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WAS LONDON THE CONDUCTOR OF THE INTERNATIONAL ORCHESTRA OR JUST THE TRIANGLE PLAYER? AN EMPIRICAL ANALYSIS OF ASYMMETRIES IN INTEREST RATE BEHAVIOUR DURING THE CLASSICAL GOLD STANDARD, 1876–1913

Giuseppe Tullio and Jürgen Wolters***

ABSTRACT

This paper analyses the interrelationships of official and private discount rates between seven European financial centres and in particular between London, Berlin, and Paris. Looking at the days and directions of all official discount rate changes in the seven centres, pairwise leads and lags are analysed. As to private discount rates, which seem to be stationary, correlations and coherencies are measured, multivariate Granger-causality tests are performed and impulse response functions are calculated. The paper shows that there are strong mutual feedbacks between interest rates in London, Paris, and Berlin, suggesting that the classical gold standard was a decentralized, multipolar system.

I INTRODUCTION

This paper[1] deals with asymmetries in balance of payments adjustment between European countries during the classical gold standard and the role of London and the Bank of England in the system. Thus it deals only with how countries adjusted to one another and not with how they, as a group, stabilised (or destabilised) the world price level. To be more precise the paper focuses on how interest rates in London determined interest rates elsewhere and how they were in turn influenced by them, and draws conclusions from the empirical tests presented about the role of London in managing the international monetary system.

The rules of the gold standard do not per se induce an asymmetric working of international adjustment, unlike the Bretton Woods system. But asymmetries

[1] The paper presented at the Brescia conference also contained an analysis of the History of Economic Thought on the issue of asymmetries during the gold standard. See Tullio and Wolters (1996).

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can arise also from differences in preferences of the Central Bank and the public, two examples being Germany's low inflation preference under the European Monetary System or the strong French propensity to hoard gold under the gold standard. Asymmetries can arise from differences in countries' structural/institutional features of the national economy and the monetary system: the relative size of the economy, the share of exports in world exports, the degree of diversification of exports, the gold stock of the Central Bank in relation to its liabilities, the gold stock in circulation, the development of the banking system and demand deposits, the spreading of the gold exchange standard and the use of gold devices (capital controls). Some of these characteristics are closely related and often undistinguishable from national preferences.

There are two extreme views about the power of British interest rates to determine world money market conditions and of the role of London in managing the world monetary system. On the one hand Keynes is generally believed to consider London as being almost 'the conductor of the international orchestra' and on the other McCloskey and Zecher, after reporting that in 1913 UK GDP was only 13% of world GDP as opposed to 27% for the US (McCloskey and Zecher, 1976, p. 65), conclude instead that the Bank of England may have been just 'the triangle player in the world orchestra'. In the words of Keynes:

> During the latter half of the 19th century the influence of London on credit conditions throughout the world was so predominant that the Bank of England could almost have claimed to be the conductor of the international orchestra. By modifying the terms on which she was prepared to lend, aided by her own readiness to vary the volume of her gold reserves and the unreadiness of other Central Banks to vary the volume of theirs, she could to a large extent determine the credit conditions elsewhere (Keynes, 1930, Vol. II, p. 306/7).

And in the words of McCloskey and Zecher:

> Apparently the Bank was no more than the second violinist, not to say the triangle player, in the world's orchestra (McCloskey and Zecher, 1976, p. 65).

Reviewing the history of economic thought one finds first of all that Keynes was not so sure in other passages of the Treatise on Money that London was as powerful as it appears from the sentence quoted above. Second, one finds that most writers were well aware that the enormous gold stock of France and the slender gold reserves of the Bank of England increased the vulnerability of British interest rates to foreign influences. Third, one finds that most writers who believed in a very asymmetric working of the classical gold standard had either implicitly or explicitly more the balance of payments adjustment between the UK and her colonies (or raw material producing countries) in mind than the adjustment between London and the two other main European financial centres, Berlin and Paris. Fourth, one finds that several authors believed in a much more symmetric adjustment between London, Paris and Berlin than implied by Keynes' sentence above. They were Haberler (1937), Meade (1951) and

Eichengreen[2] (1992). In particular, Eichengreen defined the classical gold standard as a 'decentralized, multipolar system'.

Most, but not all, of the scanty econometric evidence which exists on interest rate interrelationships during the classical gold standard tends to conclude that lagged German interest rates tends to Granger-cause French and British rates and much less vice versa (Neuburger and Stokes, 1979; Giovannini, 1989). Eichengreen (1987) found instead that interest rates in London Granger-caused German interest rates and found weak evidence in favour of the reverse causality; however, Giovannini reports that he is unable to replicate Eichengreen's results. Lindert (1969) also finds that London official discount rates were more powerful than German ones in influencing the exchange rate, but warns the reader that his results may be influenced by the less frequent changes of foreign discount rates or in his words 'by the relative inaction of foreign Central Banks'. These studies cover only subsets of the last 13 years of the period, except for Lindert who covers the last 23 years.

The paper is divided in three further sections. In Section II we focus on official discount rate changes in the main financial centres and present data on the days and direction of all changes in London, Berlin and Paris from January 1876 to December 1913. We measure the number of times each centre led the other and the average leads and lags in days, separately for the two periods and for changes in the same direction and in the opposite direction. The division of the period in two is suggested also by the fact that the structural/institutional features mentioned above changed substantially between the two periods, in particular the use of the pound as foreign exchange by other central banks, the relative size of the countries and the relative gold stocks. Assuming no use of gold devices, if London was the undisputed 'conductor of the international orchestra' we would expect Berlin and Paris to always follow London with a short lag and London never to have to follow Berlin or Paris. In this section we also extend the analysis to the time lags of official discount rate changes between London on the one hand and the smaller financial gold standard centres of Brussels, Amsterdam, Vienna and St. Petersburgh.

In Section III we use monthly data of private discount rates, a market determined interest rate which is more variable than the official rate and, after checking for stationarity, we measure correlations and coherencies between the seven European private discount rates to study their tendency to move together at low and high frequencies. In Section IV we continue our analysis of the interrelationships between monthly observations of private discount rates by generalising bivariate Granger-causality tests to a 3-dimensional system composed of the private discount rates in the three main financial centres and calculate also the impulse response of each centre to the other. We repeat the multivariate Granger-causality tests and the calculation of the impulse response functions in the 7-dimensional system which includes private interest rates in the three main centres and the four minor ones mentioned above. We did not perform the tests of this section with the official discount rates because they

[2] For a detailed analysis, of the views of these authors, see Tullio and Wolters (1996).

moved in a too discontinuous fashion, especially in France. Section V contains a summary of our main findings, and concluding comments.

The novelties of this paper are first that we extend the sample period to the 38 years from 1876 to 1913 and divide the whole period in to two: the period of falling world prices from 1876 to 1895 and the period of rising world prices from 1896 to 1913. We want to see whether there were significant changes between the two periods. Second, we study both the official discount rates and the private discount rates. Third, we extend the analysis to seven European gold standard financial centres: the three main ones plus Amsterdam, Brussels, Vienna and St. Petersburgh. Fourth, we use a whole battery of more sophisticated econometric techniques than has been the case so far, including multivariate Granger-causality tests (rather than bivariate ones), impulse response functions and we calculate also coherencies.

Our results show strong mutual feedbacks between London, Paris and Berlin with maybe just a slight dominance of London. They suggest that the balance of payments adjustment between the three largest European countries (the UK, Germany and France) was much more symmetric than implied by Keynes' sentence above.

II Leads and Lags in Official Discount Rate Changes in the Main European Financial Centres

If London was the undisputed 'conductor of the international orchestra' we would expect the Bank of England's official discount rate and London's private discount rate to lead temporally and cause (in a Granger sense) interest rates all over the world, without being in turn much affected by them. In addition British rates should be expected to be highly correlated with interest rates around the world and show a high coherency with them both at high and low frequencies, provided foreign countries did not use gold devices and financial controls on a large scale. Mainly because they moved 'in steps', for official discount rates we preferred to gather data on the days and direction of their changes in the seven main European gold standard financial centres for which we could find the data (London, Berlin, Paris, Bruxelles, Amsterdam, Vienna, St. Petersburgh) and calculate pairwise the average leads and lags in days rather than performing causality tests and calculating coherencies and impulse responses, as we shall do in the next section for private discount rates. We allow for a maximum response lag of one month,[3] as responses tended to be rather rapid in the cases in which they occurred. If we had allowed for a longer maximum response lag we would have run the risk of considering as a response what may have been an independent move (we do not possess statements on the motivations of each move). We do all the tests of this section separately for the period of falling prices (January 1876 to December 1895) and the period of rising prices (January 1896 to December 1913). All the data are obtained from Vergleichende Notenbankstatistik (1925).

[3] Giovannini (1989) considered a maximum response lag of one week. We shall see below that one week is too short.

First of all it is worth recalling that the Bank of France possessed a huge stock of precious metals. In 1910 it amounted to 71·3% of its short term liabilities and 61·5% of French exports, as opposed to a Bank of England stock equal to 44·4% of liabilities and 8·6% of UK exports. The stock of the Reichsbank was only marginally higher than the one of the Bank of England (46·8% of liabilities and 13·9% of exports). As a consequence the Bank of France could afford to change the official discount rate very infrequently compared to the Bank of England. During the period 1876–1895 the Bank of France changed the official discount rate only 21 times (1·1 times per year) as opposed to 133 times (6·6 times per year) of the Bank of England and 66 times of the Reichsbank. From 1896 to 1913 the changes were 14 (0·8 per year) for the Bank of France, 88 for the Bank of England (4·9 per year) and 70 for the Reichsbank. The fact that the Bank of England was managing the international gold standard on such a 'thin film of gold' made it very vulnerable to foreign shocks.

Table 1 analyses the respose of official discount rate changes in London and Berlin to one another. Taking the 133 changes of the Bank of England, first we observe that in the first period of falling world prices (upper quadrant of the table), the Reichsbank followed the Bank of England 43 times within one month i.e the Reichsbank followed in 32.3% of the Bank of England's moves. Of these 40 changes were in the same direction and only three in the opposite direction.[4] In the second period of rising prices (lower quadrant in Table 1) the Reichsbank followed the Bank of England 43 times within one month i.e the Reichsbank followed in 48·9% of the Bank of England moves. Of these 39 changes were in the same direction and only four in the opposite direction. For the whole 38-year period the numbers are: out of 221 Bank of England changes Berlin followed 86 times or in 39% of the cases. We conclude that the influence of London on Berlin was very strong indeed and that it increased substantially from the first to the second period in line with increased capital market integration.

But if we analyse in the same way the leads of Berlin over London we find an even stronger influence of Berlin over London. In the first period London followed Berlin within one month 35 times out of 66 total Berlin changes (53% of the changes) and in the second period it followed 30 times out of 70 Berlin changes (42.3%). For the whole period London followed Berlin in 48% of Berlin's discount rate changes, while as we saw before Berlin followed London in 39% of London's changes. The picture does not change if we consider only changes in the same direction. It should also be noted that we did not consider the changes enacted on the same day, as we do not know who took the lead. It would be tempting to say that the power of Berlin over London was higher than the power of London over Berlin; however, one should be careful in interpreting the numbers of Table 1 in this way. What they reveal

[4] The relative infrequency of movements in opposite directions, which is common to all the centres and both subperiods may have important implications for asymmetries in balance of payments adjustment between the centre countries and the periphery. This point is analysed in Tullio and Wolters (1996).

TABLE 1
Official discount rate changes in London and Berlin

1876–1895				
No. of Bank of England changes followed within one month by Berlin change	43		32·3%[1]	
Average lag (in days)	8·9			
of which: in same direction		40		30%
Average lag (in days)		9		
In opposite direction		3		2·3%
Average lag (in days)		8·3		
No. of simultaneous discount rate changes in London and Berlin (same day)	0		0	
No. of Reichsbank changes followed within one month by Bank of England change	35		53%[2]	
Average lag (in days)	13·8			
of which: in same direction		31		47%
Average lag (in days)		12·9		
In opposite direction		4		6%
Average lag (in days)		20·25		
No. of simulations discount rate changes in Berlin and London (same day)	0		0	
1896–1913				
No. of Bank of England changes followed within one month by Berlin change	43		48·9%[3]	
Average lag (in days)	10·5			
of which: in same direction		39		44·3%
Average lag (in days)		9·5		
In opposite direction		4		4·6%
Average lag (in days)		20·3		
No. of simultaneous discount rate changes in London and Berlin (same day)	2		2·3%	
No. of Reichsbank changes followed within one month by Bank of England change	30		42·9%[4]	
Average lag (in days)	10·7			
of which: in same direction		24		34·3%
Average lag (in days)		10·2		
In opposite direction		6		8·6%
Average lag (in days)		12·6		
No. of simultaneous discount rate changes in Berlin and London (same day)	2		2·9%	

Notes:
[1] Number of changes in % of total Bank of England discount rate changes during the period 1876–1895.
[2] Number of changes in % of total Reichsbank discount rate changes during the period 1876–1895.
[3] Number of changes in % of total Bank of England discount rate changes during the period 1896–1913.
[4] Number of changes in % of total Reichsbank discount rate changes during the period 1896–1913.
Source: Vergleichende Notenbankstatistik (1925).

with certainty is that Berlin had a powerful influence on London and vice versa.

The ratios in the last column of Table 1 show an increase through time in the influence of London over Berlin, which is consistent with the view that capital market integration increased through time and a reduction in the influence of

Berlin over London. This reduction may be related to the gold acquisition policy of Germany in the years after 1871. As explained in great detail by Hawtrey (1927) Germany's gold policy was one of the main causes of the long decline in world prices. It is plausible to assume that during the first period London must have felt very strongly the waves of Germany's gold policy both because London was the gold market of the world and because the Bank of England was operating on such a 'thin film of gold.'

Turning to the average response lags, those in the same direction ranged from 9 to 13 days. Thus the reaction, when it occurred, was relatively fast. Giovannini (1989) performs the same analysis as in Table 1 from January 1889 to December 1907 but he considers a maximum lag of one week, which is clearly too short given the average lags of 9–13 days we calculated.

Table 2 contains the same analysis for London and Paris. In the first period France followed London's discount rate changes within one month in only 6·8% of the cases in which London moved and in the second period it followed in 11·4% of the cases. These numbers suggest that the use of gold devices by France may have been a substitute of discount rate policy and above all that France's discount rates were protected by the huge gold stock of the Bank of France. Vice versa London followed Paris in 19% of the cases in the first period and 28·6% in the second, suggesting a greater influence of Paris on London than of London on Paris. In the London-Paris case the percentage of movements in the opposite direction is much larger than in the London-Berlin case; in addition there are almost as many moves on the same day as delayed moves, suggesting possibly a higher degree of short run cooperation in times of crisis in the management of the gold standard than between London and Berlin, as opposed to cooperation for the long run maintenance of the stability of the system which was clearly lacking.

The average response lags were again quite short: from 8 to 13 days for lags of Paris with respect to London and 17 days for London with respect to Paris. However, if one considers also the frequent movements occurring on the same day, the lags are substantially shorter (about a week).

In the analysis of time lags between Berlin and Paris performed in Table 3 the powerful influence of the huge metal stock of the Bank of France emerges even more clearly: on those rare occasions in which Paris moved (only 21 times in the first period and 14 in the second) Berlin had to follow in 39% of the times in the first period and in 71% in the second. On the other hand Paris's gold reserves allowed it to take Berlin changes more leisurely: it followed in 15% of the cases in the first period and in 9% of the cases in the second. Most of the changes tended to be in the same direction, especially in the second period. Noteworthy is also the fact that the average lag of Berlin with respect to Paris fell considerably from 15 to 7 days from the first to the second period.

In conclusion, the three tables presented do not give strong support to the 'conductor of the international orchestra' hypothesis of the classical gold standard. They rather suggest that we are dealing with three powerful countries mutually influencing each other, each with its own peculiarities. They suggest

TABLE 2
Official discount rate changes in London and Paris

1876–1895				
No. of Bank of England changes followed within one month by Paris change	9		6·8%[5]	
Average lag (in days)	13·1			
of which in same direction		6		4·5%
Average lag (in days)		14·2		
In opposite direction		3		2·3%
Average lag (in days)		11		
No. of simultaneous discount rate changes in London and Paris (same day)	8		6·0%	
No. of Bank of France changes followed within one month by London change	4		19·0%[6]	
Average lag (in days)	17·5			
of which: in same direction		3		14·3%
Average lag (in days)		14		
In opposite direction		1		4·8%
Average lag (in days)		28		
No. of simultaneous discount rate changes in Berlin and Paris (same day)	8		38·1%	
1896–1913				
No. of Bank of England changes followed within one month by Paris change	10		11·4%[7]	
Average lag (in days)	8·2			
of which: in same direction		9		10·3%
Average lag (in days)		6·6		
In opposite direction		1		1·1%
Average lag (in days)		28		
No. of simultaneous discount rate changes in London and Paris (same day)	6		6·8%	
No. of Bank of France changes followed within one month by London change	4		28·6%[8]	
Average lag (in days)	17·3			
of which: in same direction		2		14·3%
Average lag (in days)		13·5		
In opposite direction		2		14·3%
Average lag (in days)		21		
No. of simultaneous discount rate changes in London and Paris (same day)	6		42·9%	

Notes:
[5] Number of changes in % of total Bank of England discount rate changes during the period 1876–1895.
[6] Number of changes in % of total Bank of France discount rate changes during the period 1876–1895.
[7] Number of changes in % of total bank of England discount rate changes during the period 1986–1913.
[8] Number of changes in % of total Bank of France discount rate changes during the period 1986–1913.
Source: Vergleichende Notenbankstatistik (1925).

more symmetry between these three main European countries than has been so far assumed.

We have constructed tables similar to Tables 1–3 to analyse pairwise the relationships between official discount rate changes in London and the four smaller financial centres for which data are available (Brussels, Amsterdam,

TABLE 3
Official discount rate changes in Berlin and Paris

1876–1895				
No. of Reichsbank changes followed within one month by Paris change	10		15·2%[9]	
Average lag (in days)	14			
of which: in same direction		8		12·1%
Average lag (in days)		13·7		
In opposite direction		2		3·1%
Average lag (in days)		15		
No. of simultaneous discount rate changes in Berlin and Paris (same day)	0		0	
No. of Paris changes followed within one month by Berlin changes	8		39·0%[10]	
Average lag (in days)	14·7			
of which: in same direction		6		28·7%
Average lag (in days)		14·2		
In opposite direction		3		14·3%
Average lag (in days)		11		
No. of simultaneous discount rate changes in Paris and Berlin (same day)	8		39·0%	
1896–1913				
No. of Reichsbank changes followed within one month by Paris change	6		8·6%[11]	
Average lag (in days)	7·3			
of which: in same direction		6		8·6%
Average lag (in days)		7·3		
In opposite direction		0		0%
Average lag (in days)		0		
No. of simultaneous discount rate changes in Berlin and Paris (same day)	0		0	
No. of Paris changes followed within one month by Berlin changes	10		71·4%[12]	
Average lag (in days)	8·2			
of which: in same direction		9		64·3%
Average lag (in days)		6		
In opposite direction		1		7·1%
Average lag (in days)		28		
No. of simultaneous discount rate changes in Paris and Berlin (same day)	0		0	

Notes:
[9] Number of changes in % of total Reichsbank discount rate changes during the period 1876–1895.
[10] Number of changes in % of total Bank of France discount rate changes during the period 1876–1895.
[11] Number of changes in % of total Reichsbank discount rate changes during the period 1876–1895.
[12] Number of changes in % of total Bank of France discount rate changes during the period 1896–1913.
Source: Vergleichende Notenbankstatistik (1925).

Vienna and St. Petersbugh). Then we have done the same for Berlin and the four smaller centres. We briefly discuss only the four tables relating to London without showing them because of lack of space.[5]

[5] The four tables relating to London and the four relating to Berlin are available from the authors on request.

Surprisingly the picture that emerges is one where London followed the smaller centres more often than the other way around. This is particularly the case for Amsterdam, Vienna and St. Petersburgh. One explanation may be that these smaller European Central Banks were holding large foreign exchange reserves in London and that the increase in their discount rate may have been for the Bank of England an alarm bell of pending sterling conversions into gold, inducing her to take pre-emptive action. Another explanation could be that some tensions originating in the world were at times transmitted faster to the smaller and weaker European Central Banks and only later to the Bank of England. An example could be the following: consider a fall in export revenues of the British and Dutch colonial empire hitting more rapidly the current account of Holland than the current account of Great Britain, forcing Amsterdam to increase the official discount rate first.

A third explanation could be related to the following observations. Private discount rates tended to lead official discount rates as shown for Germany by Sommariva and Tullio (1987, Chapter 2); shocks originating anywhere in the system were therefore transmitted first to private discount rates in London and other centres, causing their increase; the increasing spread between the variable private discount rate and (for the moment) fixed official discount rate led to a fall in the ratio of metals to liabilities in both Central Banks' balance sheets. To defend internal convertibility (the only 'rule of the game' the gold standard Central Banks followed) they sooner or later raised the official discount rate to reverse the reserve drain. It is possible that the Bank of England could on average afford to move more leisurely, given the central position of the London financial market in the system and the greater power of London to attract funds from everywhere. The smaller Central Banks had to react instead more promptly. For more details on the role of the spread between the private and the official discount rates in influencing liquidity ratios in Germany and of changes in the liquidity ratios in influencing the discount rate, see Sommariva and Tullio (1987).

Whatever the causes of these findings, they do not suggest a Bank of England which unambiguously led the Central Banks of smaller European financial centres.

III Private Discount Rates in Seven European Financial Centres: Stationarity, Correlations and Coherency

Whether the private discount rates are stationary or not is tested using the Augmented Dickey-Fuller test in Table 4. The interest rate series are all stationary at least at the 10% level in both periods. This means that we can perform the traditional statistical tests using the interest rate levels.

Table 5 contains the means, standard deviations and coefficients of variation of monthly private discount rates in seven European financial centres, separately for the two periods. London had the lowest average interest rates in the first period (2·33%), St. Petersburgh the highest (5·44%). In the second period average interest rates were higher in all countries, most likely as a result of a

TABLE 4
Augmented Dickey-Fuller tests

Test equation: $\Delta X_t = a_0 + \rho x_{t-1} + \sum_{i=1}^{k} a_i \Delta x_{t-i} + u_t$

	1877(1)–1895(12)		1896(1)–1913(12)	
	t	k	t	k
England	−5·51**	3	−3·27*	6
France	−2·60(*)	4	−2·72(*)	4
Germany	−4·93**	6	−3·45*	6
Belgium	−3·72**	1	−3·37*	1
Austria	−7·43**	3	−2·64(*)	2
Holland	−3·51**	1	−3·48**	6
Russia	−5·13**	5	−2·84(*)	4

Notes:
(*), *, ** indicates that H_0: the variable is I(1), can be rejected on a 10, 5, 1% level, respectively.
k is chosen such that the residuals are empirically white noise.
t denotes the t-statistic of ρ.

TABLE 5
Descriptive statistics of private discount rates

	1876(1)–1895(12)			1896(1)–1913(12)		
	Mean	Std. dev.	Var. coef.	Mean	Std. dev.	Var. coef.
England	2·33	1·11	0·48	3·07	1·10	0·36
France	2·38	0·65	0·27	2·57	0·67	0·26
Germany	2·79	0·91	0·32	3·59	1·04	0·29
Belgium	2·71	0·73	0·27	3·03	0·89	0·29
Austria	3·80	0·50	0·13	3·93	0·81	0·21
Holland	2·64	0·76	0·29	3·13	0·87	0·28
Russia	5·44	1·02	0·19	5·64	0·82	0·15

change in inflationary expectations, a higher productivity of capital and maybe more frequent financial crises which threatened convertibility, although the increase is remarkably small in relation to changes in actual inflation and in real economic growth. London lost, in the second period, the privilege of the lowest average rate in favour of Paris (3·07% in London as opposed to 2·57% in Paris). London rates show the highest variability in both periods, suggesting that its central role as manager of the gold standard with such small gold reserves had a cost.

Table 6 contains correlation coefficients between the seven series. In the first period London had the highest correlation coefficient with Brussels (0·71), followed by Berlin (0·64) and Paris (0·58) and the lowest with St. Petersburgh (0·05). Berlin's correlation with Amsterdam and especially Vienna and St. Petersburgh was higher than London's. Paris had the highest correlation with

TABLE 6
Correlation coefficients of private discount rates
Upper part: period 1876(1)–1895(12)
Lower part: period 1896(1)–1913(12)

	Engl.	France	Germ.	Belg.	Austria	Holland	Russia	Median correl.
England	x	0·58	0·64	0·71	0·39	0·53	0·05	0·56
France	0·78	x	0·51	0·83	0·11	0·49	0·19	0·50
Germany	0·74	0·74	x	0·60	0·57	0·61	0·26	0·59
Belgium	0·82	0·88	0·82	x	0·20	0·64	0·24	0·62·
Austria	0·55	0·69	0·89	0·77	x	0·33	0·25	0·29
Holland	0·74	0·71	0·69	0·81	0·63	x	0·16	0·51
Russia	0·48	0·43	0·56	0·57	0·48	0·47	x	0·22
Median correl.	0·74	0·73	0·74	0·82	0·66	0·70	0·48	x

Brussels. In the second period all correlation coefficients are higher (increased capital mobility) and many are over 0·8. The largest increase is recorded by London's correlation with St. Petersburgh. Interest rates in Berlin and Vienna move almost together (0·89). What emerges from Table 6 is a high degree of capital mobility (with the exception of St. Petersburgh) increasing through time and a stronger correlation of Vienna and St. Petersburgh with Berlin than with London.

The coherencies, (comparable to a determination coefficient for each frequency) between London's private discount rate and those in Berlin, Paris, Vienna and St. Petersburgh are presented in Figure 1. Figure 2 contains the coherencies between Berlin and the other centres. The solid line refers to the first period, the dashed one to the second. The coherencies close to the origin are for low frequencies (the frequency $\pi/6$ corresponds to a one year cycle). The dashed horizontal line represents the approximate 90% confidence band. Thus all coherencies above the dashed horizontal line are significant. The coherencies tend to increase from the first to the second period at most frequencies. Again this has to be most likely attributed to the increased integration of financial markets. The average coherency (not reported here) is higher for low frequencies (2–4 years) than for high frequencies (1/2 year),[6] confirming Morgenstern's (1959) result that the medium run cycles of the main European interest rates were most of the time in the same phase. Russia presents the lowest average coherency at all frequencies both with London and Berlin in both periods. London has significant coherencies with Berlin and Paris at low frequencies in both periods (Figure 1). They increase in period two. Between Berlin and Paris there is evidence of a significant coherency also at higher frequencies (Figure 2). However, maybe the most interesting result is the very large increase in the coherency at low frequencies between Berlin and Vienna, but also to a smaller degree between Berlin and St. Petersburgh. These

[6] A table with average coherencies by frequency ranges for all pairs of interest rates is available from the authors on request.

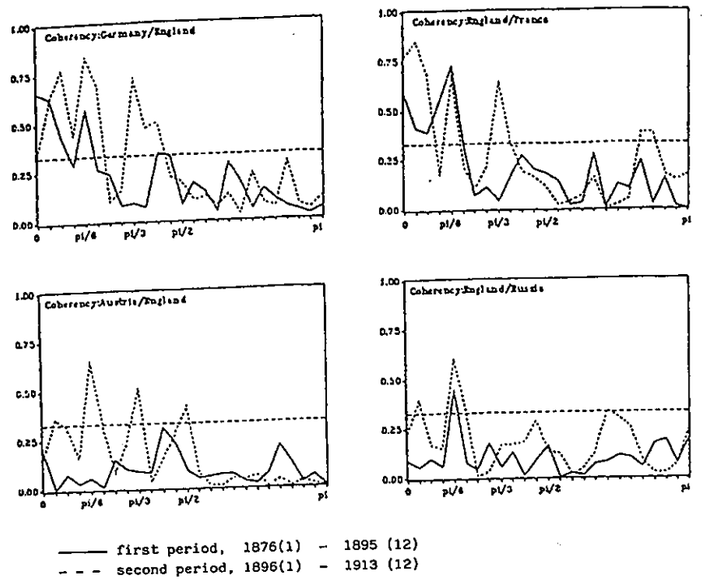


Figure 1. Coherencies with England.

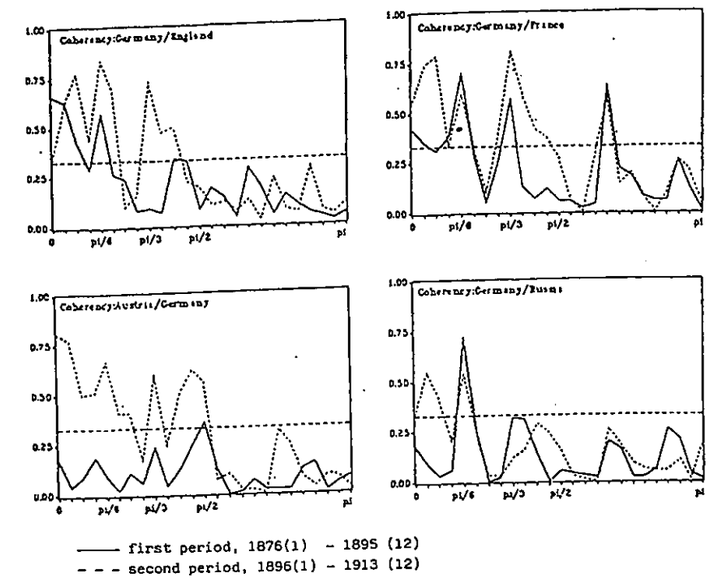


Figure 2. Coherencies with Germany.

increases are more significant than for London. We conclude that the degree of financial market integration between Berlin and these smaller centres increased more than between them and London and that probably the power of attraction of Berlin's financial market with respect to Vienna and St. Petersburgh increased more than London's.

IV Private Discount Rates in Seven European Financial Centres: Granger Multivariate Causality Tests and Impulse Response Analysis

In this section we present the results of Granger-causality tests and impulse response functions first in the 3-dimensional system formed by the London, Berlin and Paris private discount rates; then in the 7-dimensional system formed by the private discount rates in all 7 financial centres considered in Sections II and III. We use monthly data as in Section III. First we describe the methodological approach followed.

With y_t, u_t, and μ as $(n, 1)$-vectors and A_i $(i = 1, \ldots p)$ as (n, n) matrices a vector autoregressive process of order p (VAR(p)) is given as[7]

$$y_t = \mu + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + u_t \tag{1}$$

where u_t has zero expectation and

$$E(u_t u_t') = \Sigma \qquad \text{and} \qquad E(u_t u_s') = \phi \qquad t \neq s.$$

These models can be used for structural analysis: (i) Granger-causality and (ii) impulse response analysis. Within this framework one can generalize the bivariate Granger-causality tests. If one partitions the set of variables y_t in two subsets x_t and z_t, one can test whether there exists a simple Granger-causal relation from x_t to z_t and whether these two subsets of variables are instantaneously Granger causal.

Moreover, one may be interested in the response of one variable to an impulse in another variable in the whole system. This can be done with so-called impulse response functions. Suppose we want to investigate the effect of an innovation in the London rate on other interest rates of the system. This can be done by assuming that prior to time $t = 0$ all variables are equal to their mean value and that only the London rate increases by one unit in period $t = 0$. Assuming that no further shocks occur we can evaluate the reaction of the whole system during periods $t = 1, 2, 3, \ldots$

With this type of analysis it is assumed that a shock occurs in one variable at a time. This assumption may be problematic if the shocks in the different variables may be not independent. Therefore, prior to performing the impulse response analysis one transforms the residuals in such a way that they are uncorrelated and have unit variance. One problem with this kind of analysis is that the results of the orthogonalised impulse responses may depend on the ordering of the variables in system (1).

[7] See especially Luetkepohl (1991, p. 35).

We estimated two VAR(2)-models . The order was chosen by applying information criteria.[8] One VAR(2) is 3-dimensional and contains the interest rates of London, Berlin and Paris. The other VAR(2) is 7-dimensional and contains all interest rates.[9] The results for the period from 1876–1895 are given in Tables 7 and 8 and Figures 3 to 8. With the F-statistic we test the hypothesis H_0: 'x is not Granger-causal to z'. With the χ^2-statistic we test H_0: 'no instantaneous causality between x and z'. Considering the 3-dimensional system first (Table 7), we find that both hypotheses can always be rejected. PR stands for private discount rate and E, G, F are the country codes. Thus we find strong linkages between the three interest rates. In the 7-dimensional system (Table 8) we see again that there exist strong instantaneous causal relations. Moreover, the centre countries have a highly significant Granger-causal relation to all the other countries, whereas the periphery and smaller countries have no Granger-causal influence on the other countries.

To get more detailed information about the reaction between the three countries in the centre we look at the impulse respone functions between PRE, PRG, and PRF. The results do not change substantially between the 3- or the 7-dimensional system. We report only the impulse response functions in the 3-dimensional system for lack of space.[10] We find that:

(i) Innovations in PRG have a significant influence on PRF (until 5 months), and on PRE (between 2 and 4 months).

TABLE 7
Granger-causality tests in the 3-dimensional system, 1876(1)–1895(12)

x	z	$F(x \longrightarrow z)$	$\chi^2(x - z)$
PRE	PRG, PRF	6·77(0·000)	30·40(0·000)
PRG	PRE, PRF	12·33(0·000)	27·67(0·000)
PRF	PRE, PRG	5·78(0·000)	9·33(0·000)

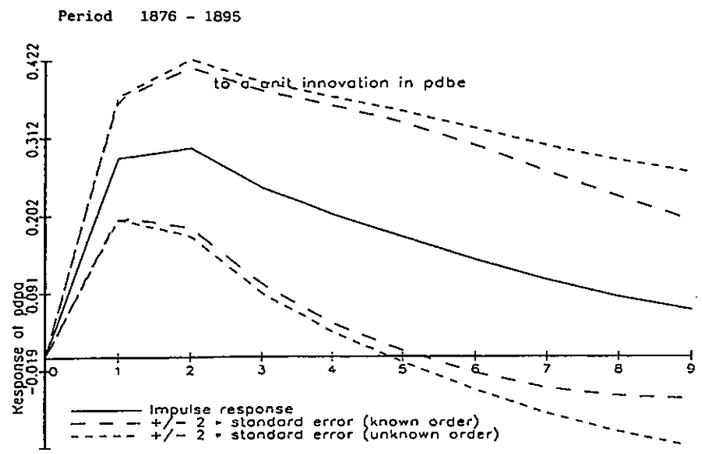
Notes:
P-values in parenthesis.

TABLE 8
Granger-causality tests in the 7-dimensional system, 1876(1)–1895(12)

x	z	$F(x \longrightarrow z)$	$\chi^2(x - z)$
PRE	PRG, PRF, PRH, PRB, PRA, PRR	2.78(0.001)	47.96(0.000)
PRG	PRE, PRF, PRH, PRB, PRA, PRR	6.54(0.000)	51.75(0.000)
PRF	PRE, PRG, PRH, PRB, PRA, PRR	3.56(0.000)	25.21(0.000)
PRA, PRR	PRE, PRG, PRF, PRH, PRB	1.00(0.452)	48.17(0.000)
PRA, PRR, PRH	PRE, PRG, PRF, PRB	1.39(0.171)	56.57(0.000)
PRA, PRR, PRB	PRE, PRG, PRF, PRH	1.71(0.065)	82.26(0.000)

Note:
P-values in parenthesis

[8] See Luetkepohl (1991, pp. 128).
[9] The programme used is MULTI, written by Haase *et al.* (1992).
[10] The impulse response functions in the 7-dimensional system are available from the authors on request.



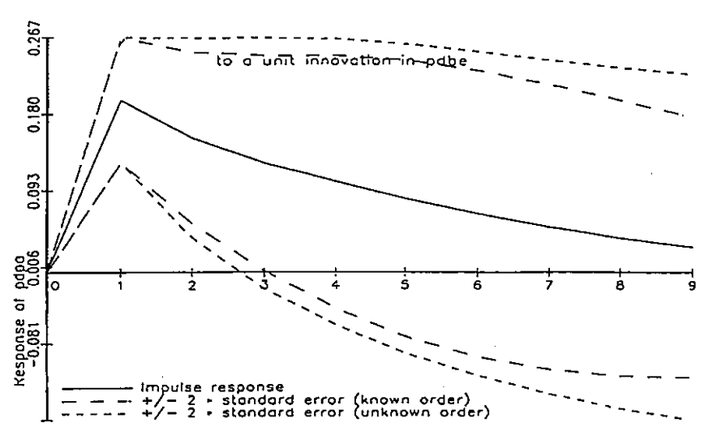
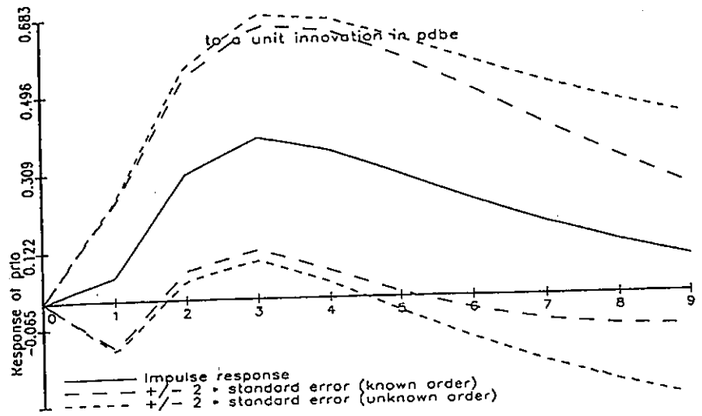


Figure 3. Response of France to a unit shock in Germany (3-dimensional system).

(ii) Innovations in PRE have a very short run (up to 2 months) significant influence on PRG and no significant influence on PRF.

(iii) Innovations in PRF have a very short run significant influence on PRE but no influence on PRG.

Thus there seems to exit a feedback relation between England and Germany, whereas France is influenced by Germany and influences England.



Period 1896 - 1913

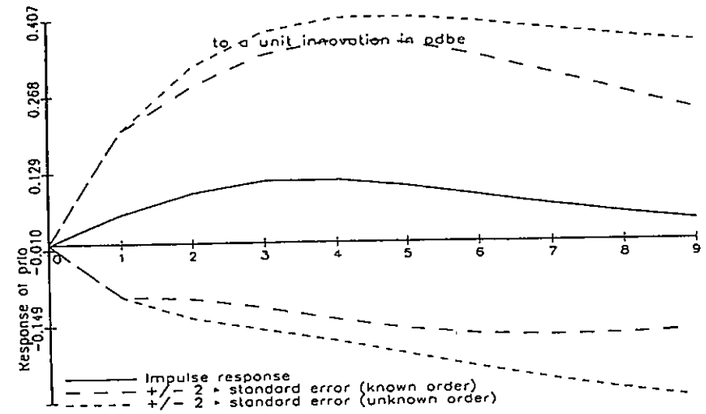


Figure 4. Response of England to a unit shock in Germany (3-dimensional system).

The results for the period from 1896 to 1913 are reported in Tables 9 and 10 and Figures 3 to 8. Again we estimated two VAR(2)-models, one with the three variables PRE, PRF, and PRG and the other with all 7 interest rates. In the 3- dimensional system, the Granger-causality tests (Table 9) show that the influence of France on the other two countries seems to be weaker, whereas England shows a highly significant Granger-causal relation to the others. The same holds for Germany. In the 7-dimensional system

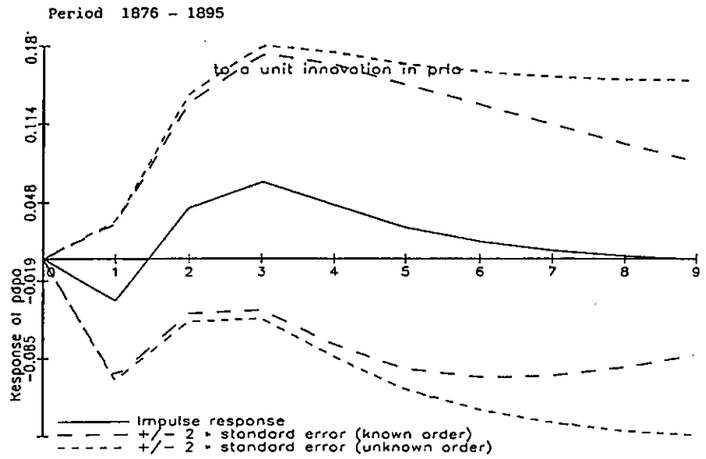


Figure 5. Response of France to a unit shock in England (3-dimensional system).

(Table 10) we find again strong instantaneous causal relations. With the exception of France and Russia each country shows a significant Granger-causal relation to all the remaining countries. Between the group of the centre countries and the other countries there exist feedback relations. However, the influence is much more significant from the centre to the periphery.

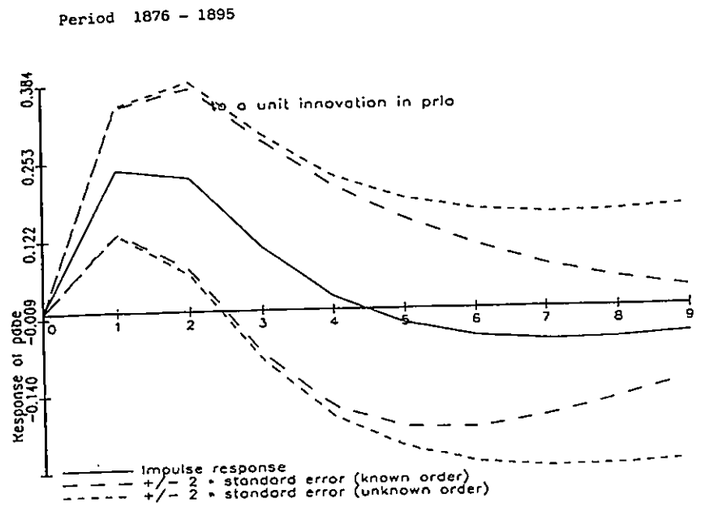


Figure 6. Response of Germany to a unit shock in England (3-dimensional system).

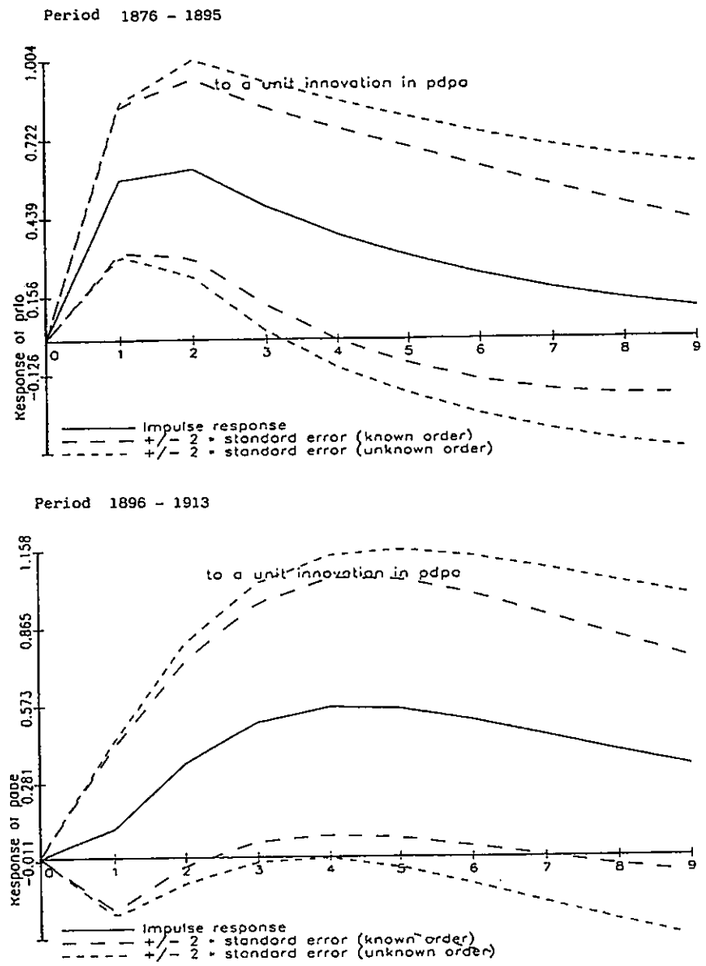


Figure 7. Response of England to a unit shock in France (3-dimensional system).

In Figures 3–8 we look at the impulse response functions between PRE, PRG, and PRF. The results do not differ very much for the 3- and the 7-dimensional systems. Again we report only the results for the 3-dimensional system for lack of space. We find that:

(i) Innovations in PRG have only a very short-run (one to two months) significant influence on PRF and no significant influence on PRE.

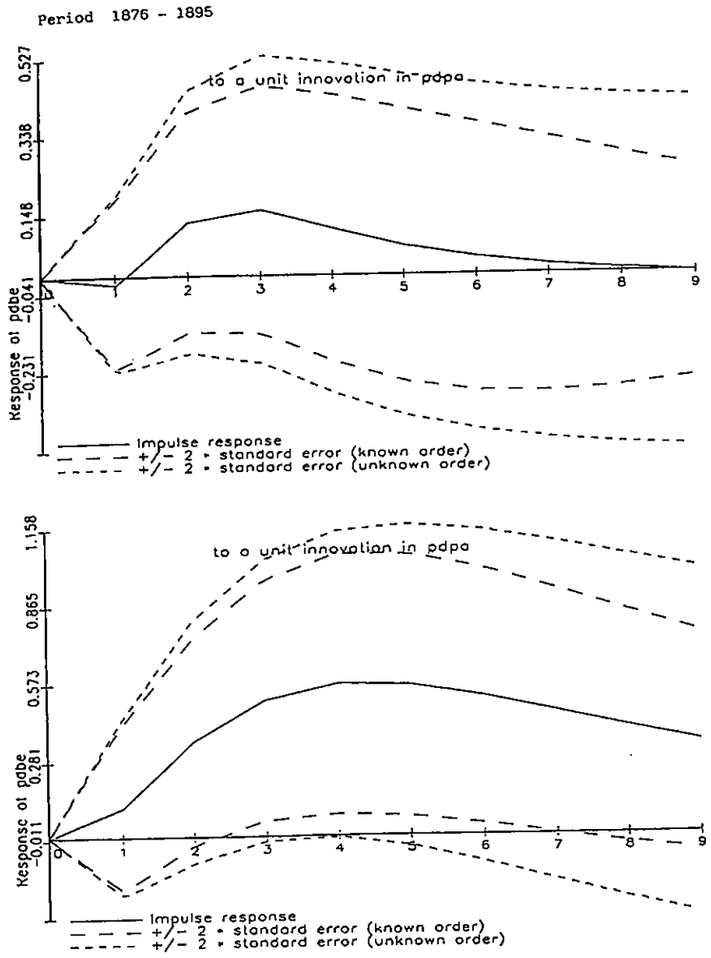


Figure 8. Response of Germany to a unit shock in France (3-dimensional system).

(ii) Innovations in PRE have a short run significant influence on Germany (one to two months) as well as on France (one to three months).
(iii) Innovations in PRF influence both PRE and PRG.

Thus it seems that the position of England and France becomes stronger compared to the previous period, whereas the position of Germany weakens, although it may be that Germany influenced England primarily via France.

TABLE 9
Granger-causality tests in the 3-dimensional system, 1896(1)–1913(12)

x	z	$F(x \rightarrow z)$	$\chi^2(x-z)$
PRE	PRG, PRF	6·74(0·000)	45·62(0·000)
PRG	PRE, PRF	8·39(0·000)	41·95(0·000)
PRF	PRE, PRG	2·03(0·091)	30·67(0·000)

Notes:
P-values in parenthesis.

TABLE 10
Granger-causality tests in the 7-dimensional system, 1896(1)–1913(12)

x	z	$F(x \rightarrow z)$	$\chi^2(x-z)$
PRE	PRG, PRF, PRH, PRB, PRA, PRR	3.91(0.000)	61.13(0.000)
PRG	PRE, PRF, PRH, PRB, PRA, PRR	2.66(0.003)	65.77(0.000)
PRF	PRE, PRG, PRH, PRB, PRA, PRR	1.33(0.205)	40.72(0.000)
PRH	PRE, PRG, PRF, PRB, PRA, PRR	1.94(0.032)	33.16(0.000)
PRB	PRE, PRG, PRF, PRH, PRA, PRR	1.95(0.031)	58.86(0.000)
PRA	PRE, PRG, PRF, PRH, PRB, PRR	3.10(0.000)	57.79(0.000)
PRR	PRE, PRG, PRF, PRH, PRB, PRA	1.85(0.042)	22.64(0.001)
PRE, PRG, PRF	PRH, PRB, PRA, PRR	3.12(0.000)	112.36(0.000)
PRH, PRB, PRA, PRR	PRE, PRG, PRF	2.55(0.004)	112.36(0.000)

Note:
P-values in parenthesis.

V Summary and Comparisons with Previous Empirical Studies

In this paper we have analysed the interrelationships of official and private discount rates between seven European financial centres and in particular between London, Berlin and Paris during the period 1876–1913. We have looked at the days and direction of all official discount rate changes in the seven centres and analysed pairwise leads and lags (Section II). As to private discount rates we have tested for stationarity, measured correlations and coherencies, performed multivariate Granger-causality tests and calculated impulse response functions. The main objective of the paper was to gather new evidence on the degree of asymmetry in balance of payments adjustment between the three main European financial gold standard centres and about the alleged role of London as the 'conductor of the international orchestra'. We find strong mutual feedbacks between interest rates in London, Paris and Berlin, suggesting that the classical gold standard was a decentralised, multipolar system as suggested by Eichengreen (1992).

Hence London was neither the conductor of the international orchestra nor a triangle player. It was probably the most influential country in the system, but our analysis shows that the balance of payments adjustment between at least the three main European countries, the UK, Germany and France must have been much more symmetric than implied by Keynes' 'conductor of the international

orchestra' view, with the latter two countries being in the position to influence significantly London interest rates and most likely being able to throw at least at times a large share of the burden of adjustment on the UK. This is confirmed by the study of leads and lags in official discount rate changes in Section II as well as by the multivariate Granger-causality tests and impulse response functions of Section IV. Germany and France were large international capital exporters and net creditors, had a larger gold stock than the UK and had their own financial sphere of influence in Continental Europe. The sphere of influence of Germany in Continental Europe (especially on Vienna and St. Petersburgh) increased in the period 1896–1913 more than London's, as the coherencies presented in Section III seem to suggest. In addition the mark and the franc were used as reserve currencies on an increasing scale in Continental Europe and by the end of the period they were more important on the Continent than sterling (Lindert, 1969). Finally, also the fact that on the eve of World War I the German economy had already overtaken that of the UK contributes to explain our findings.

As a result, the role played by France and especially Germany during the classical gold standard should be upgraded and the role of London downgraded at least with respect to the 'conductor of the international orchestra' view. For the sake of completeness one should, however, remind the reader that Keynes held a much more sophisticated view than believed by those who quote his famous sentence.

Our results do not confirm the results of any of the four previous empirical studies on interest rates interrelationships during the classical gold standard which we could find. Two seem to attribute an even larger role to Berlin than we do in this paper (Neuburger and Stokes, 1979; Giovannini, 1989). Eichengreen (1987) found a strong influence of British rates on the French and German rates and weaker evidence of the reverse. Finally, Lindert (1969) found that the Bank of England clearly enjoyed a short run command over most of the sterling exchanges, especially with respect to shallow money markets, like Portugal and Russia. He concluded that 'London also enjoyed hegemony among the three main centres, although her supremacy was less pronounced. She had a clear edge on Berlin and a more ambiguous advantage on Paris.' (Lindert, 1969, p. 52). One problem with the above mentioned studies, except that of Neuburger and Stokes, is that the official discount rates they use were moving in steps, especially in France, and this may make the results less reliable.

The second conclusion of our tests is that even the smaller European financial centres (especially Amsterdam, Vienna, St. Petersburgh) seemed at times able to influence London's official discount rates or at least transmit to London disturbances originating elsewhere, as shown by the fact that there were many instances in which the official discount rates in these centres led the Bank of England's official discount rate. In addition, the 7-dimensional Granger-causality tests presented in Section IV with monthly private discount rates show that at least in the second period the periphery of Europe Granger-caused the private discount rates in the three main centres (Table 10), although the causality was not as strong as from the centre to the periphery.

Third, an interesting corollary of the tests presented in this paper is that they show that capital mobility and financial market integration was significantly higher in the period 1896–1913 with respect to the period 1876–1895. This comes out rather clearly particularly from the correlation coefficients and the coherencies calculated in Section III.

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