence of autocorrelation (see the Box-Pierce test Q(10)) and there is evidence of functional form misspecification, while they pass the absence of heteroskedasticity test (White) and the normality test (Jarque-Bera). The stability tests for this regression (Cusum of Squares tests and recursive parameter estimates) are shown in Figure 2.

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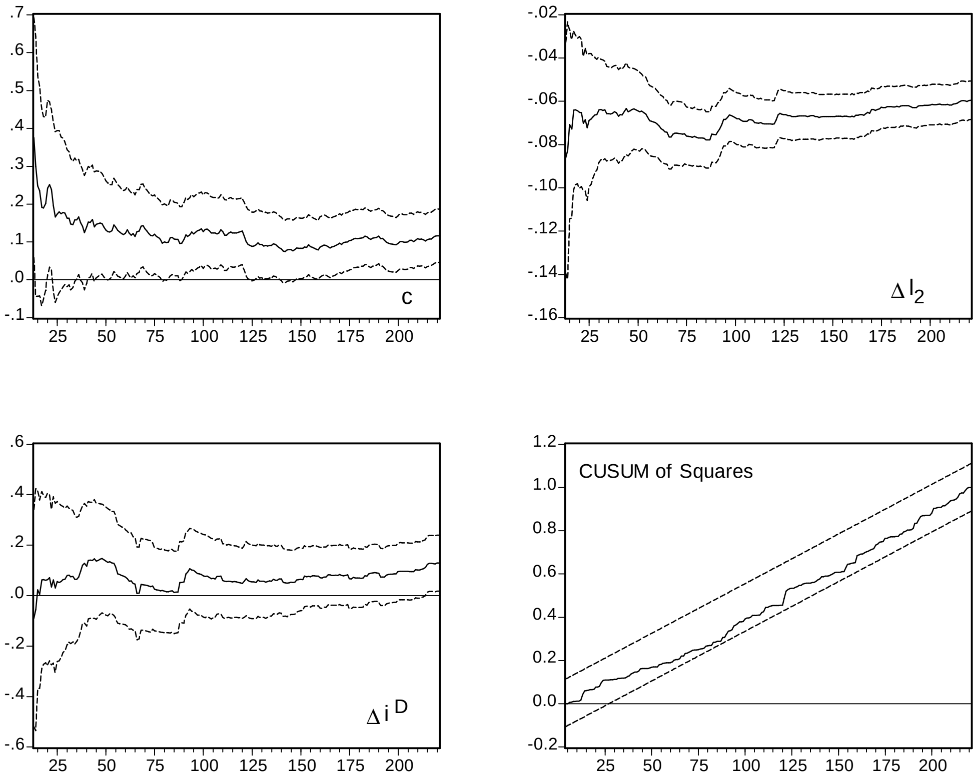
[14] Recursive estimates of the coefficient of Δi^F (not shown here) indicate that this coefficienti s significantly

Figure 2: Recursive coefficients and CUSUM of Squares test for regression (3) of Table 2



The residuals do not behave as satisfactorily and the regression is not as stable as for the regression using the narrow definition. Especially, the parameters show greater signs of instability (see the coefficient of Δi^D, the causes of which will be discussed in the next sections. These results suggest that the broad liquidity ratio was less important for the Bank of England.

4 Estimating the model separately for the periods 1876-1895 and 1896-1913

In this section we present estimates of the reaction function of the Bank of England separately for the periods 1876-1895 and 1896-1913. The first period corresponds to observations 1 to 133 and the second to observations 134 to 221. Since in 1895 there were no changes in the Bank of England's discount rate we decided to choose this year as the dividing line to split the period. This still leaves us with a comfortable number of observations in each sub-period (133 in the first and 88 in the second). The split is suggested also by the drift in the coefficient of Δl_1 in regression (2) of Table 2 (see Figure 1) and by the end of a period characterized by the intensive use of gold devices on the part of the Bank of England. This period lasted from about 1885 to 1892/3. Furthermore the degree of international financial

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different from zero only for the last few observations.

market integration increased substantially in the second period owing to the progress in communication technology. In addition the year 1895 coincides with the beginning of the period of rising prices after the gold discoveries of the previous years. Finally Tullio and Wolters found a structural break around 1895 in the regressions explaining changes in the British liquidity ratios (2004).

Table 3 presents the estimates of the reaction function using the narrow and the broad definition of the liquidity ratio. The reaction function using the narrow definition estimated for the whole sample was rather stable (see Table 2, column (2) and Figure 1). Hence we should not expect dramatic differences before and after 1895. However, comparing columns (1) and (2) of Table 3 one observes a significant reduction in the absolute value of the coefficient of the liquidity ratio, and an increase in the coefficient of changes in the German discount rate. A formal Chow-break test confirms a significant difference of the vectors of the coefficients in regressions (1) and (2) of Table 3 between the two periods (F-value: 3.59 (0.01)). At the same time the explanatory power of the regression falls significantly in the second period. The Adjusted R^2 of the second regression is lower despite the much lower number of degrees of freedom. The residuals are well behaved and the estimated reaction functions are stable within each sub-period, despite the fact that both regressions do not pass the functional form misspecification test[15].

Columns (3) and (4) in Table 3 show that when the broad liquidity ratio is used a substantially larger reduction in the explanatory power of the regression occurs. In addition in the second period the coefficient of the German discount rate becomes significantly different from zero while in the first period it was not. The residuals are well behaved and the estimated reaction functions are stable also for each sub-period[16], in contrast to the estimates for the whole period.

The estimates presented in Table 3 show an increased direct influence of the German discount rate on the British one in the second period in parallel with a reduction of the influence and significance of the domestic variable (the Proportion). Market exchange rates and official discount rates in Paris and Vienna never have significant coefficients.

[15]The stability tests are not shown here. They are available from the authors upon request.

[16]Again the stability tests are not shown here to save space. They are available from the authors upon request.

Table 3: The determinants of Bank Rate

Period	1876-1895 (T = 133) (1) Δi^E	1896-1913 (T = 80) (2) Δi^E	1876-1895 (T = 133) (3) Δi^E	1896-1913 (T = 80) (4) Δi^E
c	0.069	0.100	0.086	0.129
	(1.7)	(2.0)	(2.0)	(2.1)
Δl_1	-0.046	-0.032		
	(14.4)	(8.7)		
Δl_2			-0.069	-0.049
			(14.5)	(6.3)
Δi^D	0.188	0.204		0.207
	(3.1)	(2.6)		(2.3)
$\overline{R}^2$	0.674	0.563	0.612	0.436
DW	1.80	1.65	1.52	1.76
AIC	1.261	1.337	1.429	1.592
SC	1.326	1.422	1.472	1.677
Q(10)	7.21	10.97	20.12	8.66
	[0.71]	[0.36]	[0.03]	[0.57]
HET	0.46	0.79	0.74	1.63
	[0.76]	[0.54]	[0.48]	[0.17]
JB	2.44	1.89	0.88	0.91
	[0.30]	[0.39]	[0.64]	[0.63]
RESET	6.08	4.71	5.23	8.96
	[0.02]	[0.03]	[0.02]	[0.00]

Notes: see Table 2

5 Tests for asymmetric reaction of the Bank of England.

So far we performed only a very rudimentary test of asymmetric reaction on the part of the Bank of England by introducing into equation (1) the level of the liquidity ratios. No evidence of asymmetric behaviour was found. A more formal test consists in splitting the observations of each explanatory variable into two groups: the observations referring to episodes of increases in the discount rate and those referring to decreases. For this purpose we defined the dummy variables DP and DN. DP is equal to one if Δi^E is positive and zero otherwise and DN is equal to 1-DP. Then we multiplied each explanatory variable with DP and with DN and ran regressions (2) and (3) of Table 2 again with all new variables thus formed. The results for regression (2) of Table 2 are shown in Table 4 for the whole period and in Table 5 for the two sub-periods.

<u>Table 4</u>: The determinants of Bank Rate: Tests of asymmetry

Period	1876-1913 (T=221)	
	(1) Δi^E	(2) Δi^E
C	-0.102 (1.9)	-0.042 (0.8)
DP Δl_1	-0.055 (11.3)	
DN Δl_1	-0.027 (6.5)	
DP Δl_2		-0.087 (9.6)
DN Δl_2		-0.045 (7.0)
DP Δi^D	0.346 (4.8)	0.258 (3.2)
DN Δi^D	0.109 (1.7)	0.042 (0.6)
$\bar{R}^2$	0.649	0.576
DW	1.77	1.70
AIC	1.248	1.436
SC	1.325	1.513
WALD (Δl_i)	13.48 [0.00]	11.32 [0.00]
WALD (Δi^D)	5.95 [0.02]	3.98 [0.05]
Q(10)	8.50 [0.58]	13.80 [0.18]
HET	8.78 [0.00]	24.65 [0.00]
JB	2.80 [0.25]	11.57 [0.00]
RESET	42.94 [0.00]	0.12 [0.73]

Notes: see Table 2

A Wald F-test indicates that the hypothesis of equality of the coefficients of Δl_1 and Δl_2 can be rejected at the 1% level of significance for the whole period, suggesting a strongly asymmetric behaviour on the part of the Bank with respect to changes in the narrow and broad liquidity ratio (cf. regressions (1) and (2) of Table 4).

Table 5: The determinants of Bank Rate: Tests of asymmetry

Period	1876-1895 (T=133)	1896-1913 (T=88)	1876-1895 (T=133)	1896-1913 (T=88)
	(1) Δi^E	(2) Δi^E	(3) Δi^E	(4) Δi^E
c	-0.171	-0.019	-0.094	0.019
	(2.5)	(0.2)	(1.4)	(0.2)
$DP\,\Delta l_1$	-0.068	-0.038		
	(10.8)	(5.1)		
$DN\,\Delta l_1$	-0.028	-0.026		
	(5.0)	(4.4)		
$DP\,\Delta l_2$			-0.095	-0.069
			(9.1)	(3.6)
$DN\,\Delta l_2$			-0.049	-0.040
			(5.6)	(4.2)
$DP\,\Delta i^D$	0.361	0.376	0.209	0.330
	(3.9)	(3.4)	(2.0)	(2.5)
$DN\,\Delta i^D$	0.107	0.043	-0.006	0.058
	(1.4)	(0.4)	(0.1)	(0.5)
$\overline{R}^2$	0.711	0.581	0.643	0.455
DW	1.80	1.61	1.61	1.84
AIC	1.157	1.317	1.369	1.581
SC	1.266	1.457	1.478	1.722
WALD (Δl_i)	14.90	1.14	8.58	1.57
	[0.00]	[0.29]	[0.00]	[0.21]
WALD (Δi^D)	4.42	4.49	2.40	2.19
	[0.04]	[0.04]	[0.12]	[0.14]
Q(10)	5.60	10.33	21.37	10.55
	[0.85]	[0.41]	[0.02]	[0.39]
HET	3.77	5.36	9.86	16.45
	[0.00]	[0.00]	[0.00]	[0.00]
JB	1.19	3.75	4.25	4.95
	[0.55]	[0.15]	[0.12]	[0.08]
RESET	54.07	5.46	7.66	1.81
	[0.00]	[0.02]	[0.01]	[0.18]

Notes: See Table 2

Splitting the period one observes that the asymmetry with respect to liquidity ratios existed only in the first sub-period. Based on this limited evidence around discount rate changes we can say that on average during the first period the Bank of England had a long run tendency to accumulate gold[17]. In the second period this policy was abandoned. The smaller concern of the Bank of England about the size of her gold stock in the second period may be

[17] Whether it actually succeeded is a different matter. From the ex-post evidence it seemed it succeeded in increasing her gold stock in absolute terms, but not relative to France and Germany. Whether she succeeded with respect to her “needs” as perceived by her, we cannot say.

connected with the large increase in world gold production observed in this period, the greater capacity of London to attract short term capital as a result of greater international financial markets integration and the fact that the Pound was rapidly developing as a reserve currency.

For the period as a whole the hypothesis of a symmetric reaction to changes in the German discount rate is rejected at the 5% level of significance. The coefficient of changes in the German discount rate is highly significantly different from zero in times of financial stress in London, while in times of ease it is insignificantly different, suggesting that while the Bank of England was following Berlin on the way up it did not follow it on the way down. When the narrow liquidity ratio is used this conclusion remains equally valid in both sub-periods (see Table 5) suggesting that the "threat" of Berlin on London did not subside in the second sub-period, despite the greater abundance of gold in the world. Using the broad liquidity ratio, the hypothesis of asymmetric reaction with respect to Δi^D can only be accepted at much lower levels of significance.

In concluding this section we can say that while the asymmetric reaction of the Bank of England to changes in liquidity ratios disappeared in the second sub-period, the competition from Germany for the world gold production did not subside and the role of Germany in influencing the London financial market and Bank Rate remained very important, especially in times of stress in London.

6 Summary and conclusions

In this paper we present estimates of a reaction function of the Bank of England explaining the determinants of her official discount rate (Bank Rate) for the period 1876-1913. It is assumed that changes in Bank Rate are explained by changes in the Proportion as suggested by Bloomfield (1959), Goodhart (1972) and Sommariva and Tullio (1987), by the exchange rates of the Pound and by changes in foreign discount rates. Two objectives are important in this reaction function of the Bank of England: keeping internal convertibility of outstanding banknotes into gold and reacting defensively to foreign discount rate changes.

We do not use annual or monthly time series like in Bloomfield (1959) and Goodhart (1972), but a unique set of data published in "Vergleichende Notenbankstatistik" (1925) consisting of 221 observations of all the variables of the model.

Besides presenting estimates of the reaction function we also conduct stability tests in order to detect possible significant changes over time in the working of the gold standard and asymmetry tests to make inferences about the long-run gold accumulation policy of the Bank of England.

The main conclusions of the paper are the following. *First*, the reaction function of the Bank of England is a very well behaved function of only two variables: changes in the liquidity ratio and in the German official discount rate. It passes all the stability tests. This implies that the Bank of England's main objective was to keep internal convertibility. This should not come as a major surprise in view of the survival of the gold standard in Great Britain during the whole period considered. *Second*, the tests seem to suggest that the narrowly defined liquidity ratio was more important for the Bank of England than the broad one. This is suggested in particular by the higher explanatory power of all regressions using the narrow liquidity ratio and by the somewhat greater stability of the corresponding regressions.

The *third* conclusion is that we did not find significant effects of France and Austria-Hungary on changes in the official discount rate in London. However, we did find very significant effects of Germany. The role of Germany was somewhat stronger after 1895, when London had stopped using gold devices, the communication technology was more advanced, financial markets were more integrated internationally and Germany was economically and financially more powerful.

Fourth, the significant effect of changes in the Reichsbank's discount rate on Bank Rate, coupled with the strong effect from London to Berlin found by Tullio and Wolters (1996, 2003), supports the hypothesis that the classical gold standard was a decentralized multi-polar system (or at least a bi-polar one) as suggested by Eichengreen (1992) in which even London was subject to significant foreign influences. This view of the gold standard stands in contrast with the "conductor of the international orchestra" view supported by Keynes (1930) in which the gold standard is seen to be a system fully dominated by London.

Fifth, the tests of asymmetries show that the Bank of England reacted more strongly to changes in the Reichsbank's discount rate in periods of stress than in periods of ease. They also show that the Bank of England reacted in an asymmetric way to changes in the liquidity ratio in the first sub-period; she reacted much more significantly to reductions in the liquidity ratio than to increases. This suggests that in the first sub-period she followed a policy of long run accumulation of gold, while in the second she became more relaxed, except when conditions of financial stress in London made the competition for gold with Berlin more threatening.

References

Bloomfield, Arthur I., *Monetary Policy Under The International Gold Standard, 1880-1914.* Federal Reserve Bank, New York, 1959.

Contamin, Remy and Denise Caroline, "Quelle autonomie pour les politiques monetaires sous l'étalon d'or 1880-1913?". *Revue Economique*, no. 78, 2nd quarter 1999, 59-84.

Eichengreen, Barry, *Golden Fetters,* Oxford University Press, Oxford and New York, 1992.

Gallarotti, Giulo, *The Anatomy of International Monetary Regime*, Oxford University Press, 1995.

Goodhart, Charles, *The Business of Banking,* Weidenfeld and Nicholson, London, 1972.

Keynes, John M., *A Treatise on Money*, McMillan, London 1930.

Sommariva, Andrea and Tullio, Giuseppe, *German Macroeconomic History: a study of the effect of the monetary policy on inflation, currency depreciation and growth,* MacMillan, London and St. Martin Press, New York. 1987.

Taylor, John B., Discretion versus Policy Rules in Practice, *Carnegie Rochester Conference Series on Public Policy* 39, (1993), 195-214.

Tullio, Giuseppe and Wolters, Jürgen, Was London the conductor of the international orchestra or just the triangle player? An empirical analysis of asymmetries in interest rates behaviour during the classical gold standard, 1876-1913, in: *The Scottish Journal of Political Economy,* vol. 43, no. 3, September 1996, 419-443.

Tullio, Giuseppe and Wolters, Jürgen, The Objectives of German Monetary Policy during the Classical Gold Standard, 1876-1913: an econometric analysis of the determinants of the Reichsbank's discount rate, *Diskussionsbeiträge des Fachbereichs Wirtschaftswissenschaft der Freien Universität Berlin* Nr.2003/14 (2003).

Tullio, Giuseppe and Wolters, Jürgen , Domestic and International Determinants of the Bank of England's Liquidity Ratios during the Classical Gold Standard, 1876-1913: an econometric analysis, *Diskussionsbeiträge des Fachbereichs Wirtschaftswissenschaft der Freien Universität Berlin* (2004)

Vergleichende Notenbankstatistik, *Organisation und Geschäftsverkehr Europäischer Notenbanken, 1876-1913,* Berlin, Reichsdruckerei, 1925.