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The International Transmission of Price Levels during the Classical Gold Standard Period: Evidence from the UK and the US

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Abstract

It is known that during the classical gold standard period, the UK and the US shared close economic ties and the price levels between the two countries were considerably linked. We examine which country played the leading role in price levels using the causality test of the lag augmented vector autoregression (LA-VAR). Our results indicate that the UK price level caused the US price level whereas the reverse was not the case regardless of the variety of the specifications in the LA-VAR model. Therefore, we conclude that the UK price level determined the US price level at the time.

Keywords: Price level; International transmission; Price leader; LA-VAR; Causality test; Classical gold standard; The UK and the US

JEL classification: E31; F42; N10

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1. Introduction

The UK and the US during the classical gold standard period—the period between the end of the nineteenth century and World War I—had close economic as well as political ties.[1] Exports from the UK to the US amounted to more than 10 percent of the total UK exports, and the exports from the US to the UK was more than 20 percent of the total US exports in 1890.[2] In addition, at the end of 1913, the flow of foreign investment from the UK to the US amounted to 850 million pound, which was approximately 20 percent of the foreign investment in the UK. The scale was considerable because foreign investment in the UK was more than double of that in France, which had the second largest inflow of foreign investment in the world during the period.[3]

As Findlay and O'Rourke (2003) referred, price convergence is the best measure of the market integration. There are many researches on the linkage between the price levels of the UK and the US at the time. Harley (1980, 1992), and Findlay and O'Rourke (2003) insisted that the prices of identical commodities in separate markets of the UK and the US tended to be strongly connected. These evidences are also supported by the fact that the trade flourished, which fostered the convergence of factor prices, living standards, and income

[1] These days, the researches that compare the contemporary world economy with the one during the classical gold standard period are animatedly discussed from the viewpoint of globalization. Some researchers label the globalization that occurred during the classical gold standard period as the first age (era) of globalization, the earlier age (era) of globalization, or the previous age (era) of globalization. For example, see Bordo, Eichengreen and Irwin (1999), Bordo (2002), and Bordo and Murshid (2002).

[2] Saul (1960), Table 30.

[3] The scales of foreign investment in countries of the time are from Feinstein (1960), p.121 on the UK and Cameron (1961), p.486 on France.

distribution between both countries.[4]

Figure 1 illustrates the producer price indices for the UK and the US from January 1885 to June 1914, with the data of January 1885 set to 100. The paths of the price levels in both countries appeared similar for thirty years. Figure 2 illustrates the dollar-pound exchange rate during the same period.[5] The rate tended to range within a narrow limit. These evidences indicate that the relative price between both countries, that is, the real exchange rate, was not adjusted by the nominal exchange rate but by the price levels of both countries.[6] Therefore, the synchronization of the price levels of both countries is apparent.

[Figure 1 about here.]

[Figure 2 about here.]

Then, was there a relationship of leader and follower between the price levels of the UK and the US? In historical perspective, either UK or US could be the price leader considering that both countries had notable presences in the world economy. In fact, it is no wander that the US was the price leader. The GDP of the US was more than twice as that of the UK.[7] The official gold reserve in the US was 1290.4 million dollars, while the official gold reserve in the

[4] Bordo (2002), p.28 and O'Rourke and Williamson (1994).

[5] See Grilli and Kaminsky's (1991) Appendix 1 if you want to know the detail information about the data source of price levels and exchange rate of the UK and the US.

[6] McCloskey and Zecher (1984) and Diebold, Husted, and Rush (1991) strongly supported Purchasing Power Parity (PPP) at the time.

[7] Maddison (1991), Table A-2.

UK at the time was 164.9 million dollars; in other words, the US held more than seven times the amount of gold in the UK.[8] Furthermore, it is possible that the US pulled at the business cycles of both countries because the US was an investment-led economy and the UK was an export-driven economy.

On the other hand, it is reasonable to claim that the UK was the price leader. In fact, the UK and the Bank of England played an important role in the international monetary system and some researchers insist that the international monetary system of the time was operated as the sterling exchange standard.[9] [10] The money market conditions in London had immediate repercussions in other countries for a variety of reasons: London was the world's largest financial center, the UK was the world's principal capital exporter, commercial contracts even between third countries tended to be discharged by payments in sterling, the world's gold tended to flow to London, and the world's principal organized commodities markets were located there. Thus, London was the source of the world's liquidity and a tightening or loosening of the money market there could affect the liquidity of all those who had stakes there. [11] In fact, Lindert (1969) insisted that the Bank of England acted as a leader and that the interest rate of the UK spilled over to rest of the world. In a recent notable paper, Bordo and Murshid (2002) argued that financial shocks were largely transmitted in one direction from the advanced countries of Europe (particularly the UK) to

[8] Lindert (1969), Table 1.

[9] Brown (1940), p784.

[10] Some researchers argued that the discretionary actions of policymakers of countries were considerably limited and the system was a symmetrical and rule-based regime at the time. See Eichengreen (1987) for details.

[11] Dam (1982), p.18, and Mundell (1968), p.139.

the emerging countries of the world.

It is also considered that the UK acted as a price leader from another perspective. It is well known that the Bank of England managed to keep the sterling convertible into gold on the basis of a small gold reserve in contrast to the major countries of the period. Therefore, the Bank of England tended to intervene frequently and swiftly as compared to other major central banks in order to maintain appropriate gold reserves.[12] This case would introduce that that the change of price level appeared first in the UK and then transmitted to the US with a lag even if the common disturbances appeared simultaneously in the UK and the US.[13]

As just described, it is difficult to conclude which country played a leading role in the price levels by the narration of historical facts. Therefore, we try to verify it by the statistical method. This could be an interesting research question because there was no previous research that verified in this regard.[14] To find an answer, we examine the cause and effect relationship by the causality test of the lag augmented vector autoregression (LA-VAR), one of the modern time-series techniques. Empirical results indicate that the UK price level caused the US price level, whereas the US price level did not cause the UK price level. In

[12] There is consensus that central banks did not strictly play by the rules of the game at the time. See, Bloomfield (1959). However, from recent research, it is known that the deviation from the rules of the game was restricted to the short-run. For example, Obstfeld and Taylor (2004).

[13] This vision is discussed by Eichengreen (1987), p.13.

[14] The work of Huffman and Lothian (1984) is most closely related to our research. However, they did not use only the so-called classical gold standard period's sample because they used the data from combined sub-periods 1837–1859 and 1882–1914. In addition, we need to take notice of their econometric evidence because of some problems. For example, see Connolly (1984).

addition, we confirmed that the evidences were highly robust regardless of lag length and sample period in the model. Therefore, it is probable that the UK acted as a price leader to the US during the classical gold standard period.

The rest of this paper is organized as follows. Section 2 introduces the LA-VAR approach. Section 3 describes the empirical analysis and the implications of the results. Finally, Section 4 provides some concluding remarks.

2. Empirical Technique

This section introduces the LA-VAR approach developed by Toda and Yamamoto (1995), which we use in the empirical analysis.[15] This approach has two merits for our research. First, we can verify the causal relationship among variables by estimating the VAR model as well as the technique developed by Granger (1969), which has been applied to many research areas. Therefore, we can reduce the dependence on the potentially inappropriate theoretical restrictions of structural models. Since we cannot perfectly comprehend the complicated channels of transmission mechanisms, the technique would be an effective means of characterizing the dynamic interactions among economic variables. Second, the LA-VAR approach can overcome the problems that might occur in the traditional Granger causality test because it is applicable by the VAR model formulated in level regardless of whether the VAR process is stationary, integrated, or cointegrated.[16]

Suppose an n-vector y_t is generated by the following model:

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[15] The explanation in this section is based on Toda and Yamamoto (1995) and Hamori (2003), ch.2.

[16] As Engle and Granger (1987) insisted, a VAR model formulated in first-order differences is misspecified if variables in the level are cointegrated.

$$y_t = \gamma_0 + \gamma_1 t + J_1 y_{t-1} + J_2 y_{t-2} + \cdots + J_k y_{t-k} + \varepsilon_t \ , \quad t = 1 \ , 2 \ , \cdots \ , T \ , \qquad (1)$$

where t is the time trend, k is the order of the true lag length, ε_t is the vector of the error terms with mean zero and variance-covariance matrix Σ_ε, γ_0 and γ_1 are vectors of parameters, and J_1, J_2, $\cdots$, J_k are matrices of parameters. The null hypothesis is as follows:

$$H_0 : \ f(\phi) = 0 \ , \qquad (2)$$

where $\phi = vec(\Phi)$ of model (1), $\Phi = (J_1, J_2, \cdots, J_k)$, and $f(\cdot)$ is an m-vector valued function. In order to test hypothesis (2), we estimate a VAR formulated in levels by the ordinary least squares method as follows:

$$y_t = \hat{\gamma}_0 + \hat{\gamma}_1 t + \hat{J}_1 y_{t-1} + \hat{J}_2 y_{t-2} + \cdots + \hat{J}_p y_{t-p} + \hat{\varepsilon}_t \ , \qquad (3)$$

where p is equal to the true lag length (k) plus the maximum integration order considered in the process (d), $\hat{\gamma}_0$ and $\hat{\gamma}_1$ are the vectors of parameter estimates, and $\hat{J}_1$, $\hat{J}_2$, $\cdots$, $\hat{J}_p$ are the matrices of parameter estimates.[17] For example, the maximum integration order is one if the integration orders of the variables included in y_t are less than one, and the maximum integration order is two if the integration orders of the variables included in y_t are less than two. Since the true values of $\hat{J}_{k+1}, \cdots, \hat{J}_p$ are zero, restriction (2) does not include them. The Wald statistic can be calculated with parameter estimates $\hat{\phi} = vec(\hat{\Phi})$. When the null hypothesis is true, the Wald statistic has an asymptotic chi-square distribution with m degrees of freedom.[18]

Since it is possible to test the hypothesis for any restriction using the chi-square distribution, the causality test by the LA-VAR approach is applicable in this framework. We

[17] Note that the integration order of the process should not exceed the true lag length of the model ($d \leq k$).

[18] It is noted that $k \leq m \leq p - 1$. For details, see Toda and Yamamoto (1995).

can formulate the null hypothesis as zero restrictions on the first k coefficients of the lags under the condition where the last d lagged vectors in the model are ignored.[19]

Consequently, it is obvious that LA-VAR approach unlike the traditional approach is beneficial for our research. In fact, it is no wander that price levels tend to link internationally in the long run if the exchange rate is fixed despite capital control and sterilization. That is, it was possible to have cointegration relationships among the price levels of the UK and the US during the classical gold standard period, which was the era of globalization.[20] It is known that traditional Granger test cannot apply the case of the cointegration.[21]

3. Empirical results

[19] We can regard the traditional Granger causality test as a particular case of the causality test by the LA-VAR approach. In fact, the causality test by the LA-VAR approach is tantamount to the traditional Granger causality test when y_t is a vector that comprises only the variables of an I(0) process, that is, $d = 0$.

[20] Cointegration refers to the long-run stable relationship among variables. For example, if some variables are non-stationary in levels and the residual of the linear relationship of each variable is stationary, it is said that these variables are cointegrated. The movements of variables are linked if the variables have cointegration.

[21] In addition, it is well known that the results of these tests to check whether there are cointegration relationships are not robust although they are very important. Consequently, cointegration relationship might indeed exist even if cointegration does not appear from the test. In this case, the analysis of the VAR model formulated in first-order differences would assume a risk, given that it would induce imprecise results with regard to the causal relationship between the UK and the US. See Toda and Yamamoto (1995), p.226 for details.

The monthly data of producer price indices for the UK and the US from January 1885 to June 1914 are used for empirical analysis.[22] By using not annual data but monthly data, it is hoped that we can capture the transmission mechanism through the direct effects of the international price arbitrage.[23] The variables are measured in natural logs.

In this research, we require the lag length (k) and the maximum integration order (d) in order to estimate equation (3), that is, a ($k+d$)th order VAR formulated in levels. First, we select k until lag 12 by the Akaike information criterion (AIC) and the Schwarz Bayesian information criterion (SBIC). The results are reported in Table 1, which shows that both AIC and SBIC select lag 2, i.e., $k=2$. Table 2 presents the results of the diagnostic test for the selected lag length. LM (h) is the Lagrange multiplier test statistic for the null hypothesis that there is no autocorrelation up to $h=6,\ 12,\ 24$, and the test statistic has an asymptotic chi-square distribution with 4 degrees of freedom. In Table 2, the specification with the lag lengths 2 selected by AIC and SBIC is empirically supported because the null hypothesis is not rejected at the 5% level.

[Table 1 about here.]

[Table 2 about here.]

Second, we determine the maximum integration order (d). In other words, we need to know the integration order of the PPI of the UK and the US. The data generating process of

[22] See Section 1 for the data source.

[23] Connolly (1984).

the price level usually tends to be considered an I(1) process, that is, $d = 1$.[24] However, some researchers find that the price level is an I(2) process, that is, $d = 2$ by further investigation.[25] Unfortunately, it is known that the power of several tests for unit root tests is very low as opposed to the alternative hypothesis of stationary although it is very important for us to arrive at the precise information of the maximum integration order of the price levels in the UK and the US. For this reason, we might assume the risks of the bias in the unit root test when we strictly specify the integration order of the price levels of the UK and the US. Therefore, we apply $d = 1$ and $d = 2$ in order to avoid the problem of the pretest bias and acquire credible results considering the possibility that price levels are either an I(1) or an I(2) process.

We estimate equation (3) and carry out the causality test. Table 3 presents the empirical results of the causality test by the LA-VAR approach. The test statistics have an asymptotic chi-square distribution with 2 degrees of freedom. The null hypothesis that the UK price level does not cause the US price level is rejected, whereas the null hypothesis that the US price level does not cause the UK price level is not rejected at the 5% significance level in both cases of $d = 1$ and $d = 2$. Fortunately, we need not be concerned about inconsistent results because they do not conflict with the two maximum integration orders. That is, our results indicate the transmission of price levels from the UK to the US.

[Table 3 about here.]

[24] To give an actual example, if a variable is non-stationary in levels and the first difference of the variable is stationary, then the variable is integrated of order one, that is, I(1) process.

[25] For example, Johansen (1992) and Crowder (1996).

However, we need to cautiously verify the robustness of the results because the results of the VAR analysis are particularly susceptible to lag lengths and the sample period. For this reason, we estimate equation (3) in cases of $k = 6$, $k = 12$, and $k = 24$ as well as in the case of $k = 2$, considering that the lag order 2 on the monthly data may be short even if $k = 2$ is selected by AIC and SBIC and the specification is empirically supported by the Lagrange multiplier test. In Table 4, each test is applied in both cases of $d = 1$ and $d = 2$. The test statistics have an asymptotic chi-square distribution with 6 degrees of freedom when $k = 6$, 12 degrees of freedom when $k = 12$, and 24 degrees of freedom when $k = 24$. As shown in Table 4, the null hypothesis that the UK price level does not cause the US price level is rejected, whereas the null hypothesis that the US price level does not cause the UK price level is not rejected at the 5% significance level in all cases.

[Table 4 about here.]

It is interesting that the results are not reversed by the lag length. The quick response might exist between the price levels of both countries as background of the results. In fact, international capital moved rather freely and interest rates among the countries were closely connected to each other because there were no capital controls during the classical gold standard period.[26] In addition, wages and prices were relatively flexible at the time.[27]

[26] In fact, it is widely accepted that it was only in the 1990s that the scale of international capital flow reached the levels of the classical gold standard period. This interesting trend traced over time by the level of international capital mobility is frequently referred to as the U-shaped pattern. For example, Eichengreen (1996), p.3, Bordo (2002), and Obstfeld and Taylor (2004), p28.

Therefore, it is probable that the international transmission mechanism of the price levels was adjusted within one year.[28]

We conduct our analysis by breaking the sample period into two because the classical gold standard period covers a long sample period and the power balance and the transmission process of the price levels between the UK and the US could change during the period.[29] The first half of the period ranges from January 1885 to December 1900 and the latter half of the period ranges from January 1901 to June 1914. As Table 5 shows, the test statistic in the latter half of the period is smaller than the first half for the null hypothesis that the UK price level causes the US price level. Although it is possible that the power of the UK declined relatively, the null hypothesis is still rejected at the 1% significance level in the latter half of the period. From the verifications above, we would be able to conclude that the UK price level determined the US price level during the classical gold standard period.

[Table 5 about here.]

4. Conclusion

In recent years, the researches on the economic situation during the classical gold

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[27] Eichengreen (1996), p.31.

[28] For confirmation, we presume that the price levels of the UK and the US are I(1) processes and that these variables have no cointegration, and test using the traditional Granger approach. The result does not turn the result of LA-VAR approach, although detailed results does not appear in this paper.

[29] In fact, economic growth in the US was faster than in the UK during the classical gold standard period.

standard period, which was the previous era of globalization, have become the topic of much interest in relation to the wave of recent globalization. It is known that the UK and the US shared close economic ties and the price levels between the two countries were considerably linked. Many researchers have found the price convergence of both countries.

However, we could find almost no previous research that verified which country's price level pulled at world price level. The US already possessed overwhelming economic power, while the UK acted as a leader in the international monetary system and international trade at the time. Verifying the transmission among countries is very important for understanding the character of the classical gold standard period. Therefore, we examine the international transmission of price levels in the UK and the US using the LA-VAR approach, which is one of the modern time-series techniques.

The results of this paper are summarized as follows. The causality tests show that the UK price level caused the US price level; however, the US price level did not cause UK price level. Moreover, we find that the evidence is very robust regardless of the variation in the lag length and sample period despite the fact that the VAR analysis tends to be influenced by them. Therefore, it appears that the UK price level determined the US price level during the classical gold standard period.

Our research is noteworthy in that we discovered the pattern from the UK to the US during the classical gold standard period using a robust investigation. However, further investigation is required in order to clarify the in-depth transmission mechanism in future research.

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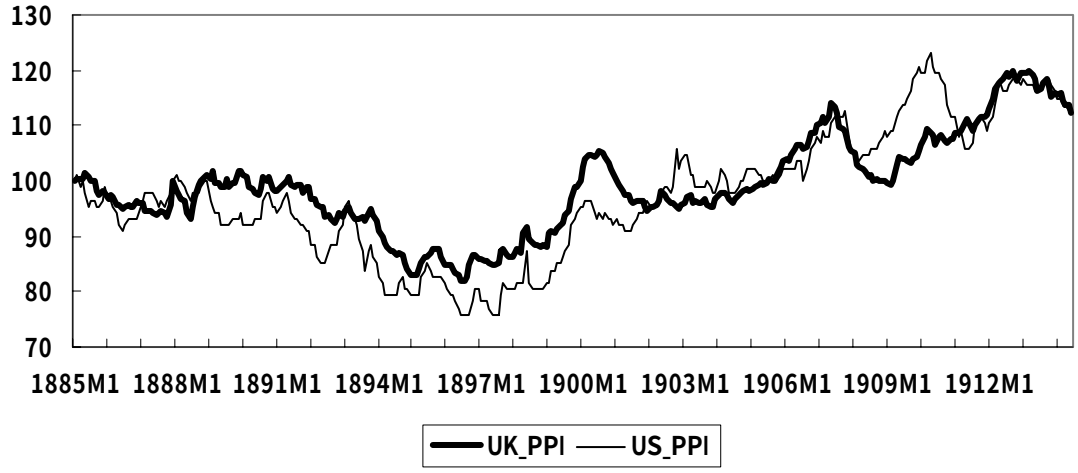
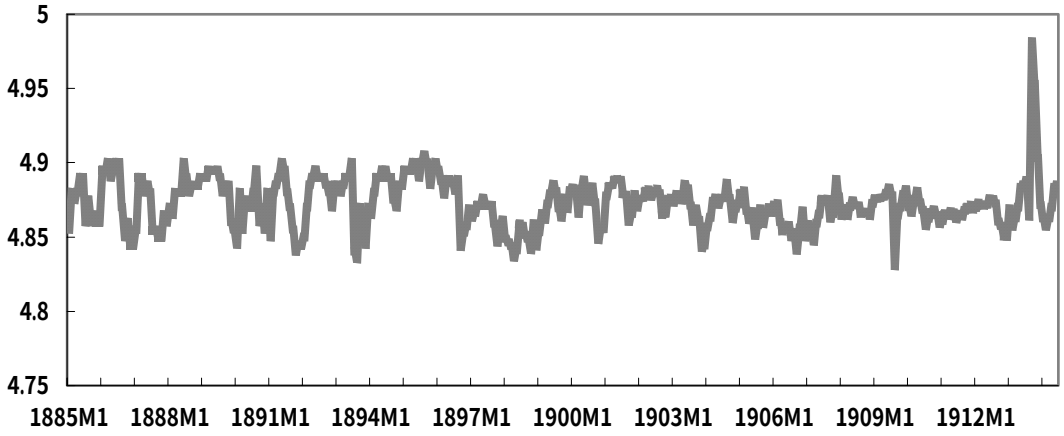
Figure 1. UK and US Producer Price Indices



Note: See Section 1 for the data source.

Figure 2. Dollar/Pound Exchange Rate



Note: See Section 1 for the data source.

Table 1. VAR Lag Order Selection Criteria

Lag	AIC	SBIC
1	-11.99	-11.90
2	-12.09*	-11.96 *
3	-12.08	-11.90
4	-12.06	-11.83
5	-12.05	-11.78
6	-12.03	-11.71
7	-12.02	-11.66
8	-12.00	-11.60
9	-12.02	-11.57
10	-12.03	-11.53
11	-12.01	-11.47
12	-12.00	-11.41

Note: * indicates the lag length selected by AIC and SBIC. See Section 3 for details.

Table 2. Diagnostic by LM Test

	Test Statistics	P-value
LM (6)	5.637	0.228
LM (12)	3.325	0.505
LM (24)	0.516	0.972

Note: See Section 3 for details.

Table 3. LA-VAR Causality Test under k = 2

	d = 1		d = 2	
	Test Statistics	P-value	Test Statistics	P-value
The UK does not cause the US	29.934	0.000	29.658	0.000
The US does not cause the UK	0.211	0.900	0.055	0.973

Note: See Section 3 for details.

Table 4. LA-VAR Causality Test under Alternative Lag Lengths

	d = 1		d = 2	
	Test Statistics	P-value	Test Statistics	P-value
k = 6				
The UK does not cause the US	37.207	0.000	37.721	0.000
The US does not cause the UK	1.497	0.960	2.026	0.917
k = 12				
The UK does not cause the US	41.273	0.000	41.083	0.000
The US does not cause the UK	12.702	0.391	13.131	0.360
k = 24				
The UK does not cause the US	47.357	0.003	48.544	0.002
The US does not cause the UK	25.254	0.392	23.164	0.510

Note : See Section 3 for details.

Table 5. LA-VAR Causality Test of Sub-Sample Periods

	d = 1		d = 2	
	Test Statistics	P-value	Test Statistics	P-value
First Half (1885-1900)				
The UK does not cause the US	22.373	0.000	21.878	0.000
The US does not cause the UK	1.123	0.570	1.001	0.606
Latter Half (1901-1914)				
The UK does not cause the US	9.381	0.009	9.717	0.008
The US does not cause the UK	0.234	0.889	0.185	0.912

Note : See Section 3 for details.