What Determines Utility of International Currencies?[*]

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Abstract

Ogawa and Muto (2017a, 2017b) estimated time series of coefficients on five international currencies (the US dollar, the euro, the Japanese yen, the British pound, and the Swiss franc) in a utility function. We call the coefficient as utility of an international currency. The time series show that utility of the US dollar as an international currency has kept at the first position in the changing international monetary system where the euro created as a single common currency in European countries. On one hand, utility of the Japanese yen has been declining as an international currency. In this paper, we investigate what determines utility of the international currencies. We use a dynamic panel data model to analyze the issue with GMM. Specifically, liquidity shortage in terms of an international currency means that it is inconvenient for economic agents to use the relevant currency for international economic transactions. In other words, the liquidity shortage might reduce utility of an international currency. In this analysis we focus on liquidity premium which represents liquidity shortage in terms of an international currency. We make empirical analysis of whether liquidity risk premium in an international currency affects utility of the relevant international currency.

Key Words: utility of international currency, inertia, liquidity risk premium, US dollar, Japanese yen

JEL Classification Codes: F33, F41, G01

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1. Introduction

The United States (US) dollar had been as a rule a key currency in the Bretton Woods international monetary system. The monetary authority of the United States fixed the US dollar to gold while the monetary authorities of other countries fixed their home currencies to the US dollar under the Bretton Woods system. It could keep stability of exchange rates among the currencies in the world economy. However, the Bretton Woods system broke down in 1971 because the monetary authority of the United States could not keep a value of the US dollar against gold to stop convertibility of the US dollar to gold. Afterwards, a position of the US dollar as a key currency has been still kept in the current international monetary system even though we have no longer the rule under which we have to use the US dollar as a key currency. The phenomenon is called as inertia of a key currency.

Given that a key currency is chosen for economic reasons which include costs and benefits of an international currency, comparison in costs and benefits of international currencies determines a key currency in the current international monetary policy. Also, inertia of a key currency should be related with inertia of costs and/or benefits of holding an international currency. The costs of holding an international currency are related with its depreciation that caused by inflation in the relevant country. On one hand, the benefits of holding an international currency are caused by utility of holding it.

In a Sidrauski (1967)-type of money-in-the-utility model (Calvo (1981, 1985), Obstfeld (1981), Blanchard and Fischer (1989)), real balances of money as well as consumption are supposed as explanatory variables in a utility function. We can use the money-in-the-utility model to analyze costs and benefits of holding international currencies. Ogawa and Muto (2017a, 2017b) used expected inflation rates and BIS data on total of domestic currency denominated debt and foreign currency denominated debt of the euro currency market to estimate time series of coefficients on five international currencies (the US dollar, the euro, the Japanese yen, the British pound, and the Swiss franc) in a utility function. We call the coefficient as utility of an international currency. The time series show that utility of the US dollar as an international currency has kept at the first position even though the euro was introduced into some of the European Union (EU) states while it increased utility of the euro as an international currency. On one hand, utility of the Japanese yen has been declining as an international currency.

In this paper, we have an objective to investigate what determines utility of the international currencies. We use a dynamic panel data model to analyze the issue with Generalized Method of Moments (GMM). Specifically, liquidity shortage in terms of an international currency means that it is inconvenient for economic agents to use the relevant currency for international economic transactions. In other words, the liquidity shortage might reduce utility of an international currency. In this analysis we focus on liquidity premium which represents liquidity shortage in terms of an international currency. We make empirical analysis of whether liquidity risk premium in an international currency affects utility of the relevant international currency.

We obtain the following results from the empirical study. Firstly, change in utility of the currency in the previous period has significantly a positive effect on the change of utility of the currency in the current period. This suggests that utility of the currency tends to fluctuate in the same direction as the change in the previous term. For example, if the utility of the currency declines, we assumed that the currency is less likely to be used than in the previous period, which will continue in the next period. Secondly, the change of liquidity risk premium has significantly a negative effect on the change of utility of the currency. This suggests that liquidity shortage reduce the utility of the international currency. Thirdly, the change of effective exchange rate has significantly a positive effect on the change of utility of the currency. This suggests that changes in currency value affect the utility of the international currency.

In the next section, we describe previous literatures. In the third section, we explain our theoretical model in terms of utility of an international currency. In the fourth section, we explain empirical model for analyzing determinants of utility of an international currency. In the fifth section, we explain data used for the analysis and calculation method. In the sixth section, we discuss hypothesis of estimated coefficients and influence of each variable on utility of an international currency. In the seventh section, we show results of dynamic panel analysis. Finally, we conclude this research.

2. Previous Literature

Krugman (1984) adopted three functions of money as a medium of exchange, a unit of account, and a store of value to consider six roles of an international currency for both private and official sectors. According to his definition, it is used as a medium of exchange in private international economic transactions ("vehicle" currency or settlement currency), while it is transacted by monetary authorities in order to intervene in foreign exchange markets ("intervention" currency). Private sector makes trade contracts which are denominated in terms of a currency ("invoice" currency). Monetary authorities set par values for exchange rates which are stated in terms of a currency ("peg" currency). Private sector holds liquidity dollar denominated assets ("banking" role) as a store of value. Also, monetary authorities hold a currency as an international reserve ("reserve" currency) which is related with a store of value. Matsuyama *et al.* (1993) and Trejos and Wright (1996) used a search theory to investigate a role of international currency as a medium of exchange.

Previous studies focused on one of the functions of an international currency to investigate roles of a currency as an international currency and international monetary system with the US dollar as a key currency. For example, Chinn and Frankel (2007, 2008) focused on a role as international reserve currency. Eichengreen, Chițu, and Mehl (2016) focused on a role of international reserve currency to investigate whether it has changed in the determinants of the currency composition of international reserves in before and after the collapse of the Bretton Woods regime. Goldberg and Tille (2008) analyzed the US dollar and other currencies as an invoice currency in international economic transactions. Ito *et al.* (2013) conducted a questionnaire survey on the choice of invoice currency with all Japanese manufacturing firms listed in the Tokyo Stock Exchange to show that the Japanese firms use the Japanese yen second to an importing country currency as invoice currency in exporting products to the US and Europe, while the Japanese yen is the first used in exporting them to Asia.

Catão and Terrones (2016) and Honohan (2008) focused on the dollarization of financial systems in emerging market economies. Especially, Catão and Terrones (2016) pointed out a broad global trend towards financial sector de-dollarization from the early 2000s to the eve of the global financial crisis. ECB (European Central Bank 2015) reported increasing roles of the euro as an international currency in terms of each of the three functions in the international reserve, international trade, and financial markets.

3. Utility of International Currency

Ogawa and Muto (2017a, 2017b) estimated a coefficient on each of international currencies in the utility function or utility of international currencies, given that economic agents make dynamic optimization of utility in a money-in-the-utility function while they faced depreciation of international currency holdings. They have optimal holdings of an international currency by comparing benefits or utility from holding it with costs or depreciation of holding it. We can derive invisible utility of an international currency as a function of visible economic variables which include holdings of an international currency and its depreciation. We can obtain an estimate of utility of an international currency i as follows[1]:

$$\gamma_t^i = \frac{1}{1 + \left(\frac{1}{\phi_t^i} - 1\right)\frac{\pi_t^O + \bar{r}}{\pi_t^i + \bar{r}}} \qquad (1)$$

where ϕ_t^i: share of holdings of an international currency i, π_t^i: expected inflation (or depreciation) rate of country i, π_t^O: expected inflation (or depreciation) rate of the other countries, $\bar{r}$: real interest rate. Assumptions of both purchasing power parity and uncovered interest rate parity make real interest rates are equal to each other in the world.

In our previous study, we assumed real interest rates are 1.5%, 2.0%, 2.5%, and 3.0%.[2] In addition, there is also utility of an international currency calculated using the nominal interest rate as well as the expected inflation rate plus the real interest rate. However, the nominal interest rate has periods of zero-bound level. Moreover, it is considered that the nominal interest rate has a strong relationship with a liquidity risk premium. Therefore, in this analysis, utility of the international currency calculated using real interest rate was used.

Figures 1a to 1d show time series of utility of four currencies. We can find that utility of the US dollar sharply decreased while the other currencies increased in 2008Q3. It seems that this change in utility of currencies was caused by the liquidity shortage of the US dollar at this time. Throughout a whole period, changes in utility of the US dollar, the euro, the Japanese yen and the British pound are fluctuating around 0.5, 0.35, 0.03 and 0.05,

[1] See Appendix for derivation of equation (1).

[2] An arithmetic average of real economic growth rates compared to the same quarter of previous year among the three countries and the region (the United States, the euro zone, Japan, and the United Kingdom) was about 1% from 2006Q3 to 2015Q4. However, if we exclude a period of 2008Q2 to 2010Q1 where the growth rate has greatly declined due to the global financial crisis, it was about 1.8%. Given the real economic growth rates, our setting the values as a real interest rate seem to be reasonable. The real economic growth rate data obtained from the OECD website.

respectively.

4. Empirical Model

4-1. Determinants of Utility of an International Currency

We explain economic variables that can affect utility of international currencies. Firstly, utility of an international currency in the previous period can affect that in the current period if an international currency has inertia in keeping its position. Utility of an international currency may be affected in the same direction as utility of an international currency in the previous period if they have inertia in terms of changes. For example, if utility of an international currency declines, we assumed that the currency is less likely to be used than in the previous period through decline of a medium of exchange function and economies of scale. In other words, utility of an international currency has inertia in terms of keeping changes in the same direction.

Secondly, supply of liquidity in terms of an international currency can affect its utility. A liquidity risk premium in terms of an international currency is an indicator of a liquidity condition in terms of the relevant international currency or its liquidity shortage. A liquidity shortage reduces utility of an international currency through deteriorating its function as a medium of exchange.

Thirdly, an international currency is more likely to be used in proportion to economic activity in the relevant country. A larger volume of international economic transactions with the relevant country make the international currency more useful in terms of its function as a medium of exchange because of its network externalities. The economic activity in the relevant country and the volume of international economic transactions with the relevant country can be represented by GDP, nominal economic growth rate, real economic growth rate, capitalization, total international trade, total exports, international capital flows, and money stock.

Fourthly, economic agents are likely to prefer a higher value of currency in holding it as an international currency. An effective exchange rate of an international currency, that is an indicator of a currency value against the other currencies, could be a determinant of utility of the relevant international currency.

4-2. A Dynamic Panel Model

We analyze determinants of utility of international currencies by using panel data. In addition, the explanatory variables include a lag term of utility of an international currency as we explained above. For the reasons, we use a dynamic panel data model to analyze determinants of utility of international currencies. Given the above candidates for determinants of an international currency, a dynamic panel model is shown as follows:

$$
\begin{aligned}
&Utility\ of\ international\ currency_{it} \\
&\quad = \hat{b}_1 Utility\ of\ international\ currency_{it-1} + \hat{b}_2 Liquidity\ risk\ premium_{it} \\
&\quad + \hat{b}_3 \Delta GDP\ share_{it} + \hat{b}_4 Relative\ nominal\ economic\ growth_{it} \\
&\quad + \hat{b}_5 Relative\ real\ economic\ growth_{it} + \hat{b}_6 Total\ trade\ share_{it} \\
&\quad + \hat{b}_7 Total\ export\ share_{it} + \hat{b}_8 Capitalization\ share_{it} + \hat{b}_9 Capital\ flow\ share_{it} \\
&\quad + \hat{b}_{10} Nominal\ effective\ exchange\ rate_{it} + \hat{b}_{11} Real\ effective\ exchange\ rate_{it} \\
&\quad + \nu_i + \varepsilon_{it} \qquad (2)
\end{aligned}
$$

where ν_i: fixed effects, ε_{it}: disturbance term. We take a first difference of the above model (equation (2)) and remove fixed effects. Thus, its first difference model is rewritten as follows:

$$
\begin{aligned}
&\Delta Utility\ of\ international\ currency_{it} \\
&\quad = \hat{b}_1 \Delta Utility\ of\ international\ currency_{it-1} + \hat{b}_2 \Delta Liquidity\ risk\ premium_{it} \\
&\quad + \hat{b}_3 \Delta GDP\ share_{it} + \hat{b}_4 \Delta Relative\ nominal\ economic\ growth_{it} \\
&\quad + \hat{b}_5 \Delta Relative\ real\ economic\ growth_{it} + \hat{b}_6 \Delta Total\ trade\ share_{it} \\
&\quad + \hat{b}_7 \Delta Total\ export\ share_{it} + \hat{b}_8 \Delta Capitalization\ share_{it} \\
&\quad + \hat{b}_9 \Delta Capital\ flow\ share_{it} + \hat{b}_{10} \Delta Nominal\ effective\ exchange\ rate_{it} \\
&\quad + \hat{b}_{11} \Delta Real\ effective\ exchange\ rate_{it} + \Delta\varepsilon_{it} \qquad (3)
\end{aligned}
$$

where Δ: difference operator.

There is a correlation between $\Delta Utility\ of\ international\ currency_{it-1}$ and $\Delta\varepsilon_{it}$. Therefore, according to Arellano and Bond (1991), the first difference model is estimated by GMM.

5. Sample Period and Data

5-1. Sample Period

It is the US dollar, the euro, the Japanese yen, and the British pound that we analyze as international currencies in this paper. The Swiss franc has characteristics that is different from other international currencies and was excluded from the analysis in this paper.

A whole sample period covers a period from 2006Q3 to 2015Q4 due to constraints of data on a liquidity risk premium and a capitalization share. Specifically, we investigate an effect of liquidity shortage on utility of international currencies. In this sample period, the world economy faced US dollar liquidity shortage. Moreover, the Federal Reserve Board (FRB) conducted quantitative easing monetary policy to solve the US dollar liquidity shortage from the end of 2008. The US dollar liquidity shortage could affect utility of the US dollar.

5-2. Data for Estimating Utility of International Currencies

We should use data on shares of the international currencies according to the theoretical money-in-the-utility model in which they are regarded as real balances of international currencies. However, it is difficult to obtain data on the real balance of international currencies which include international currencies held by private sector in the world economy. Instead, we use BIS data on total of domestic currency denominated debt and foreign currency denominated debt of the euro currency market. The data are obtained from a BIS website.

The expected inflation rates are calculated by taking logarithm difference between actual price level and expected price level estimated under the assumption that the price level of each period follows ARIMA (p, d, q) process.[3] We use monthly data on the price level for the last five years to estimate an ARIMA model. The Augmented Dickey–Fuller test is used to unit root test. The AIC is used for lag selection. The estimated ARIMA model is used to predict a price level of one period ahead. Thus, we use the actual price level and the predicted price level of one period ahead to calculate the expected inflation rate. Consumer price index data are used as the price level. The data are obtained from the FRED website.

The expected inflation rate in the euro zone is a weighted average of the expected inflation rate in the original euro zone countries. They include Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. A weight

[3] We may use a method of Fama and Gibbons (1984) to estimate expected inflation rates. A sample period is much shorter than that by using the ARIMA model due to data constraints if we use the method. For the reason, we choose to use the ARIMA model.

in calculating a weighted average of the expected inflation rate is based on their GDP share among the countries. The data obtained from the Penn World Table website.[4]

5-3. Data for Determinants of Utility of International Currencies

Figures 2a to 2d show movements in three spreads of London Interbank Offered Rate (LIBOR) (3 months) minus Treasury Bills (TB) rate (3 months), LIBOR (3 months) minus Overnight Indexed Swap (OIS) rate (3 months), and OIS rate (3 months) minus TB rate (3 months). The spread of LIBOR minus OIS rate is regarded as credit risk premium because LIBOR is the interest rate at which banks borrow unsecured funds from other banks. OIS rate is the interest rate at which banks borrow secured funds from other banks. Given that banks mainly face and liquidity risk as well as credit risk, the spread of OIS rate minus TB rate is regarded as liquidity risk premium. The data were obtained from *Datastream*.

From Figure 2a, we can find that the US dollar liquidity shortage continues from 2006 to 2008. However, it has decreased to a level smaller than 0.1% since the FRB started quantitative easing monetary policy late 2008 when it at the same time concluded and extended currency swap arrangements[5] with other major central banks to provide US dollar liquidity to other countries. From Figure 2b, we can find that the euro liquidity shortage from 2006 to 2008 has not occurred except for the Lehman Brothers bankruptcy in September 2008. However, the liquidity risk premium in terms of the euro increased from June 2010 to June 2012. Figures 2c and 2d do not show any significant increases in liquidity risk premium in terms of the Japanese yen and the British pound during the analysis period. The stable movements in the liquidity risk premium in terms of these currencies are different those in terms of the US dollar and the euro.

GDP share is a share of GDP of each of the three countries and the region in terms of a total GDP of the three countries and the region (the United State, the euro Area, Japan, the United Kingdom). We used seasonally adjusted nominal GDP for the calculation. The data were obtained from the *International Financial Statistics* (*IFS*) of International Monetary Fund (IMF) website.

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[4] See Feenstra, Inklaar, and Timmer (2013) for reference.

[5] The FRB concluded new currency swap arrangements with the ECB and the Swiss National Bank on December 12, 2007. Afterwards, it increased amount of currency swap arrangements and concluded them with other central banks.

Relative nominal economic growth rate and relative real economic growth rate are ratio of GDP growth rate of each of the three countries and the region in terms of an arithmetic average of GDP growth rate of the three countries and the region. Nominal economic growth rate compared to previous quarter was calculated from seasonally adjusted nominal GDP. In addition, we used seasonally adjusted real economic growth rate compared to previous quarter to calculate a relative real economic growth rate. The data were obtained from the Organization for Economic Co-operation and Development (OECD) website.

Total trade share is a share of trade amount of each of the three countries and the region in terms of a total trade amount of the three countries and the region with the rest of the world. When we sum up the total trade amount for the three countries and the region, we exclude exports and imports among them. Also, total export share is a share of export value of each of the three countries and the region in terms of a total export value of the three countries and the region with the rest of the world. The data were obtained from the *Direction of Trade Statistics* of IMF website.

Capitalization share is a share of capitalization of each of the three countries and the region in terms of a total capitalization of the three countries and the region. We could not obtain the data of United Kingdom in 2010 and quarterly data of the three countries and the region. For the reason, we estimated quarterly data using linear interpolation from annual data. We used data on market capitalization of listed domestic companies for the calculation. The data were obtained from website of the World Bank and the European Central Bank.

Capital flow share is a share of international capital flows of each of the three countries and the region in terms of a total international capital flows of the three countries and the region. In this paper, the international capital flows are defined as sum of absolute values of direct investments, portfolio investments, and other investments of net acquisition of financial assets and direct investments, portfolio investments, and other investments of net incurrence of liabilities. The data were obtained from the *Balance of Payments and International Investment Position* of IMF website.

Money stock share is a share of money stock of each of the three countries and the region in terms of a total money stock of the three countries and the region. We used seasonally adjusted nominal money stock (M1). The data were obtained from the OECD website.

Data on both nominal and real effective exchange rates of each of the currencies were obtained from the *IFS* of IMF website.

6. Empirical Analysis on Determinants of Utility of International Currencies

6-1. Expected Effect of Determinant on Utility of International Currencies

We expect that each of determinants affects utility of international currencies in as a direction as follows.

If there is inertia of an international currency in terms of changes in utility, a change in utility of an international currency in the previous period has a positive effect on a change in utility of the international currency in the current period. For example, if utility of an international currency declines, demand for the relevant international currency as one with a function as medium of exchange should decrease. The decrease in the demand for the international currency, in turn, makes utility of an international currency decline further. We investigate a hypothesis that a change in utility of an international currency in the previous period has a positive effect on change in utility of the international currency in the current period.

An increase in the liquidity risk premium in terms of an international currency means liquidity shortage in terms of the relevant international currency. The liquidity shortage reduces convenience of the international currency for economic agents to use for medium of exchange. Thus, an occurrence of liquidity shortage decreases utility of the international currency. When the liquidity shortage worsens, the liquidity risk premium indicated by OIS rate minus TB rate increases. Therefore, an increase in the liquidity risk premium reduces utility of the international currency. We investigate a hypothesis that liquidity risk premium has a negative effect on utility of the international currency. Figures 1a to 1d and 2a show that the increase in the US dollar liquidity risk premium in 2008 and the decline in utility of the US dollar in 2008Q3 seems to co-occur.

GDP share, relative nominal economic growth rate, relative real economic growth rate, total trade share, total export share, capitalization share, capital flow share, and money stock share are economic variables that represent relative economic size of the relevant country. Network externalities works in selecting an international currency as medium of exchange. For the reason, a change in an economic size of the relevant country has a positive effect on utility of the international currency. We investigate a hypothesis that coefficients of explanatory variables that represent relative economic size are positive.

As we have already explained, economic agents are likely to prefer a higher value of currency in holding it as an international currency. An effective exchange rate of an international currency, that is an indicator of a currency value against the other currencies, could be a determinant of utility of the relevant international currency. We investigate a hypothesis that a higher value of an international currency increase or an increase in an effective exchange rate increases utility of the relevant international currency.

6-2. Empirical Results

Tables 1a to 1d show results of the dynamic panel analysis. A head line in Tables represents empirical analysis number. Table 1a shows determinants of utility of international currency supposing that a real interest rate is 1.5%. Coefficients on change in utility of international currencies in the previous period are significantly positive in all of the cases. The coefficients are estimated from 0.06 to 0.13. Coefficients on change in liquidity risk premium are significantly negative in all of the cases. The coefficients are estimated from -0.16 to -0.11. In the analyses 1 and 5, the coefficients on change in nominal effective exchange rate are positive at the significance level 10%. The coefficient is estimated to be 0.004. However, in the analyses 3 and 7, the coefficients on change in nominal effective exchange rate are not significant. Moreover, all of the coefficients on change in economic variables associated with relative economic size do not satisfy a sign condition or significance levels.

Table 1b shows determinants of utility of international currency supposing that a real interest rate is 2.0%. In analyses 11, 12, 15 and 16, coefficients on change in utility of international currencies in the previous period are significantly positive. However, in the analyses 9, 10, 13 and 14, coefficients on change in utility of international currencies in the previous period are not significant. The coefficients are estimated from 0.23 to 0.24. Coefficients on change in liquidity risk premium are significantly negative in all of the cases. The coefficients are estimated from -0.14 to -0.11. Coefficients on change in nominal effective exchange rate are significantly negative in all of the cases. The coefficients are estimated 0.003. In analyses 10 and 14, coefficients on change in real effective exchange rate are significantly positive. The coefficients are estimated to be 0.002. However, in the analyses 12 and 16, coefficients of change in real effective exchange rate are not significant.

Moreover, most of the coefficients on change in economic variables associated with relative economic size do not satisfy a sign condition or significance levels.

Table 1c shows determinants of utility of international currency supposing that a real interest rate is 2.5%. Coefficients on change in utility of the currency in the previous period are not significant except for analyses 19 and 23. Coefficients on change in liquidity risk premium are significantly negative in all of the cases. The coefficients are estimated from -0.08 to -0.06. Coefficients on change in nominal effective exchange rate and real effective exchange rate are significantly negative in all of the cases. The coefficients on change in nominal effective exchange rate are estimated to be 0.002. On one hand, the coefficients on change in real effective exchange rate are estimate to be 0.001. However, all of the coefficients on change in economic variables associated with relative economic size do not satisfy a sign condition or significance levels.

Table 1d shows determinants of utility of international currency supposing that a real interest rate is 3.0%. The coefficients on change in liquidity risk premium are significantly negative in all of the cases. The coefficients are estimated to be from -0.06 to -0.04. Coefficients on change in nominal effective exchange rate are significantly negative in all of the cases. The coefficients are estimated to be 0.001. All of the coefficients on change in economic variables associated with relative economic size do not satisfy a sign condition or significance levels.

We summarize the above empirical results. Firstly, the coefficients on utility of international currency in the previous period are significantly positive in the case of supposing that a real interest rate is 1.5%. In the case of supposing that a real interest rate is 2.0%, the coefficients are significantly positive in half of the results. These results suggest that change in utility of an international currency in the previous period in the same direction has effect on change in utility of the international currency in the current period. There is inertia in terms of change in the international monetary system.

Secondly, the coefficients on liquidity risk premium are significantly negative in all of the cases. The empirical result is consistent with the hypothesis that liquidity risk premium has a negative effect on utility of the international currency. We find that utility of an international currency is affected by liquidity condition or liquidity shortage. Specifically, the liquidity shortage reduces utility of the international currency through a reduction in convenience for economic agents to use the relevant international currency as a medium of exchange.

Thirdly, the coefficients on effective exchange rate are significantly positive in about half of the empirical results. The results indicate that change in the effective exchange rate have a positive effect on utility of an international currency. It implies that economic agents are likely to prefer a higher value of currency in holding it as an international currency.

7. Conclusion

In this paper, we investigated what determines utility of the international currencies among the current major currencies which include the US dollar, the euro, the Japanese yen, and the British pound. We used a dynamic panel data model to analyze the issue with GMM. We focused on effects of liquidity shortage in terms of an international currency on utility of the international currencies as well as inertia of the US dollar as the key currency. We made empirical analysis of whether liquidity risk premium in an international currency as well as other possible determinant factors affect utility of the relevant international currency.

We obtained the following results from the empirical analysis. Firstly, change in utility of the currency in the previous period has significantly a positive effect on the change of utility of the currency in the current period. This suggests that utility of the currency tends to fluctuate in the same direction as the change in the previous term. For example, if the utility of the currency declines, we assumed that the currency is less likely to be used than in the previous period, which will continue in the next period. Secondly, the change of liquidity risk premium has significantly a negative effect on the change of utility of the currency. This suggests that liquidity shortage reduce the utility of the international currency. Thirdly, the change of effective exchange rate has significantly a positive effect on the change of utility of the currency. This suggests that changes in currency value affect the utility of the international currency.

In the future we have further study regarding what factors are important to help an emerging new international currency which includes the Chinese yuan. In recent years, the Chinese government has been promoting the Chinese yuan to be internationalized while the IMF has added it into major international currencies that is component currencies of the Special Drawing Rights (SDR). It is important for us to investigate how a local currency can emerge as an international currency and, in turn, make it into a key currency in the current international monetary system where we do not as a rule set any currencies as a key currency.

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Appendix: Derivation of Equation (1)

We base on a Sidrauski (1967)-type of money-in-the-utility model in which real balances of money as well as consumption are supposed as explanatory variables in a utility function. According to Ogawa and Sasaki (1998), we extend the money-in-the-utility model to a dynamic one with parallel international currencies[6]. We suppose that the international currencies are held by private economic agents in a third country. For simplicity, we suppose that two monetary authorities supply international currencies.

For convenience, we suppose that it is both the monetary authorities in the Country i and other countries O that supply their international currencies. The monetary authorities in Country i supply currency i while the monetary authorities in other countries O supply their own currencies O. The private sector in the third country A is able to use both the currencies i and O as international currencies in international economic transactions. The monetary authorities in country A adopt a flexible exchange rate system.

We suppose a situation that bonds in currencies i and O are available to the private sector in country A and that no bonds denominated in currency A are issued in country A. We assume perfect capital mobility and perfect substitution for the bonds of different currencies. Moreover, we assume that the private sector has perfect foresight. Thus, uncovered interest parity holds in the model. On one hand, we assume perfect flexible prices and a law of one price. Thus, the purchasing power parity always holds in the model. For simplicity, we assume that its rate of time preference is constant over time and is equal to a real interest rate. Given the assumptions, the real interest rate is constant over time. Real interest rates in all countries are equal to each other by both the uncovered interest parity and purchasing power parity.

The private sector in country A holds home currency A, international currencies i and O, and bonds in currencies i and O. Instantaneous budget constraints for the private sector are represented in real terms:

$$\dot{w}_t^p = \bar{r}w_t^p + y_t - c_t - \tau_t - i_t^A m_t^A - i_t^i m_t^i - i_t^O m_t^O \quad \text{(A1a)}$$

$$w_t^p \equiv b_t^i + b_t^O + m_t^A + m_t^i + m_t^O \quad \text{(A1b)}$$

---

[6] See Ogawa and Muto (2017a) for the detailed derivation.

where y: real gross domestic products, τ: real taxes, c: real consumption, i^j: nominal interest rate in currency j $(j = A, i, O)$, w^p: real balance of financial assets held by the private sector, m^j: real balance of home currency $j(j = A, i, O)$ held by the private sector, b^j: real balance of bond in currency j $(j = i, O)$ held by the private sector, $\bar{r}$: real interest rate. A dot over variables implies a change in the relevant variables. We assume no-Ponzi game conditions for the real balance of financial assets held by the private sector (w^p).

$$\lim_{t \to \infty} w_t^p \, e^{-\bar{r}t} \geq 0 \tag{A2}$$

We assume that the private sector maximizes its utility over an infinite horizon subject to budget constraints (A1a) and (A1b). We specify a Cobb-Douglas type of instantaneous utility function:

$$\int_0^\infty U\left(c_t, m_t^A, m_t^i, m_t^O\right) e^{-\delta t} dt \tag{A3a}$$

$$U\left(c_t, m_t^A, m_t^i, m_t^O\right) \equiv \frac{\left[c_t^\alpha \left\{m_t^{A^\beta} \left(m_t^{i^\gamma} m_t^{O^{1-\gamma}}\right)^{1-\beta}\right\}^{1-\alpha}\right]^{1-R}}{1-R} \tag{A3b}$$

$$0 < \alpha < 1, 0 < \beta < 1, 0 < \gamma < 1, 0 < R < 1$$

where δ: rate of time preference, R: reciprocal of instantaneous elasticity of substitution between intertemporal consumption σ: $\sigma \equiv -\frac{U_c}{U_{cc}c_t}$

We assume that the public sector in country A holds only bonds in currencies i and O. Instantaneous budget constraints for the public sector are represented in real terms:

$$\dot{f}_t = \bar{r} f_t + \tau_t + \mu_t^A m_t^A - g_t \tag{A4a}$$

$$f_t \equiv f_t^i + f_t^O \tag{A4b}$$

where g: real government expenditures, f: foreign assets held by the public sector, μ^A: growth rate of currency A. We assume no-Ponzi game conditions for foreign assets held by the public sector.

$$\lim_{t \to \infty} f_t \, e^{-\bar{r}t} \geq 0 \tag{A5}$$

A stock of foreign exchange reserves held by the monetary authorities should be unchanged under a flexible exchange rate system because the monetary authorities will not intervene in foreign exchange markets $(f_t = \bar{f})$. Also, they are able to control nominal money supply. Here, we assume that they increase the nominal money supply at a constant growth rate μ^A.

Thus we obtain an instantaneous budget constraint equation for the public sector under a flexible exchange rate system:

$$g_t - \tau_t = \bar{r}\bar{f} + \bar{\mu}^A m_t^A \tag{A6}$$

From the instantaneous budget constraint equations for the private sector and the public sector Equations (A1a) and (A6), we derive an instantaneous budget constraint equation for the whole economy of country A under a flexible exchange rate system:

$$\dot{b}_t^i + \dot{b}_t^O + \dot{m}_t^i + \dot{m}_t^O = \bar{r}\left(b_t^i + b_t^O + m_t^i + m_t^O + \bar{f}\right) + y_t - c_t - g_t - i_t^i m_t^i - i_t^O m_t^O \tag{A7}$$

The private sector maximizes its utility functions (A3a) and (A3b) subject to budget constraint equation (A7). We assume that the private sector has perfect foresight that economic variables do not diverge to infinity, but converge to equilibrium values along a saddle path to rule out a possibility of multiplicity of equilibria in the model.

From the first-order conditions for maximization, we derive optimal real balances of international currencies:

$$m_t^i = \frac{(1-\alpha)(1-\beta)\gamma}{\alpha}\frac{\bar{c}}{i_t^i} = \frac{(1-\alpha)(1-\beta)\gamma}{\alpha}\frac{\bar{c}}{i_t^i + \bar{r}} \tag{A8a}$$

$$m_t^O = \frac{(1-\alpha)(1-\beta)(1-\gamma)}{\alpha}\frac{\bar{c}}{i_t^O} = \frac{(1-\alpha)(1-\beta)(1-\gamma)}{\alpha}\frac{\bar{c}}{i_t^O + \bar{r}} \tag{A8b}$$

where π_t^j: inflation rate of currency j $(j = i, O)$,

$$\bar{c} = \bar{r}\left\{a_0 + \int_0^\infty y_t e^{-\bar{r}t} dt - \int_0^\infty g_t e^{-\bar{r}t} dt - \int_0^\infty (i_t^i m_t^i - i_t^O m_t^O) e^{-\bar{r}t} dt\right\}$$

From Equations (A8a) and (A8b), an optimal share ϕ of i is derived:

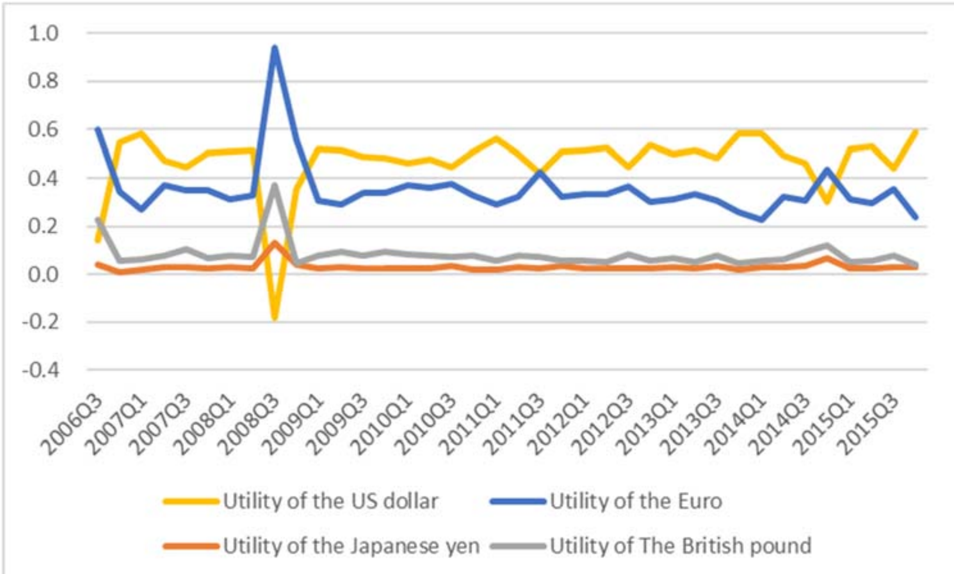
$$\phi_t \equiv \frac{m_t^i}{m_t^i + m_t^O} = \frac{1}{1 + \frac{1-\gamma}{\gamma}\frac{i_t^i}{i_t^O}} = \frac{1}{1 + \frac{1-\gamma}{\gamma}\frac{\pi_t^i + \bar{r}}{\pi_t^O + \bar{r}}} \tag{A9}$$

Equation (A9) implies that the optimal share of i depends on both the inflation or depreciation rates of the international currencies (π^i and π^O) and a parameter γ in the utility function Equation (A3b).

From Equation (A9), the parameter γ_t^i is derived:

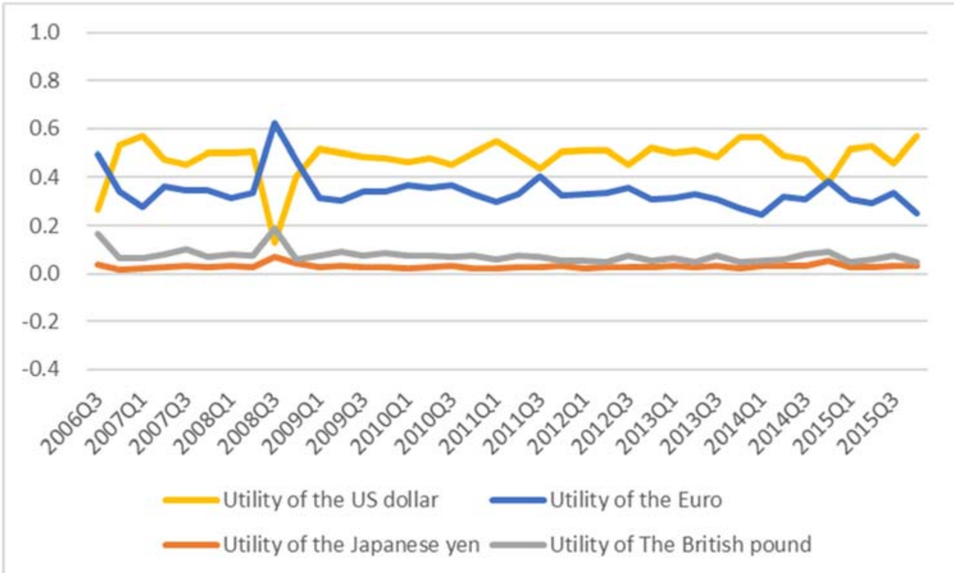
$$\gamma_t^i = \frac{1}{1 + \left(\frac{1}{\phi_t^i} - 1\right)\frac{\pi_t^O + \bar{r}}{\pi_t^i + \bar{r}}} \tag{A10}$$

Figure 1a: Utility of international currencies (real interest rate = 1.5%)



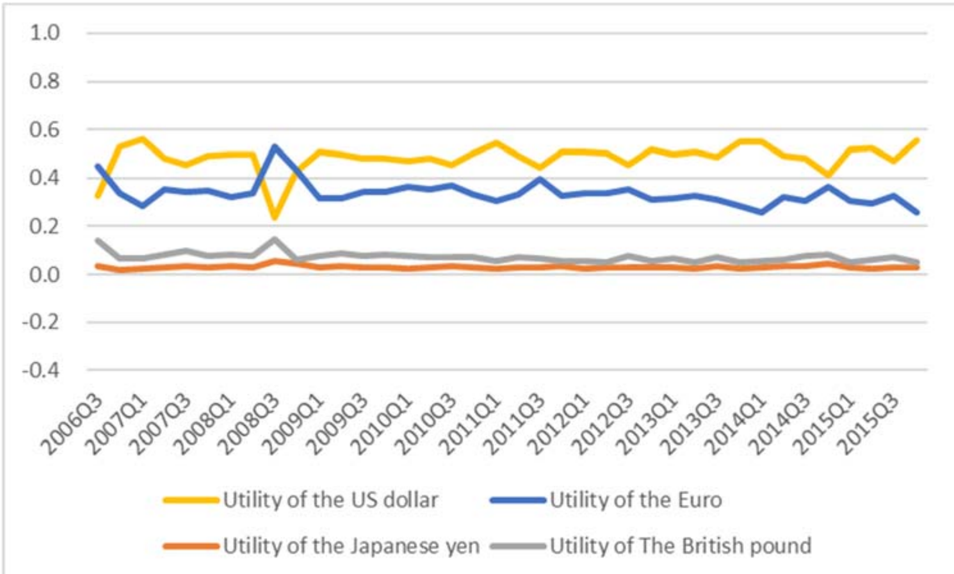
*The four lines represent time series of estimated coefficients on four international currencies (the US dollar, the euro, the Japanese yen, and the British pound) in a money-in-the-utility function. The coefficients were estimated from share of holdings of an international currency and expected inflation rates with a real interest rate supposed to be 1.5%. We used BIS data on total of domestic currency denominated debt and foreign currency denominated debt of the euro currency market as the share of holdings of an international currency. The expected inflation rates are calculated by taking logarithm difference between actual CPI level and expected CPI level estimated under the assumption that the price level of each period follows ARIMA (p, d, q) process.

Figure 1b: Utility of international currencies (real interest rate = 2.0%)



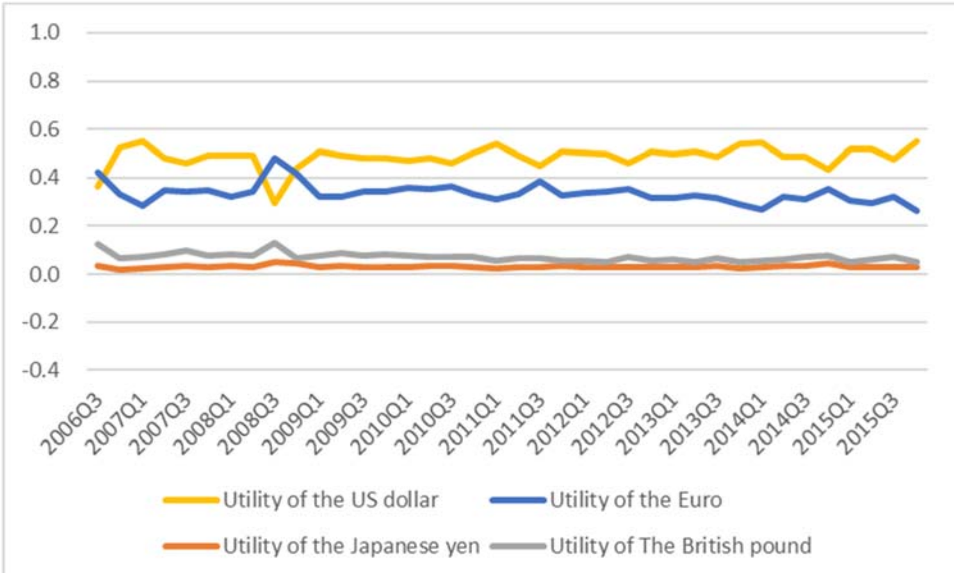
*The four lines represent time series of estimated coefficients on four international currencies (the US dollar, the euro, the Japanese yen, and the British pound) in a money-in-the-utility function. The coefficients were estimated from share of holdings of an international currency and expected inflation rates with a real interest rate supposed to be 2.0%. We used BIS data on total of domestic currency denominated debt and foreign currency denominated debt of the euro currency market as the share of holdings of an international currency. The expected inflation rates are calculated by taking logarithm difference between actual CPI level and expected CPI level estimated under the assumption that the price level of each period follows ARIMA (p, d, q) process.

Figure 1c: Utility of international currencies (real interest rate = 2.5%)



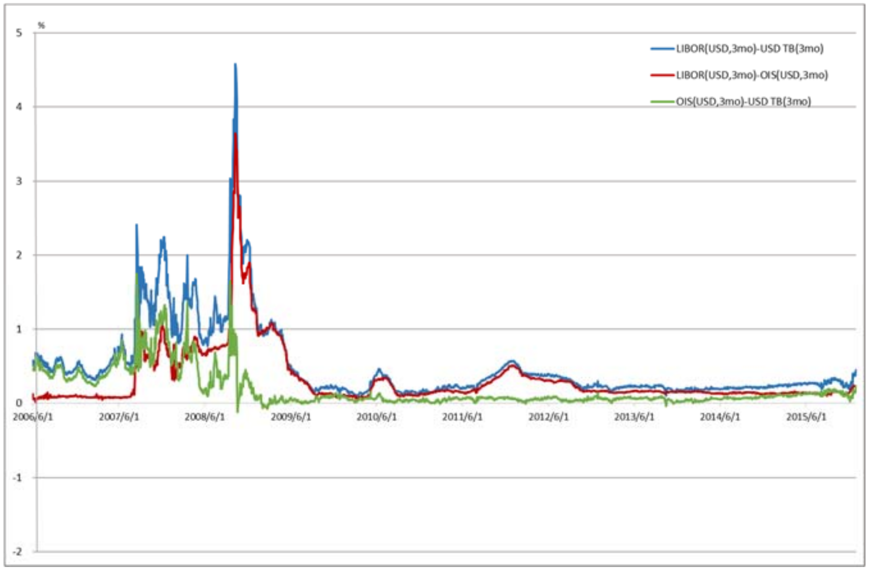
*The four lines represent time series of estimated coefficients on four international currencies (the US dollar, the euro, the Japanese yen, and the British pound) in a money-in-the-utility function. The coefficients were estimated from share of holdings of an international currency and expected inflation rates with a real interest rate supposed to be 2.5%. We used BIS data on total of domestic currency denominated debt and foreign currency denominated debt of the euro currency market as the share of holdings of an international currency. The expected inflation rates are calculated by taking logarithm difference between actual CPI level and expected CPI level estimated under the assumption that the price level of each period follows ARIMA (p, d, q) process.

Figure 1d: Utility of international currencies (real interest rate = 3.0%)



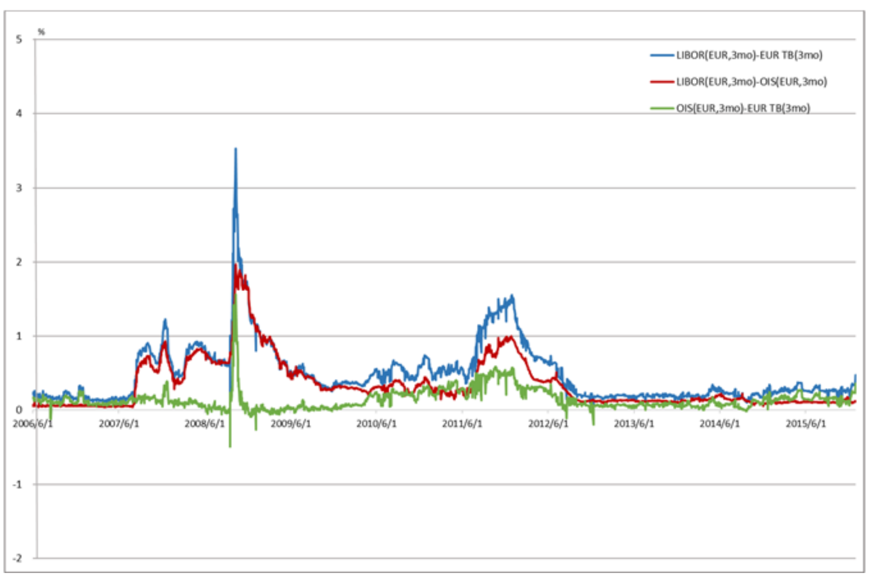
*The four lines represent time series of estimated coefficients on four international currencies (the US dollar, the euro, the Japanese yen, and the British pound) in a money-in-the-utility function. The coefficients were estimated from share of holdings of an international currency and expected inflation rates with a real interest rate supposed to be 3.0%. We used BIS data on total of domestic currency denominated debt and foreign currency denominated debt of the euro currency market as the share of holdings of an international currency. The expected inflation rates are calculated by taking logarithm difference between actual CPI level and expected CPI level estimated under the assumption that the price level of each period follows ARIMA (p, d, q) process.

Figure 2a: Credit Risk Premium and Liquidity Risk Premium for the USD



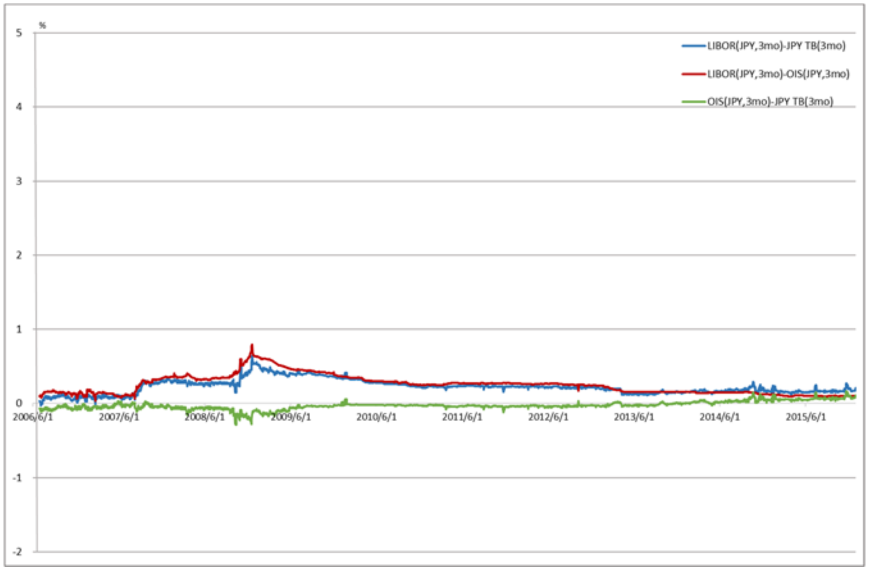
Data: Datastream, Credit risk = London Interbank Offered Rate (LIBOR) (USD, 3months) minus Overnight Indexed Swap (OIS) rate (USD, 3 months), liquidity risk = OIS minus US Treasury Bills (TB) rate (USD, 3 months)

Figure 2b: Credit Risk Premium and Liquidity Risk Premium for the EUR



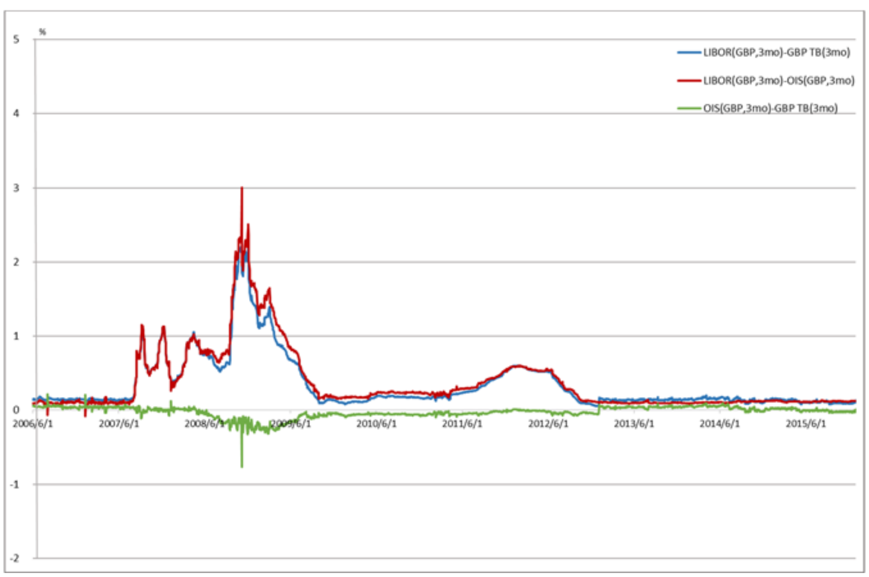
Data: Datastream, Credit risk = London Interbank Offered Rate (LIBOR) (EUR, 3months) minus Overnight Indexed Swap (OIS) rate (EUR, 3 months), liquidity risk = OIS minus yields on German treasury discount paper (Bubills) (EUR TB rate) (euro, 3months)

Figure 2c: Credit Risk Premium and Liquidity Risk Premium for the JPY



Data: Datastream, Credit risk = London Interbank Offered Rate (LIBOR) (JPY, 3months) minus Overnight Indexed Swap (OIS) rate (JPY, 3 months), liquidity risk = OIS minus yields on Japanese Treasury Discount Bills (JPY TB rate) (JPY, 3 months)

Figure 2d: Credit Risk Premium and Liquidity Risk Premium for the GBP



Data: Datastream, Credit risk = London Interbank Offered Rate (LIBOR) (GBP, 3months) minus Overnight Indexed Swap (OIS) rate (GBP, 3 months), liquidity risk = OIS minus Yields on UK Government bonds (gilts) (GBP TB rate) (GBP, 3 months)

Table 1a: Determinants of utility of international currency (real interest rate 1.5%)

	1	2	3	4	5	6	7	8
ΔUtility of the international currency$_{jt-1}$	0.07** (0.04)	0.06* (0.06)	0.13*** (0.00)	0.12*** (0.00)	0.08** (0.02)	0.07** (0.03)	0.13*** (0.00)	0.13*** (0.00)
ΔLiquidity risk premium$_{jt}$	-0.11* (0.06)	-0.12** (0.02)	-0.15*** (0.00)	-0.16*** (0.00)	-0.12* (0.06)	-0.12** (0.02)	-0.16*** (0.00)	-0.16*** (0.00)
ΔMoney stock share$_{jt}$	1.36 (0.40)	1.62 (0.34)	1.36 (0.42)	1.58 (0.37)	1.43 (0.34)	1.70 (0.29)	1.47 (0.35)	1.70 (0.31)
ΔRelative nominal economic growth$_{jt}$	0.004 (0.71)	0.004 (0.70)	0.001 (0.92)	0.001 (0.90)				
ΔRelative real economic growth$_{jt}$					-0.003 (0.51)	-0.004 (0.48)	-0.005 (0.28)	-0.005 (0.26)
ΔGDP share$_{jt}$	0.33 (0.48)	0.89 (0.19)	0.03 (0.97)	0.57 (0.56)	0.30 (0.55)	0.87 (0.23)	0.01 (0.99)	0.57 (0.60)
ΔCapitalization share$_{jt}$	-0.03 (0.98)	-0.28 (0.80)	-0.21 (0.78)	-0.40 (0.58)	-0.01 (0.99)	-0.26 (0.79)	-0.11 (0.87)	-0.31 (0.63)
ΔTotal trade share$_{jt}$	-6.37*** (0.00)	-6.34*** (0.00)			-6.27*** (0.00)	-6.23*** (0.00)		
ΔTotal export share$_{jt}$			-4.23* (0.06)	-4.30* (0.05)			-4.27* (0.07)	-4.33* (0.06)
ΔCapital flow share$_{jt}$	-0.06 (0.38)	-0.07 (0.35)	-0.09 (0.24)	-0.09 (0.23)	-0.06 (0.33)	-0.06 (0.30)	-0.09 (0.15)	-0.10 (0.14)
ΔNominal effective exchange rate$_{jt}$	0.004* (0.06)		0.003 (0.17)		0.004* (0.06)		0.003 (0.19)	
ΔReal effective exchange rate$_{jt}$		0.003 (0.15)		0.001 (0.50)		0.002 (0.16)		0.001 (0.57)
Sargan test	0.14	0.16	0.12	0.14	0.18	0.21	0.16	0.18
AR(1) serial correlation test	0.12	0.12	0.11	0.11	0.12	0.12	0.11	0.11
AR(2) serial correlation test	0.91	0.98	0.10	0.08*	0.86	0.96	0.10*	0.08*

*The parentheses are p-value. *, **, *** are significance level 10%, 5%, 1%. Instrument variables for period t are utility of the international currency of periods t-3 and t-4. The null hypothesis of Sargan test is that over-identification is valid. The null hypothesis of AR(1) and AR(2) serial correlation test is that there is no serial correlation.

Table 1b: Determinants of utility of international currency(real interest rate 2.0%)

	9	10	11	12	13	14	15	16
ΔUtility of the international currency$_{jt-1}$	0.08 (0.41)	0.07 (0.55)	0.23*** (0.00)	0.23** (0.02)	0.09 (0.36)	0.08 (0.51)	0.24*** (0.00)	0.23** (0.01)
ΔLiquidity risk premium$_{jt}$	-0.11** (0.03)	-0.11** (0.02)	-0.13*** (0.00)	-0.14*** (0.00)	-0.11** (0.02)	-0.11** (0.01)	-0.13*** (0.00)	-0.14*** (0.00)
ΔMoney stock share$_{jt}$	0.05 (0.93)	0.20 (0.75)	0.00 (1.00)	0.15 (0.80)	0.05 (0.92)	0.20 (0.74)	0.00 (1.00)	0.15 (0.80)
ΔRelative nominal economic growth$_{jt}$	0.004 (0.56)	0.004 (0.58)	0.002 (0.81)	0.001 (0.83)				
ΔRelative real economic growth$_{jt}$					0.002 (0.16)	0.001 (0.22)	0.000 (0.96)	0.000 (0.88)
ΔGDP share$_{jt}$	0.24 (0.58)	0.64 (0.18)	-0.24 (0.35)	0.18 (0.66)	0.22 (0.63)	0.62 (0.23)	-0.24 (0.47)	0.18 (0.70)
ΔCapitalization share$_{jt}$	0.57 (0.21)	0.43 (0.34)	0.59* (0.07)	0.47 (0.12)	0.56 (0.17)	0.41 (0.31)	0.61* (0.09)	0.48 (0.14)
ΔTotal trade share$_{jt}$	-4.32*** (0.00)	-4.26*** (0.00)			-4.27*** (0.00)	-4.21*** (0.00)		
ΔTotal export share$_{jt}$			-2.67** (0.05)	-2.65** (0.05)			-2.65* (0.06)	-2.63* (0.07)
ΔCapital flow share$_{jt}$	-0.07 (0.26)	-0.07 (0.27)	-0.10** (0.04)	-0.10** (0.03)	-0.06 (0.22)	-0.06 (0.23)	-0.10** (0.01)	-0.10*** (0.01)
ΔNominal effective exchange rate$_{jt}$	0.003*** (0.00)		0.003** (0.03)		0.003*** (0.00)		0.003** (0.04)	
ΔReal effective exchange rate$_{jt}$		0.002** (0.03)		0.002 (0.20)		0.002** (0.02)		0.002 (0.20)
Sargan test	0.42	0.41	0.48	0.49	0.42	0.41	0.49	0.50
AR(1) serial correlation test	0.10*	0.08*	0.12	0.10	0.10	0.09*	0.12	0.10
AR(2) serial correlation test	0.75	0.85	0.15	0.13	0.86	1.00	0.15	0.13

*The parentheses are p-value. *, **, *** are significance level 10%, 5%, 1%. Instrument variables for period t are utility of the currency of periods t-3. The null hypothesis of Sargan test is that over-identification is valid. The null hypothesis of AR(1) and AR(2) serial correlation test is that there is no serial correlation.

Table 1c: Determinants of utility of international currency(real interest rate 2.5%)

	17	18	19	20	21	22	23	24
ΔUtility of the international currency$_{jt-1}$	-0.04	-0.06	0.12*	0.10	-0.03	-0.05	0.13*	0.11
	(0.80)	(0.71)	(0.08)	(0.16)	(0.86)	(0.77)	(0.07)	(0.15)
ΔLiquidity risk premium$_{jt}$	-0.06***	-0.06***	-0.08***	-0.08***	-0.06***	-0.06***	-0.08***	-0.08***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ΔMoney stock share$_{jt}$	-0.30	-0.23	-0.36	-0.29	-0.30	-0.23	-0.36	-0.28
	(0.70)	(0.79)	(0.63)	(0.72)	(0.70)	(0.79)	(0.62)	(0.71)
ΔRelative nominal economic growth$_{jt}$	0.004	0.003	0.002	0.002				
	(0.43)	(0.43)	(0.65)	(0.65)				
ΔRelative real economic growth$_{jt}$					0.001	0.001	0.000	0.000
					(0.18)	(0.24)	(0.96)	(0.92)
ΔGDP share$_{jt}$	0.42	0.67	0.09	0.35	0.39	0.65	0.07	0.34
	(0.36)	(0.17)	(0.63)	(0.16)	(0.39)	(0.19)	(0.71)	(0.21)
ΔCapitalization share$_{jt}$	0.18	0.05	0.17	0.07	0.17	0.04	0.19	0.08
	(0.80)	(0.94)	(0.65)	(0.85)	(0.80)	(0.96)	(0.61)	(0.83)
ΔTotal trade share$_{jt}$	-3.49***	-3.48***			-3.44***	-3.43***		
	(0.00)	(0.00)			(0.00)	(0.00)		
ΔTotal export share$_{jt}$			-2.27**	-2.29**			-2.23**	-2.24**
			(0.03)	(0.03)			(0.04)	(0.05)
ΔCapital flow share$_{jt}$	-0.04	-0.03	-0.07*	-0.06*	-0.03	-0.03	-0.07**	-0.06*
	(0.45)	(0.50)	(0.07)	(0.08)	(0.45)	(0.52)	(0.05)	(0.06)
ΔNominal effective exchange rate$_{jt}$	0.002***		0.002***		0.002***		0.002***	
	(0.00)		(0.01)		(0.00)		(0.01)	
ΔReal effective exchange rate$_{jt}$		0.001**		0.001**		0.001**		0.001**
		(0.04)		(0.03)		(0.03)		(0.03)
Sargan test	0.18	0.15	0.24	0.23	0.18	0.16	0.26	0.25
AR(1) serial correlation test	0.19	0.19	0.16	0.15	0.21	0.21	0.17	0.15
AR(2) serial correlation test	0.81	0.60	0.12	0.12	0.72	0.51	0.12	0.12

*The parentheses are p-value. *, **, *** are significance level 10%, 5%, 1%. Instrument variables for period t are utility of the currency of periods t-3. The null hypothesis of Sargan test is that over-identification is valid. The null hypothesis of AR(1) and AR(2) serial correlation test is that there is no serial correlation.

Table 1d: Determinants of utility of international currency(real interest rate 3.0%)

	25	26	27	28	29	30	31	32
ΔUtility of the international currency$_{jt-1}$	-0.18	-0.22	-0.05	-0.07	-0.17	-0.21	-0.03	-0.05
	(0.57)	(0.54)	(0.83)	(0.77)	(0.61)	(0.58)	(0.90)	(0.83)
ΔLiquidity risk premium$_{jt}$	-0.04***	-0.04***	-0.05***	-0.06***	-0.04***	-0.04***	-0.05***	-0.06***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
ΔMoney stock share$_{jt}$	-0.31	-0.26	-0.38	-0.34	-0.31	-0.27	-0.39	-0.34
	(0.71)	(0.77)	(0.64)	(0.70)	(0.70)	(0.76)	(0.63)	(0.69)
ΔRelative nominal economic growth$_{jt}$	0.003	0.003	0.002	0.002				
	(0.28)	(0.25)	(0.39)	(0.37)				
ΔRelative real economic growth$_{jt}$					0.001	0.001	0.000	0.000
					(0.19)	(0.26)	(0.97)	(0.99)
ΔGDP share$_{jt}$	0.52	0.70	0.31	0.47*	0.50	0.67	0.28	0.45
	(0.24)	(0.17)	(0.16)	(0.08)	(0.27)	(0.19)	(0.19)	(0.10)
ΔCapitalization share$_{jt}$	-0.04	-0.14	-0.09	-0.16	-0.05	-0.16	-0.08	-0.16
	(0.96)	(0.88)	(0.87)	(0.78)	(0.95)	(0.86)	(0.88)	(0.78)
ΔTotal trade share$_{jt}$	-3.06***	-3.08***			-3.01***	-3.03***		
	(0.00)	(0.00)			(0.00)	(0.00)		
ΔTotal export share$_{jt}$			-2.13**	-2.16**			-2.07**	-2.09**
			(0.02)	(0.02)			(0.03)	(0.03)
ΔCapital flow share$_{jt}$	-0.02	-0.01	-0.04	-0.04	-0.01	-0.01	-0.04	-0.03
	(0.74)	(0.82)	(0.31)	(0.37)	(0.81)	(0.90)	(0.32)	(0.39)
ΔNominal effective exchange rate$_{jt}$	0.001**		0.001*		0.001**		0.001**	
	(0.03)		(0.06)		(0.02)		(0.04)	
ΔReal effective exchange rate$_{jt}$		0.001		0.001		0.001		0.001
		(0.26)		(0.24)		(0.23)		(0.22)
Sargan test	0.12	0.10*	0.16	0.15	0.11	0.10*	0.16	0.15
AR(1) serial correlation test	0.45	0.50	0.37	0.39	0.48	0.52	0.37	0.40
AR(2) serial correlation test	0.47	0.38	0.09*	0.09*	0.44	0.36	0.09*	0.09*

*The parentheses are p-value. *, **, *** are significance level 10%, 5%, 1%. Instrument variables for period t are utility of the currency of periods t-3. The null hypothesis of Sargan test is that over-identification is valid. The null hypothesis of AR(1) and AR(2) serial correlation test is that there is no serial correlation.