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On the indirect causality relation from exchange rates to fundamentals

Hsiu-Hsin Ko
National University of Kaohsiung

Abstract

In this study, we examine whether the monetary-transmission mechanism of exchange rate changes also explains the finding of the causality relation from exchange rates to fundamentals, which is taken as a validation for the present value model for exchange rates in a prominent work. To take account of the indirect causality relation between variables implied by the monetary-transmission mechanism, we apply the method proposed by Dufour and Taamouti (2010) to estimate the causality and perform the test. We observe that the causality relation from exchanger rates to UIP and PPP fundamentals could be stronger in the middle horizon than the short and long horizon, which implies the exchange rate change has inertial effect on the fundamentals. However, the effect is not statistically significant, which implies that the role of the exchange rate may not be so important as to influence the monetary policy rule.

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Contact: Hsiu-Hsin Ko - hhko@nuk.edu.tw.
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1. Introduction

In Engel and West (2005), the authors uncover the causality relationship from exchange rates to fundamentals. This finding is taken as a validation for the present-value model of the exchange rate, which implies that the exchange rate reflects the market's expectations of future monetary policy difference between home and foreign countries, and helps resolve the long-lasting puzzle since Meese and Rogoff (1983).

While the causality from exchange rates to fundamental is an implication of the present value model for exchange rates, the present value model is not the only model that implies the causality relation. As argued in Taylor (2001), the monetary authority may react to the exchange rate change indirectly via other macroeconomic variables such as inflation and real output even though the exchange rate does not plays an important role in the interest rate rule. To see this, an appreciation of the home currency can lower the relative inflation rate and the relative real GDP across countries by expenditure-switching. If the price increment of imported goods is later than the appreciation of the home currency for more than one period, the effects of exchange rate changes on the relative output, the relative inflation, and thus the relative interest rate would take place with more lags. That is, there is inertia in the monetary-transmission mechanism due to an exchange rate change (Taylor, 2001). The goal of this study is to examine that whether there is causality relation from exchange rates to fundamentals at longer forecasting horizons after taking account of the inertia effect of the exchange-rate transmission.

The original concept of causality introduced by Wiener (1956) and Granger (1969) is defined to make the one-period-ahead prediction, and does not consider the causality relation in the presence of the auxiliary variable, such as the variables in the monetary transmission described above.[1] Moreover, traditional causality tests only provide evidence on the presence or the absence of causality, but a large causality effect may not be statistically significant, and a statistically significant effect may not be large from an economic viewpoint or relevant for decision making. Hence, we apply the method recently proposed by Dufour and Taamouti (2010), which enables us to measure the indirect causality relation and examine the significance of the causality measure from exchange rates to macroeconomic fundamentals at the same time.

Our empirical results show that, after taking the monetary transmission of exchange rate changes into account, we observe that the causality measure for the relation from exchange rates to PPP fundamental and UIP fundamental shows a hump shape across the short to middle horizons in many sample countries, but the estimate are not statistically significant. It implies that the effect of exchange rate changes may pass through the relative price level across countries and the relative interest rate, but the effect may not be strong enough to influence the monetary policy. In addition, the indirect causality from exchange rates to the money-income difference across countries, that is the monetary fundamental, is not significant neither at short nor longer horizons. Almost none of the sample countries show the hump-shaped relation. Hence, the causality relation from exchange rates to monetary fundamentals is very weak even though the monetary transmission is taken into account.

The remainder of this study proceeds as follows. Section 2 introduces the relationship between exchange rates and fundamentals. Section 3 presents the econometric model and the estimation procedures used in this paper. Section 4 and 5 illustrates the data and empirical results, respectively. Section 6 provides the conclusion.

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[1] While many methods have been proposed to explore the causality relation between variables (e.g. Lütkepohl, 1993; Geweke, 1982; Yamada and Toda, 1998, etc.), none of them specifically discussed the causality relation between variables in the presence of the auxiliary vector.

Table 1 The fundamental and its auxiliary vector in the causality test

Fundamental	Variables in the auxiliary vector ($\boldsymbol{Z_t}$)
$f_t = p_t - p_t^*$	$\boldsymbol{Z_t} = [\Delta(y_t - y_t^*)]$
$f_t = i_t - i_t^*$	$\boldsymbol{Z_t} = [\Delta(y_t - y_t^*), \Delta(p_t - p_t^*)]$
$f_t = (m_t - m_t^*) - (y_t - y_t^*)$	$\boldsymbol{Z_t} = [\Delta(y_t - y_t^*), \Delta(p_t - p_t^*)]$

Notes: The definitions of the fundamentals are defined in Section 2.

2. Exchange rates and fundamentals

We choose the following commonly-used specifications for fundamentals and provide the intuition implied by the monetary-transmission mechanism from an exchange rate change.

(i) Purchasing power parity (PPP) fundamentals:

$$f_t = p_t - p_t^*$$

where f_t denotes the fundamental variable for the exchange rate, and p_t denotes the price level. The asterisk represents the variable of the foreign country. An appreciation of the home currency can lower the relative output and price across countries. The decline in the relative output may also lower the relative price.

(ii) Uncovered interest rate parity (UIP) fundamentals:

$$f_t = i_t - i_t^*$$

where i_t is the short-run interest rate. If the interest-rate rule in both of the countries reacts to the output and inflation rate, an appreciation of the home currency will reduce the interest rate difference across countries.

(iii) Monetary fundamentals:

$$f_t = (m_t - m_t^*) - \gamma(y_t - y_t^*)$$

where m_t is the monetary aggregate, y_t is the output level, and γ is the income elasticity of money demand. The monetary fundamental is derived based on the monetary model of exchange rates.[2] We follow Mark's (1995) specification and assume that the income elasticity of money demand equals one. An appreciation of the home currency lowers the relative output and price level across countries, and this may in turn increase the monetary aggregate fundamental. Therefore, an appreciation may increase the monetary fundamental.

To sum up, in the presence of the monetary-transmission mechanism, changes in the exchange rate may cause changes in one macroeconomic fundamental, and the fundamental may affect other fundamentals. That is, the fundamental variable becomes an auxiliary variable in the causality relation from exchange rates to fundamentals. Table 1 summarizes the auxiliary variables for each model introduced above.

3. Econometric Model

The standard Granger (non-)causality test introduced by Granger (1969) is defined in terms of predictability one period ahead. It fails to provide the information of the causality relation at the horizon larger than one and the indirect causality relation implied by the inertial effect caused by exchange rate changes. We employ the estimator of the causality measure proposed by Dufour and Taamouti (2010), which considers the auxiliary variable helping

[2] See Mark (1995) for how to derive the relation between exchange rates and monetary fundamental based on the monetary model.

transmit the causality from one variable to another in the causality test and allows us to quantify the indirect causality at any horizon h.

We firstly set up the VAR model to compute the causality measure at horizon h and perform the non-causality test for the relation from exchange rates to fundamentals. Let s_t denote the exchange rate variable, f_t denote the fundamental variable of interest, and z_t denote the auxiliary vector. As shown in Table 1, the auxiliary variables in vector z_t may differ according to the causality relation of interest. The VAR model for the unconstrained model takes a standard form as:

(1)
$$\begin{bmatrix} f_t \\ s_t \\ z_t \end{bmatrix} = \sum_{i=1}^{p} \begin{bmatrix} \phi_i^{11} & \phi_i^{12} & \phi_i^{13} \\ \phi_i^{21} & \phi_i^{22} & \phi_i^{23} \\ \phi_i^{31} & \phi_i^{32} & \phi_i^{33} \end{bmatrix} \begin{bmatrix} f_{t-i} \\ s_{t-i} \\ z_{t-i} \end{bmatrix} + \begin{bmatrix} u_{f,t} \\ u_{s,t} \\ u_{z,t} \end{bmatrix}$$

where p is the lag length of VAR model, and which is selected by the Akaike information criterion (AIC). We estimate the parameter matrix, denoted by $\widehat{\Phi}$, with the ordinary least squares (OLS) method and compute the variance-covariance of residuals, denoted by $\widehat{\sum}_u$, for the unconstrained model.

In the constrained model, the exchange rate does not cause the fundamental. Thus, the VAR model excludes the exchange rate variable and takes the form:

(2)
$$\begin{bmatrix} f_t \\ z_t \end{bmatrix} = \sum_{i=1}^{p} \begin{bmatrix} \phi_i^{11} & \phi_i^{12} \\ \phi_i^{21} & \phi_i^{22} \end{bmatrix} \begin{bmatrix} f_{t-i} \\ z_{t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_{f,t} \\ \varepsilon_{s,t} \end{bmatrix}$$

Similarly, we obtain the coefficient matrix, denoted by $\widetilde{\Phi}$, and the residual covariance, denoted by $\widetilde{\sum}_\varepsilon$, for the restricted model in the same way as the unconstrained model.

To quantify the degree of causality at horizon h, we need to calculate the variance-covariance matrices of forecast errors for both of the constrained and unconstrained model. Suppose the unconstrained VAR model is fitted with the lag order k, and there are m variables in the unconstrained model. The variance-covariance matrices of forecast errors for the unconstrained model are computed using the equation:

(3)
$$\hat{\Sigma}_k(h) = \sum_{j=0}^{h-1} \widehat{\Psi}_j \hat{\Sigma}_u \widehat{\Psi}_j'$$

where $\widehat{\Psi}_j = \widehat{\Phi}_1^{(j)}$, $\widehat{\Phi}_k^{(j+1)} = \widehat{\Phi}_{k+1}^{(j)} + \widehat{\Phi}_1^{(j)} \widehat{\Phi}_k$, $\widehat{\Phi}_1^{(1)} = \widehat{\Phi}_1$, and $\widehat{\Phi}_1^{(0)} = I_m$ for $j \geq 1$.[3] We use the same method to calculate the variance-covariance matrix of the constrained forecast errors, denoted by $\tilde{\Sigma}_k(h)$. Last, we quantify the causality measure from exchange rates to fundamentals at horizon h by:

(4)
$$\hat{C}\left(s_t \underset{h}{\rightarrow} f_t \middle| I\right) = \ln\left[\frac{\det[J_0 \tilde{\Sigma}_k(h) J_0']}{\det[J_1 \hat{\Sigma}_k(h) J_1']}\right]$$

for $h \geq 1$, $J_0 = [1 \;\; 0]$ and $J_1 = [1 \;\; 0 \;\; 0]$. Larger values of the measure indicate larger causality. Since the causality measure must be non-negative, we impose the following non-negativity truncation for the estimates:

$$\hat{C}\left(s_t \underset{h}{\rightarrow} f_t \middle| I\right) = \max\left\{\hat{C}\left(s_t \underset{h}{\rightarrow} f_t \middle| I\right), 0\right\}.$$

Under the null hypothesis, the exchange rate does not Granger cause the fundamental at horizon h, namely $C(s \rightarrow_h f | I) = 0$; under the alternative, the causality measure is greater than zero. Hence, if the causality measure is greater than zero at the significance level, it implies that there is Granger causality from exchange rates to fundamentals.

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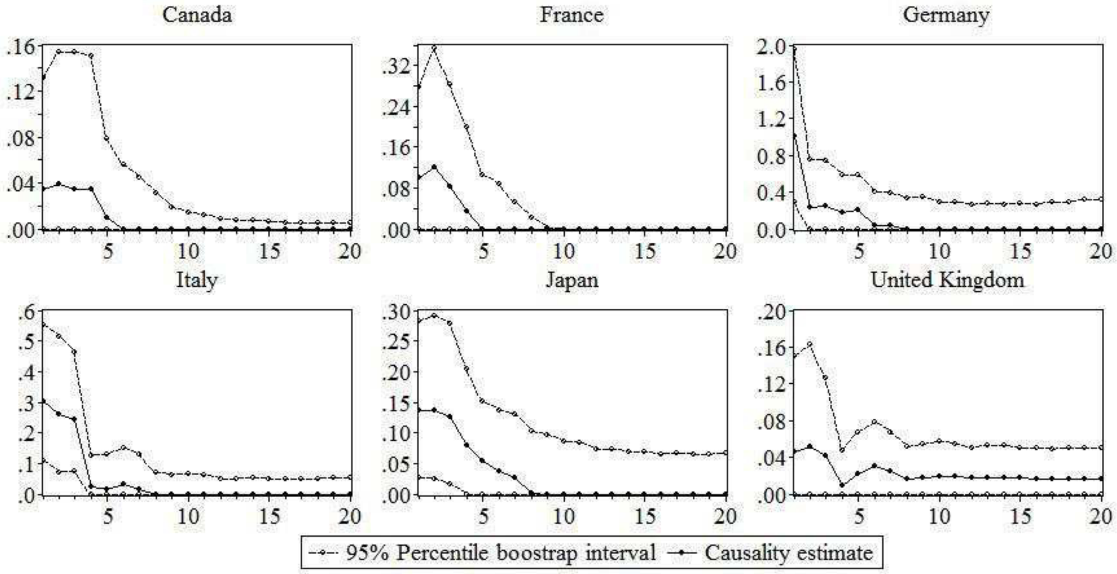
[3] See Dufour and Renault (1998), Dufour *et al.* (2006), and Dufour and Taamouti (2010) for more theoretic detail about the long-run causality test.

Figure 1. Causality measures from exchange rates to the PPP fundamental



Note: These figures present measures of causality from exchange rates to the PPP fundamental, $p_t - p_t^*$, up to 20 quarters.

To avoid the small sample problem, we follow the bootstrap algorithm suggested in Dufour and Taamouti (2010) to compute the 95% bootstrap confidence interval for the causality measure. If the confidence interval covers zero, we accept the null; otherwise, we reject it.

4. Data

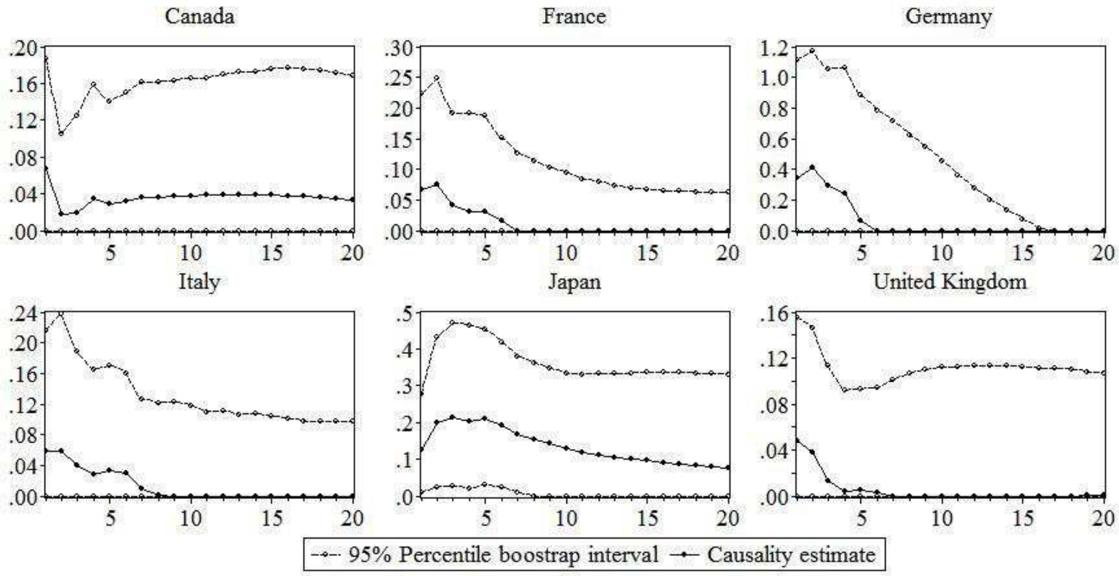
We follow Engel and West (2005) choosing G7 country as the sample country, including the United States, Canada, France, Germany, Italy, Japan, and the United Kingdom, and the U.S. is the home country. The data source is the International Financial Statistics (IFS) CD-ROM, and the data comprise quarterly data extending from 1974Q1 to 2008Q4, except for the Euro country, in which the data of exchange rates, interest rates and the monetary aggregates end in 1998Q4. The exchange rates are the end-of-quarter U.S. dollar per foreign currency. The short-run interest rate is the 3-month Treasury bill rate, and price levels are measured using the CPI. The monetary aggregate and the output level are seasonally-adjusted. All data, except for the interest rate, are converted by taking logs and multiplying by 100.

Using Dickey-Fuller tests with a constant included, we are generally unable to reject the null of a unit root for the exchange rate and all of the fundamental variables, except for the UIP fundamental. Thus, we take the first difference for all of the data, except for the interest rate, before estimating the VAR model described in Section 3. Given the maximum lag length equaling 4, the AIC is minimized at lag order $p = 4$ for most of the unconstrained model, and thus we consider the same order ($p = 4$) for the constrained model to calculate the causality measure. To avoid the small sample problem, we employ the bootstrap technique to compute the causality measure and its 95% bootstrap confidence interval for up to 20 forecasting horizons. In addition, to improve the performance of the percentile bootstrap intervals, we correct the bias directly on the measure itself.

5. Empirical Results

Figures 1 to 3 illustrate estimates of causality measures and their corresponding 95% bootstrap confidence intervals up to 20 horizons. In Figure 1, we see that the causality measure from the exchange rate to the PPP fundamental shows a hump shape in the case of

Figure 2. Causality measures from exchange rates to the UIP fundamental



Note: These figures present measures of causality from exchange rates to the UIP fundamental, $i_t - i_t^*$, up to 20 quarters.

Canada, France, Japan, and the UK. The causality measure is generally greater than zero for seven quarters. Specifically, for the case of UK, the estimated causality measure is not decaying to zero up to the forecasting horizon of interest. This implies that the output difference between countries help transmit the effect of the exchange rate change on the PPP fundamental. Nevertheless, when we check for the significance of the estimate of the causality measure and perform the non-causality test, we see that the causality measure is statistically significant only at one quarter for Germany and one to three quarters for both Italy and Japan.

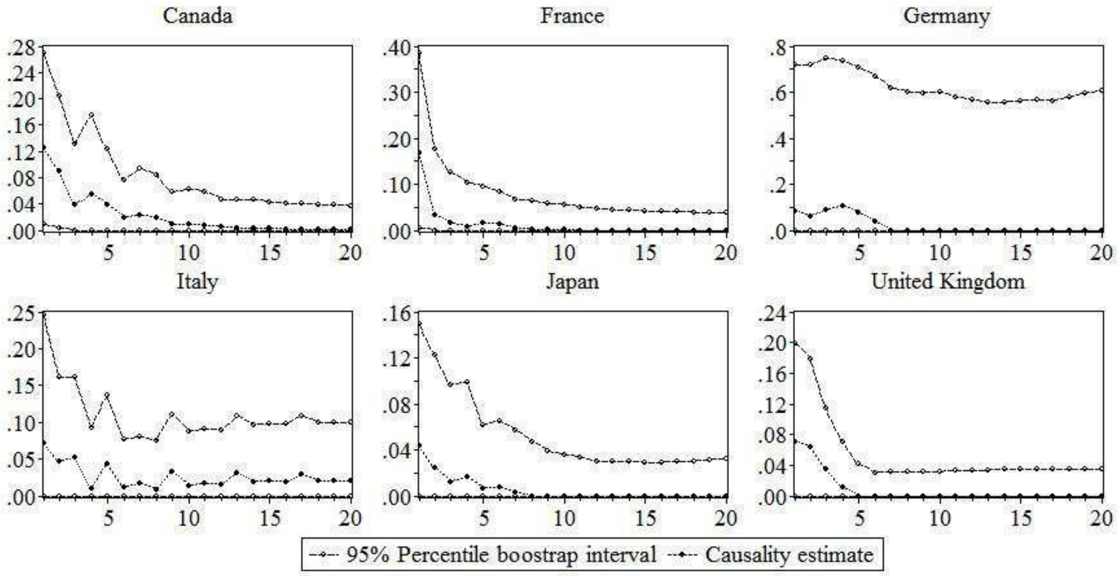
Figure 2 shows the empirical results for the UIP fundamental. We can also observe that the hump-shaped causality relation from exchange rates to fundamental in the first several periods in the case of France, Germany, Italy, and Japan. Also, the estimate of the causality measure is greater than zero for 20 forecasting horizons in Canada and Japan. This implies that the output and price level difference between countries, which are the variables in the auxiliary vector in this case, help transmit the effect of exchange rates to the UIP fundamental. Similarly, when we check the 95% bootstrap confidence interval, the causality measure is not statistically significant in many cases. The estimate is only statistically significant in the case of Japan for the first 7 quarters.

As shown in Figure 3, the hump-shaped causality relation from the exchange rate to the monetary fundamental is observed only in the case of Germany. The causality relation is significantly greater than zero only at one and two quarters forecasting horizons in Canada and at one quarter horizon in France. The result implies that the indirect causality relation is not significant from the exchange rate to the monetary fundamental.

6. Conclusion

The extant finding of the short-run causality relation from exchange rates to fundamentals is taken as a validation for the present value model of exchange rates. However, the present value model is not the only model that implies the relation. In this article, we are interested in whether the monetary-transmission mechanism of exchange rate changes also explains the causality relation from exchange rates to fundamentals. Since the traditional

Figure 3. Causality measures from exchange rates to the monetary fundamental



Note: These figures present measures of causality from exchange rates to the monetary fundamental, $(m_t - m_t^*) - (y_t - y_t^*)$, up to 20 quarters.

causality test does not take account of the auxiliary variable in the exchange rate transmission process, we apply the method proposed by Dufour and Taamouti (2010). The method allows us not only to estimate the indirect causality measure in the presence of auxiliary variables but also to perform the non-causality test for long run horizons.

The empirical results show that, the forecast improvement (causality) from exchange rates to PPP fundamental and UIP fundamental can be larger at the middle horizons, but the improvement is not statistically significant. It implies that the effect of exchange rate changes may pass through the relative price level across countries and the relative interest rate, but the effect is not strong enough to influence the monetary policy. That is, while there could be inertial effect of the exchange rate change on the monetary policy, the effect is not significant. However, for the monetary fundamental, the causality relation does not show a hump shape, and the estimates of the causality are not significant, either. Thus, we infer that the inertial effect is very weak in the causality relation from exchange rates to the monetary fundamental.

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