Empirical Analysis on the Substitution Effects of Electronic Currency

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***Abstract*—In this document, we differentiate the long-term impact and the short-term substitution effects of electronic currency by dividing money assets into three levels. We then do empirical analysis on the related seasonal data in China by unit root test, co-integration test and error correction model. The result shows that substitution effects of electronic currency will decrease in the short-term and increase in the long-term in China.**

Keywords-electronic currency; substitution effects; co-integration test; error correction model

I. INTRODUCTION

As a new method of payment based on advanced technology, electronic currency is changing the consumption concept in the real life without being noticed. It also has an unneglectable impact on the traditional means of payment. Why the development of electronic currency has substitution effects on the monetary velocity? That is because people will reduce the use of existing currency correspondingly when using the electronic currency. That is to say it may have substitution effects on different levels of currency. By the research in this document, we can have the following conclusions: as the development of electronic currency, from the horizontal view, the degree of such kind of substitution effect will grow while from the vertical view, the influenced level of currency will become higher.

II. VARIABLES AND DATA

In this document, we study the long-term trends and short-term relationship of substitution effects of electronic currency on monetary velocity in three levels.

A. Selection of Variables

We select V as the dependent variable, which is determined by GDP (gross domestic product) and money supply M , the corresponding index formulae of three levels of V are: $V_0 = GDP/M_0$, $V_1 = GDP/M_1$ and $V_2 = GDP/M_2$. The independent variables are designed through the different orders and degree of substitution. The independent variables are the indicator of financial electronic degree (FE_t), the indicator of liquidity of money supply (ML_t) and the indicator of financial interrelation ratio(FIR_t).

FE_t and ML_t reflect the substitution effects of electronic currency on the assets with high liquidity such as cash and current deposit, which can be considered theoretically as the substitution effects in the early stage of development of electronic currency. FIR_t reflects the substitution effects of electronic currency on the relatively higher level assets with low liquidity, which can be considered as the substitution effects in the mid and late stage.

1. Dependent variable: monetary velocity ($V_0 = GDP/M_0$; $V_1 = GDP/M_1$; $V_2 = GDP/M_2$). According to current statistics caliber in our country, the money supply can be divided into three levels:

$$\begin{aligned} M_0 &= C \\ M_1 &= C + D \\ M_2 &= C + D + TD \end{aligned} \tag{1}$$

Among them, C denotes the cash in circulation, D represents all the current deposit and TD means all the fixed deposit.

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2. The first independent variable: the indicator of financial electronic degree ($FE_t = {(M_2 - M_0)}/{M_2}$). It measures the proportion of non-circulating cash in broad money supply. It increases with the financial electronic degree. It reflects the degree of substitution effects of electronic currency on cash.

3. The second independent variable: the indicator of liquidity of money supply ($ML_t = {M_1}/{M_2}$). It measures the proportion of narrow money supply in broad money supply. At the beginning of development of electronic currency, it shows a strong impact of substitution on cash and current deposit, thus ML_t is able to reflect the degree of that impact to some extent.

4. The third independent variable: the indicator of financial interrelation ratio ($FIR_t = {(M_2 + L + S)}/{GDP}$). It refers to the ratio of all the value of financial assets in one country to its GDP. The more developed electronic currency, the lower liquidity of financial assets that residents prefer to hold, which will result in the sharp increase in FIR_t . Therefore, we can judge the degree of influence of electronic currency on high-level financial assets.

B. Data Processing

In order to avoid the collinearity among indicators and to smooth data in the process of empirical analysis, we take the logarithmic form of the three indicators. The seasonal data should be seasonally adjusted to remove the seasonal changes before the empirical analysis. We seasonally adjust the data by Census X12 and complete the empirical analysis by Eviews5.0.

All the data in this document are from China Economic Information Network, China Statistical Yearbook and China Financial Yearbook. The sample space includes 56 samples, which are from the first season in 1993 to the fourth season in 2006.

III. EMPIRICAL PROCESS

A. Unit Root Test

The method we use here is the Augmented Dickey-Fuller method (ADF). The results of unit root test of original sequence and the first-order differential sequence of all variables are shown in Table 1 in the Appendix.

From the results in Table 1 we can see that at the 1% level of significance, the absolute values of ADF test values of original sequence of all variables are all less than those of 1% threshold, which means there is no significant difference between δ and 0. Thus, we can accept the original hypothesis; there is unit root existing in all the original sequences of these variables and they are all Nonstationary. However, as to the first-order differential, the absolute values of ADF test values are all greater than those of 1% threshold, which means there is significant difference between δ and 0. Thus, we can refuse the original hypothesis and the first-order differential sequences of all the variables are stationary *I(0)* process. Therefore, as is shown form the table that all variables are the integration *I(1)* processes.

B. Co-integration Test

After testing one by one, we find that the best lag period is 2 for all the three vector auto regression (VAR) models. Johansen maximum likelihood value is a kind of method to test the co-integration relationships of variables by maximum likelihood estimator in the VAR model. We construct VAR models by relating all the independent variables with the three levels of monetary velocity, in which way we can measure the substitution effects. Then we calculate the trace statistic and the maximum eigenvalue statistics to find the co-integration relationships between V_0 , V_1 , V_2 and the independent variables. Here are the Johansen testing results of V_0 , V_1 , V_2 and the independent variables.

The co-integration equation after being standardized:

$$V_0 = -21.99471 \times FE_t - 27.11726 \times ML_t + 0.084230 \times FIR_t \quad (2)$$

$$V_1 = -8.958901 \times FE_t - 7.111823 \times ML_t + 0.009113 \times FIR_t \quad (3)$$

$$V_2 = -4.124551 \times FE_t - 2.737653 \times ML_t + 0.007648 \times FIR_t \quad (4)$$

All the three empirical results refuse the original hypothesis that there is no co-integration equation at the 1% level of significance. It shows that there are stable equilibriums among them in the long run. But the difference of co-integration coefficients after being standardized in the three models is significant, which implies the differences in the degree of substitution effects of electronic currency on the three levels of monetary velocity.

C. Error Correction Model

If there are co-integration relationships among variables, it means there are stable relationships among them in the long run, which are maintained by the continual adjustment in the short-term dynamic process. If there is deviation from the equilibrium in the short term for some certain reasons, the whole system will return to the equilibrium by correcting errors. Therefore, by the error correction model (ECM), the short-term fluctuations and the long-term equilibriums can be combined together to analyze the degree of changing both in the long term and the short term.

In the text below, we will show the results of the ECM between V_0 , V_1 , V_2 and the independent variables.

$$\begin{aligned} \Delta V_{0\,t} = &-0.038 \times ECM^1_{t-1} - 0.359 \times \Delta V_{0\,t-1} - 2.993 \times \Delta FE_{t-1} \\ &(-4.87242^*) \quad (-2.86245^*) \quad (-4.35126^*) \\ &-1.341 \times \Delta ML_{t-1} + 0.004 \times \Delta FIR_{t-1} + 0.009 \\ &(-3.45098^*) \quad (0.72609) \quad (1.84016) \end{aligned} \quad (5)$$

Among them, the error correction term is,

$$\begin{aligned} ECM^1_{t-1} = V_{0\,t-1} &+ 21.99 \times FE_{t-1} + 27.117 \times ML_{t-1} - 0.084 \times FIR_{t-1} - 30.95 \\ &(3.14520^*) \quad (4.53042^*) \quad (-2.15240) \end{aligned} \quad (6)$$

R^2=0.678623 , Adj. R^2=0.555372 , AIC=−18.15348 , SC=−17.12215 .

* represents 1% level of significance and ** represents 5% level of significance.

$$\Delta V_{1\,t} = -0.15 \times ECM^2_{t-1} - 0.365 \times \Delta V_{1\,t-1} - 1.486 \times \Delta FE_{t-1}$$
$$(-4.61557^*) \quad (-2.94437^*) \quad (-3.14882^*)$$
$$-0.087 \times \Delta ML_{t-1} + 0.00045 \times \Delta FIR_{t-1} - 0.001 \tag{7}$$
$$(-4.12253^*) \quad (0.81158) \quad (-2.84332^*)$$

Among them, the error correction term is,

$$ECM^2_{t-1} = V_{1\,t-1} + 8.959 \times FE_{t-1} + 7.112 \times ML_{t-1} - 0.009 \times FIR_{t-1} - 11.136 \tag{8}$$
$$(4.44210^*) \quad (4.75122^*) \quad (-2.17555)$$

R^2=0.56555 , Adj. R^2=0.42554 , AIC=−20.37316 , SC=−19.34183 .

$$\Delta V_{2\,t} = -0.01 \times ECM^3_{t-1} - 0.345 \times \Delta V_{2\,t-1} - 0.535 \times \Delta FE_{t-1}$$
$$(-3.21144^*) \quad (-2.96215^*) \quad (-3.44653^*)$$
$$-0.1864 \times \Delta ML_{t-1} + 0.0005 \times \Delta FIR_{t-1} - 0.0017 \tag{9}$$
$$(-4.32255^*) \quad (2.62530^{**}) \quad (-3.04332^*)$$

Among them, the error correction term is,

$$ECM^3_{t-1} = V_{2\,t-1} + 4.125 \times FE_{t-1} + 2.738 \times ML_{t-1} - 0.008 \times FIR_{t-1} - 4.846 \tag{10}$$
$$(3.11335^*) \quad (4.15264^*) \quad (-2.36644^{**})$$

R^2=0.63455 , Adj. R^2=0.54877 , AIC=−22.06283 , SC=−21.03150 .

From the above equations we can see that the t-statistic of all the coefficients of ECM (5), (7) and (9) refuse original hypothesis at the 1% level of significance. Especially, all the error correction terms have passed the 1% level of significance, thus it is reasonable to consider that the influences of long-term equilibriums and short-term fluctuations are significant. Moreover, the ACI and SC values are all small which means that the whole effect of the model is quite good; R^2 and Adj. R^2 also show a good condition. Therefore, it is reasonable for us to believe in the accuracy and rationality of the three ERMs.

IV. ANALYZING THE EMPIRICAL OUTCOMES

A. Long-term Trend of the Substitution Effects of Electronic Currency

First, considered from the signs, the relationships between V_0 , V_1 , V_2 and the independent variables in (2), (3) and (4) are consistent. The dependent variables are negatively correlated with FE_t and ML_t , they are positively related with FIR_t . Therefore, in the early stage of development, electronic currency will decrease the substitution effects in all the three levels of money assets; in the mid and late stage of development, it will increase the velocity.

Secondly, from the vertical view, the degree of substitution effects of all the dependent variables to the monetary velocity decreases with the raise of level, which means that the degree of impact of electronic currency is the greatest on V_0 and the least on V_2 . Since in the early stage, the electronic currency mainly substitutes low-level monetary assets, such as cash and current deposit; it will influence other high-level monetary assets gradually afterwards.

Finally, from the horizontal view, FE_t and ML_t have relatively greater influence on V than FIR_t dose. The result shows that the development of electronic currency is still in the early stage in our country.

B. Short-term Impact of the Substation Effects of Electronic Currency

On the one hand, the coefficient signs of the error correction term in (5), (7) and (9) are all negative, it means the co-integration relationship correct the increase of V reversely. Moreover, the elasticity of the adjustment of error correction term differs with the level of V . V_1 has the greatest elasticity (15%); the next one is V_0 (3.8%) and the last one is V_2 (1%)

On the other hand, the direction of impact of other independent variables on all levels of V in the short term is consistent with the long-term trend, but the degree is much less than that of long-term impact. For example, 1% reduction in ML_t will cause V_0 increases up to 27.117 in the long term, compared with 1.341 in the short term. Therefore, although the development of electronic currency will be a determinant of V in the long run, it has limited influence on all levels of V in the short term.

V. CONCLUSION

By empirical analysis, from both horizontal and vertical view, we find that electronic currency will cause the substitution effects on monetary velocity raise after a decline. That is to say, it will decrease the velocity of currency in the short term whereas increase it in the long term.

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APPENDIX

TABLE I. RESULT OF ADF TEST OF ALL VARIABLES

Variable	Testing Form	ADF Test Value	1% Threshold	Conclusion
V_{0t}	$(C,T,0)$	-2.702822	-4.133838	Nonstationary
ΔV_{0t}	$(C,0,0)$	-9.870224	-3.557472	Stationary
V_{1t}	$(C,T,0)$	-3.135621	-4.133838	Nonstationary
ΔV_{1t}	$(C,0,0)$	-9.678478	-3.557472	Stationary
V_{2t}	$(C,T,0)$	-2.401344	-4.133838	Nonstationary
ΔV_{2t}	$(C,0,0)$	-10.05634	-3.557472	Stationary
ML_t	$(C,T,2)$	-2.387672	-4.133838	Nonstationary
ΔML_t	$(C,0,0)$	-7.730625	-3.557472	Stationary
FE_t	$(C,T,0)$	-1.201448	-4.133838	Nonstationary
ΔFE_t	$(C,0,0)$	-8.804657	-3.557472	Stationary
FIR_t	$(C,T,0)$	-2.631942	-4.133838	Nonstationary
ΔFIR_t	$(C,0,0)$	-9.589339	-3.557472	Stationary