INVESTIGATING THE IMPACT OF ATM AND POS TERMINALS ON MONEY DEMAND IN NINE EUROPEAN COUNTRIES IN THE CONTEXT OF A RANDOM EFFECT MODEL AS THE APPROPRIATE PANEL DATA MODEL

Payam MOHAMMAD ALIHA
Ph.D student, Universiti Kebangsaan Malaysia (UKM), Malaysia
payammaliha@gmail.com

Tamat SARMIDI
Associate Professor Dr. at Faculty of Economics and Management, Universiti Kebangsaan Malaysia (UKM), Malaysia
tamat@ukm.edu.my

Fathin FAIZAH SAID
Associate Professor Dr. at Faculty of Economics and Management, Universiti Kebangsaan Malaysia (UKM), Malaysia
fatin@ukm.edu.my

Abstract

This study investigates the effects of financial innovations on the demand for money using panel data for 9 European countries from 2014 to 2018. Such models assist in controlling for unobserved heterogeneity when this heterogeneity is constant over time and correlated (fixed effects) or uncorrelated (random effects) with independent variables. Hausman test and Breusch and Pagan Lagrangian multiplier test (LM) both indicate that the random effects model is appropriate. We use the conventional money demand that is enriched with the number of automated teller machines (ATM) and the number of point-of-sale (POS) terminals to proxy for the financial innovations. The estimation result of the chosen random effects regression indicate that the elasticity of the demand for real money to POS is about 10 percent meaning that money demand is not elastic with regard to POS. Also, the estimated coefficient of ATM is not significant.

Keywords: EU, money demand, random effects, fixed effects, financial innovation, panel data

JEL classification: C13, C40, C51, E40, E44

1. Introduction

Trade and commerce have been transformed since the introducing of new advanced information technology and technical innovations. Low-cost and high-speed data transfer because of these advancements has created an outstanding platform for e-commerce to grow rapidly which in turn helped to improve the efficiency and boost the competitiveness and economic growth.

Modern payment instruments is a pre-requisite for modern business environment to spread across economy and replace paper-based method which is a hinder for trade to pave the way for fast and efficient transfer of funds. Electronic transfer of funds as a new payment instruments are best characterized by secure, convenient, speedy, low cost and highly efficient means of payment to satisfy the need of modern business and commerce, allow smooth functioning of its financial and real sectors and facilitate speedy, secure and reliable exchange of goods and services through real time settlement of financial transactions. Large scale using of new payment instruments has significant business, economic, political and social impacts.

Electronic payment can be made by new payment technologies such as automatic teller machines (ATMs) that include electronic money (e-money), electronic cards (e-cards) and electronic check and by point-of-sale (POS) terminals.

The purpose of this study is to examine the impact of financial innovation on money demand using panel data which includes nine European countries during 2014-2018 for a conclusive result while gaining the most accurate estimates due to the use of the richest dataset. The results of this study may be of interest to some world organizations such as the

World Bank and the International Monetary Fund and the European monetary authorities such as European Central Bank or the central banks of the these countries. This study hopes to shed light on the relationship between ATM & POS and money demand using the most recent data. The rest of the paper includes a literature review followed by theoretical background and methodology and ends up with data analysis and conclusion.

2. Literature review

Here, we briefly review major studies with focus on the effect of ATM and POS on the demand for money in chronological order.

Zilberfarb (1989) presents empirical results for Israel supports those findings based on the results that he obtained from an empirical analysis using Israel data. The hypothesis is that ATM usage lowers the transaction cost and the reduced transaction cost increases demand deposits. To test this hypothesis a model was regressed. In that regression, the dependent variable is real demand deposits (monthly data) and independent variables include the real transactions (measured by the real GDP), the opportunity cost and the intensity of use of ATM with the inclusion of a variable time trend and monthly dummy variables. The hypothesis is supported by the empirical results meaning that the use of ATM in fact increased the demand deposits. However, he mentions that more research with data covering more countries is needed for a firm conclusion regarding the impact of technological innovations on money demand.

The payment habits in the Netherlands in 1990 based on micro data is analysed by Boeschoten (1992). The results of this empirical analysis indicate that using ATMs, cheques and POS terminals considerably reduces cash holdings. Boeschoten comes to the conclusion that those who use alternative payment media end up with 20 percent lower cash balances. In other words, using check, credit/debit cards and automatic teller machines led to the reduction of demand for cash in this country. According to Boeschoten, the use of ATMs significantly reduces cash holdings. However, he mentions that this finding is not very vigorous.

Humphrey et al. (1996) estimate a system of demand equations for five payment instruments including check, electronic or paper giro, credit card, and debit card. The study cover 14 countries between 1987 and 1993. They conclude that only debit cards do not substitute for cash and other instruments do indicating that using debit cards for POS transactions and ATM withdrawals may restrict the substitution of cash for cards.

Boeschoten (1998) investigates the effect of ATM on cash demand using Dutch data in the period 1990–1994 and finds that ATMs has reduced cash demand by the public but banking sector experienced increased inventories of currency in order to use for ATM. Therefore the total effect of ATMs on the total amount of currency depends on the strengths of public and banking effects. They mostly cancel each other out and the total effect is very modest.

Attanasio et al. (1998) estimates the demand for money in Italy for the period 1989 - 1995. In their estimation, they use data on households and firms. The results reveal this fact that the elasticity of consumption and interest rate are significant and different for households with or without having ATM cards. Most notably, the interest elasticity money demand for households who are in the possession of ATM cards is much higher than that of households who do not have these cards (-0.59 compared to -0.27) due to the fact that the two groups of households use different transaction technologies.

Blanchflower et al. (1998) investigate the effects of ATM on cash demand using Dutch data for the period 1990–1994. Their findings indicate that ATMs reduces cash demand for the public and increases cash demand for the banking sector thus making the total effect of ATMs on the total cash demand quite moderate.

Hancock and Humphrey (1998) argue the impact of ATMs on cash holdings is rather mixed.

Snellman et al. (2001) use panel data method based on data for 10 European countries for the period 1987-1996 to estimate demand for money. They conclude a negative relationship between the use of ATM and cash balances and that the diffusion of both ATM and POS terminals have a negative impact on money balance.

Money demand in Belgium is estimated by Rinaldi (2001) which shows that the expansion of card payments has a dampening effect on the demand for money. She estimate demand for currency in Belgium to determine the degree of cash substitution by other payment instruments. The number of debit and credit cards, the number of EFTPOS merchants and the number of ATM machines are included in the equation as a proxy for financial innovations. Conducting stationary test reveals that real GDP, interest rates, currency in circulation and the card variables are not stationary yet cointegrated according to cointegration tests. Then, she estimate an error correction model and finds that there is a long run relationship between currency in circulation and the other variables. The number of ATMs and POS merchant acceptance have a negative effect while the number of credit and debit cards have a positive yet weak effect on currency in circulation in this long-run equilibrium relationship as attested by the cointegration test. In short, her results reveals a negative strong effect of ATMs and POS terminals and a weak positive effect of credit and debit cards on currency demand.

Goodhart and Krueger (2001) argue that the number of ATMs has a positive effect on the demand for small bank notes. On one hand, people visit ATMs more frequently and withdraw smaller amounts of cash on the other hand. The total effect, however, would be an increased demand for small bank notes.

Attanasio et al. (2002) conclude that the interest rate elasticity of money demand is lower for people who have ATM cards compared to those who do not. Furthermore, it is in line with the fact that cash holding is significantly higher in Central and in Southern Italy (where most people did not have ATM cards) than in Northern Italy (where most people had ATM cards) and that the interest rate elasticity of currency demand for households with ATM cards is more elastic than those without ATM cards. This is because, the economy of the Central and in Southern Italy was less developed compared to Northern Italy at that time.

Drehmann et al. (2002) analyse the impact of new payment technologies on the cash demand using annual data for the period 1980 - 1998 in 18 OECD countries with the results that POS terminals are negatively related to the demand for small banknotes while ATMs are positively related to the demand for small banknotes, although the impact on large notes are ambiguous. They conclude that cash will still play an important role despite the introduction of advanced payment technology.

Markose and Loke (2003) state that substitution of modern instruments for cash can be accelerated by increased accessibility to cash through high density of ATMs and other payment instruments which in turn leads to fostering cashless economy.

Stix (2004) analyze the cash withdrawals of the people in Austria from May 2003 to February 2004 with the goal of measuring the effect of ATM withdrawals and EFTPOS payments on cash demand. The results are an indication of the fact that the use of debit cards significantly impacts cash demand and that individual with frequent use of debit card will have their cash demand affected differently from cash demand of those who use debit card infrequently.

Lippi & Secchi (2009) also use ATM data for the case of Italy. By introducing POS terminals, debit cards can be used to make purchases as an alternative to ATM cards. Therefore, the use of debit cards will depend on consumers' preferences and on the availability of ATMs and POS. The effect of POS transactions on cash-electronic payment substitution is not fully known.

By investigating the transactional demand for cash for 13 OECD countries during 1988 – 2007, Amromin and Chakravorti (2009) conclude that more usage of debit card at the POS reduces cash withdrawal at ATMs.

Columba (2009) investigates the effect of ATM and POS diffusion on the demand for currency in circulation. GDP, the opportunity cost, the number of ATM and the number of POS as independent variables are used in the estimates with the result that the transaction technological innovation has a negative impact on currency in circulation.

By applying OLS method to the quarterly data for the period 2005-2010, Hataiseree and Banchuen (2010) investigates the impact of e-payment instruments on the use of cash. Debit card usage and ATM are included in currency demand equation to account for the effects of e-payment instruments. The results indicate that debit cards have a negative impact on currency in circulation, while GDP and interest rates have positive and negative impacts on currency demand that is in line with the theory. The estimated coefficient of card-cash substitution of 0.15 meaning that if debit cards transactions increase by, say, 10%, demand for cash transactions will be reduced by 1.5%.

Ramlall (2010) investigate the impact of credit cards and debit cards on currency in circulation (noted and coins are assessed separately) in Mauritius from 1999 to 2008. To test the extent to which other modes of payments has substituted the demand for currency in circulation, he employs three functions with notes and coins, notes and coins at their first differenced as dependent variables and the number of ATMs, number of debit/credit cards, CPI, interest rate, and GDP in log form as independent variables. Results indicate that the use of debit cards is complements and not substitutes to notes in circulation.

Safdar and Khan (2014) use the cointegration technique for Pakistan and conclude that there is an inverse relationship between money demand and the numbers of ATM and cards both.

3. Methodology

3.1. Empirical model

The standard specification, based on the quantity theory of money that is the conventional money demand function, used in many empirical works in several country specific models is as below. In estimating the effect of financial innovation (technology payments) proxied by the number of automated teller machines (ATMS) and the point-of-sale (POS) terminals per inhabitant on the demand for money, we estimate a semi log-linear specification of the form based on a general form of the theory of money demand (Sriram, 2000):

$$\text{Log } MOD_{it} = \beta_0 + \beta_1 \text{Log } GDP_{it} + \beta_2 \, RIR_{it} + \beta_3 \text{Log } (ATM_{it}) + \beta_4 \text{Log } (POS_{it}) + e_{it} \quad (1)$$

Five independent variables are used in our model. The amount of currency in circulation in real term for the 9 European countries (denoted by MOD) was used as the dependent variable to estimate a demand for real balance of money. Independent variables include real gross domestic product denoted by GDP, real effective exchange rate denoted by REER, real interest rate denoted by RIR, the number of automated teller machines that is denoted by ATM, the number of point of sale terminals (denoted by POS) and e_t is the error term with t spanning from 2014 to 2018. The countries under investigation in this study include Bulgaria, Czech Republic, Denmark, United Kingdom, Croatia, Hungary, Poland, Romania and Sweden. money demand data for the rest of the European countries is not available so the study had to be limited to these nine countries.

An effective exchange rate is a weighted average of a basket of foreign currencies to measure the external competitiveness of a country. The Bank for International Settlements recommends effective exchange rates for gauging whether a currency has appreciated overall relative to trading partners. Effective exchange rates has been used by researchers (most notably Bahmani-Oskooee &, Malixi, 1991) mainly to obtain exchange rate sensitivity of money demand.

Data is collected from the official websites of the World Bank and the European Central Bank. According to the World Bank, the definitions of data are as follow:

"GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2010 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2010 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

Real interest rate (expressed as percent) is the lending interest rate adjusted for inflation as measured by the GDP deflator.

Broad money (in constant 2011 international dollars ,PPP) is the sum of currency outside banks; demand deposits other than those of the central government; the time, savings, and foreign currency deposits of resident sectors other than the central government; bank and traveler's checks; and other securities such as certificates of deposit and commercial paper"

3.2. Panel estimation methods

3.2.1. Qualitative description

Random effect models assist in controlling for unobserved heterogeneity when the heterogeneity is constant over time and not correlated with independent variables. This constant can be removed from the data through differencing, for example by taking a first difference which will remove any time invariant components of the model.

Two common assumptions are made about the individual specific effect: the random effects assumption and the fixed effects assumption. The random effects assumption is that the individual specific effects are uncorrelated with the independent variables. The fixed effect assumption is that the individual specific effect is correlated with the independent variables. If the random effects assumption holds, the random effects model is more efficient than the fixed effects model. However, if this assumption does not hold, the random effects model is not consistent.[1]

3.2.2. Estimation background

The basic class of models that can be estimated using a pool object may be written as:

$$Y_{it} = \alpha + X_{it}'\beta_{it} + \delta_i + \gamma_i + \varepsilon_{it} \quad (2)$$

Where Y_{it} is the dependent variable, and X_{it} is a *k*-vector of regressors, and ε_{it} are the error terms for $i = 1, 2, \ldots, M$ cross-sectional units observed for dated periods $t = 1, 2, \ldots, T$. The α parameter represents the overall constant in the model, while the δ_i and γ_i represent cross-section or period specific effects (random or fixed). Identification obviously requires that the β coefficients have restrictions placed upon them. They may be divided into sets of common (across cross-section and periods), cross-section specific, and period specific regressor parameters. We may view these data as a set of cross-section specific regressions so that we have *M* cross-sectional equations each with *T* observations stacked on top of one another:

$$Y_i = \alpha l_T + X_i'\beta_{it} + \delta_i l_T + I_T\gamma_i + \varepsilon_i \quad (3)$$

For $i = 1, 2, \ldots, M$, where l_T is a *T*-element unit vector, I_T is the *T*-element identity matrix, and γ is a vector containing all of the period effects, $\gamma' = (\gamma_1, \gamma_2, \ldots, \gamma_T)$. Analogously, we may write the specification as a set of *M* period specific equations, each with *T* observations stacked on top of one another.

$$Y_i = \alpha l_M + X_i'\beta_{it} + I_M\,\delta + \gamma_t l_M + \varepsilon_i \quad (4)$$

for $t = 1, 2, \ldots, T$, where l_M is a *M*-element unit vector, I_M is the *M*-element identity matrix, and δ is a vector containing all of the cross-section effects, $\delta' = (\delta_1, \delta_2, \ldots, \delta_M)$. For purposes of discussion we will employ the stacked representation of these equations. First, for the specification organized as a set of cross-section equations, we have:

$$Y = \alpha l_{MT} + X\beta + (I_M \otimes l_T)\delta + (l_M \otimes I_T)\gamma + \varepsilon \quad (5)$$

where the matrices β and *X* are set up to impose any restrictions on the data and parameters between cross-sectional units and periods, and where the general form of the unconditional error covariance matrix is given by:

[1] https://en.wikipedia.org/wiki/Random_effects_model

$$\Omega = E(\varepsilon\varepsilon') = E\begin{bmatrix} \varepsilon_1\varepsilon_1' & \varepsilon_2\varepsilon_1' & \cdots & \varepsilon_M\varepsilon_1' \\ \varepsilon_2\varepsilon_1' & \varepsilon_2\varepsilon_2' & \ddots & \vdots \\ \varepsilon_M\varepsilon_1' & & \cdots & \varepsilon_M\varepsilon_M' \end{bmatrix} \quad (6)$$

If instead we treat the specification as a set of period specific equations, the stacked (by period) representation is given by:

$$Y = \alpha l_{MT} + X\beta + (l_M \otimes I_T)\delta + (I_M \otimes l_T)\gamma + \varepsilon \quad (7)$$

with error covariance:

$$\Omega = E(\varepsilon\varepsilon') = E\begin{bmatrix} \varepsilon_1\varepsilon_1' & \varepsilon_2\varepsilon_1' & \cdots & \varepsilon_T\varepsilon_1' \\ \varepsilon_2\varepsilon_1' & \varepsilon_2\varepsilon_2' & \ddots & \vdots \\ \varepsilon_T\varepsilon_1' & & \cdots & \varepsilon_T\varepsilon_T' \end{bmatrix} \quad (8)$$

The presence of cross-section and period specific effects terms δ and γ may be handled using fixed or random effects methods. The fixed effects portions of specifications are handled using orthogonal projections. In the simple one-way fixed effect specifications and the balanced two-way fixed specification, these projections involve the familiar approach of removing cross-section or period specific means from the dependent variable and exogenous regressors, and then performing the specified regression using the demeaned data (see, for example Baltagi, 2005).

The random effects specifications assumes that the corresponding effects δ_i and γ_i are realizations of independent random variables with mean zero and finite variance. Most importantly, the random effects specification assumes that the effect is uncorrelated with the idiosyncratic residual ε_{it}. The random effects models are handled using feasible GLS techniques. The first step, estimation of the covariance matrix for the composite error formed by the effects and the residual, uses one of the quadratic unbiased estimators (QUE) from Swamy-Arora, Wallace-Hussain, or Wansbeek-Kapteyn. Briefly, the three QUE methods use the expected values from quadratic forms in one or more sets of first-stage estimated residuals to compute moment estimates of the component variances (σ_δ^2, σ_γ^2, σ_ε^2). The methods differ only in the specifications estimated in evaluating the residuals, and the resulting forms of the moment equations and estimators.

Fixed Effects: If instrumental variables estimation is specified with fixed effect, any constants implied by the fixed effect will be added automatically to the instrument list so that the orthogonal projection is also applied to the instrument list. Thus, if Q is the fixed effects transformation operator, we have:

$$\beta_{OLS} = (\textstyle\sum_i X' QX_i)^{-1}(\sum_i X' QY_i)$$
$$\beta_{IV} = (\textstyle\sum_i X_i Q P_{Z_i} QX_i)^{-1}(\sum_i X_i' Q P_{Z_i} QY_i) \quad (9)$$

Where Z_i = QZ_i.

Random Effects and GLS: Similarly, for random effects and other GLS estimators, the weighting will be applied to the instruments as well as the dependent variable and regressors in the model. For example, with data estimated using cross-sectional GLS, we have:

$$\beta_{OLS} = (\textstyle\sum_i X' \Omega_M^{-1} X_i)^{-1}(\sum_i X' \Omega_M^{-1} Y_i)$$
$$\beta_{GIV} = (\textstyle\sum_i X_i \Omega_M^{-1/2} P_{Z_i} \Omega_M^{-1/2} X_i)^{-1}(\sum_i X_i' \Omega_M^{-1/2} P_{Z_i} \Omega_M^{-1/2} Y_i) \quad (10)$$

Where $Z_i^* = \Omega_M^{-1/2} Z_i$.

In the context of random effects specifications, this approach to IV estimation is termed generalized two-stage least squares (G2SLS) method. In implementing the various random effects methods (Swamy-Arora, Wallace-Hussain, Wansbeek-Kapteyn), the existing results have been extended to derive the unbiased variance components estimators in the case of instrumental variables estimation. More generally, the approach may simply be viewed as a special case of the Generalized Instrumental Variables (GIV) approach in which data and the instruments are both transformed using the estimated covariances. One should be aware that this has approach has the effect of altering the implied orthogonality conditions.[2]

4. Results

Table 1 shows the results of the estimation of the pooled regression model along with the statistics for the model.

Table 1: Pooled regression model estimates

Source	SS	df	MS			
				Number of obs	=	45
				F(5, 39)	=	404.95
Model	14.4319174	5	2.88638349	Prob > F	=	0.0000
Residual	.277979245	39	.007127673	R-squared	=	0.9811
				Adj R-squared	=	0.9787
Total	14.7098967	44	.334315834	Root MSE	=	.08443

lmod	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lgdp	1.068241	.0317673	33.63	0.000	1.003985	1.132496
rir	-.0040749	.0054913	-0.74	0.462	-.0151821	.0070322
leer	.4888103	.7000794	0.70	0.489	-.927234	1.904855
latm	.1943001	.1021895	1.90	0.065	-.0123977	.4009979
lpos	.4126154	.0843176	4.89	0.000	.242067	.5831638
_cons	-3.751424	1.274019	-2.94	0.005	-6.328371	-1.174477

We note that the coefficients of LGDP and LPOS are statistically significant at 5% level meaning that these variables have significant impact on LMD. The estimated coefficient of LATM is statistically significant at 10% level. The signs of LGDP and RIR are positive and negative, respectively, as we expected. However, the estimated coefficient of RIR is not statistically significant. The sign of LPOS is positive. To be precise, 1 percent increase in the level of POS leads to 0.41 percent increase in the level of money demand. The sign of LATM is also positive, however, it is not significant at 5 percent level. Regarding (Prob > F = 0.0000), as it is less than 0.05, we conclude that the model is OK overall. It shows that all the coefficients in the model are different from zero. Adjusted R-squared shows that 97.87 percent of variance of LMD is explained by the independent variables which is satisfactory. Next, we consider the fixed effects regression model.

The fixed effects or LSDV model allows for heterogeneity or individuality among the 9 countries by allowing them to have their own intercept values. The term fixed effects is due to the fact that although the intercept may differ across countries, but it does not vary over time, that is, it is time invariant. Table 2 shows the fixed effects regression model estimates accompanied by the resulting statistics of this estimate.

[2] https://eviews.com/help/content/panel-Estimation_Background.html

Table 2: Fixed effects regression model estimates

```
Fixed-effects (within) regression               Number of obs     =        45
Group variable: countrycode                     Number of groups  =         9

R-sq:                                           Obs per group:
     within  = 0.9179                                         min =         5
     between = 0.9652                                         avg =       5.0
     overall = 0.9650                                         max =         5

                                                F(5,31)           =     69.30
corr(u_i, Xb)  = 0.1746                         Prob > F          =    0.0000
```

lmod	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lgdp	1.0898	.2104626	5.18	0.000	.6605587	1.519041
rir	.0006647	.0012474	0.53	0.598	-.0018794	.0032089
leer	-.316012	.1321667	-2.39	0.023	-.5855677	-.0464563
latm	.0555842	.07119	0.78	0.441	-.0896088	.2007773
lpos	.102638	.0591808	1.73	0.093	-.018062	.223338
_cons	-.5973304	1.003727	-0.60	0.556	-2.644445	1.449784
sigma_u	.1147258					
sigma_e	.01100018					
rho	.99089033	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(8, 31) = 283.28                     Prob > F = 0.0000
```

Here, from table 2 it is obvious that the coefficient of LPOS is significant at 10% level while bearing the positive sign. LATM does not have significant influence on LMD. The estimated coefficients of LGDP and LEER are significant while bearing positive and negative signs, respectively. The statistics (Prob > F) indicates that all the coefficients in the model are different from zero as it is less than 0.05. corr (u_i, xb) indicates that the errors u_i are correlated with the regressors in this fixed effects model. rho which is intraclass correlation shows that 99.08 percent of the variance is due to differences across panels. sigma_u is the standard error of residuals within countries and sigma_e is the standard error of residuals (overall error term). Finally, we consider the random effects regression model as appears in Table 3. Here, the 9 countries have a common mean value for the intercept.

Table 3: Random effects regression model estimates

```
Random-effects GLS regression                   Number of obs     =        45
Group variable: countrycode                     Number of groups  =         9

R-sq:                                           Obs per group:
     within  = 0.9176                                         min =         5
     between = 0.9662                                         avg =       5.0
     overall = 0.9660                                         max =         5

                                                Wald chi2(5)      =    552.19
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =    0.0000
```

lmod	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lgdp	1.111455	.07826	14.20	0.000	.9580678	1.264841
rir	.0008179	.0011526	0.71	0.478	-.0014411	.003077
leer	-.3210563	.1297138	-2.48	0.013	-.5752908	-.0668219
latm	.0784308	.0664013	1.18	0.238	-.0517133	.208575
lpos	.100051	.0326464	3.06	0.002	.0360652	.1640368
_cons	-.7577957	.4535801	-1.67	0.095	-1.646796	.131205
sigma_u	.12230064					
sigma_e	.01100018					
rho	.99197505	(fraction of variance due to u_i)				

Here, coefficients of LGDP, LEER and LPOS are all significant and also, they have positive (LGDP and LPOS) and negative (LEER) influence on the dependent variable (LMD). To be precise, 1 percent increase in the level of POS leads to 0.10 percent increase in the level of money demand. RIR coefficient is positive and maybe that explains why it is not significant. The coefficient of LATM is positive yet insignificant. chi2 confirms that the model is overall significant. corr (u_i, xb) indicates that differences across units are uncorrelated with the regressors. To decide between fixed or random effects model, we run a Hausman test (Table 4). It basically tests whether the unique errors are correlated with the regressors, the null hypothesis is they are not.

Table 4: Hausman test (hausman Random)

	Coefficients (b) Fixed	(B) .	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
lgdp	1.0898	1.111455	-.0216546	.1953711
rir	.0006647	.0008179	-.0001532	.0004771
leer	-.316012	-.3210563	.0050444	.0253448
latm	.0555842	.0784308	-.0228466	.0256688
lpos	.102638	.100051	.002587	.0493617

```
           b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho:  difference in coefficients not systematic

              chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                      =        1.47
            Prob>chi2 =      0.9168
```

Null hypothesis is that random effect model is appropriate while alternative hypothesis is that fixed effect model is appropriate. We cannot reject null (as the probability is higher than 0.05) so we conclude that random effects model is appropriate. In the last step, we need to choose between random effects regression and the simple pooled OLS regression. For this purpose, we apply Breusch and Pagan Lagrangian multiplier test (LM) for random effects (Table 5). The LM test helps to decide between a random effects regression and a simple OLS regression. The null hypothesis in the LM test is that variances across units is zero. In other words, there is no significant difference across units (i.e. no panel effect). In other words, null hypothesis is that pooled regression model is appropriate while alternative hypothesis is that random effect model is appropriate.

Table 5: Breusch and Pagan Lagrangian multiplier test for random effects

```
lmod[countrycode,t] = Xb + u[countrycode] + e[countrycode,t]

Estimated results:
```

	Var	sd = sqrt(Var)
lmod	.3343158	.5782005
e	.000121	.0110002
u	.0149574	.1223006

```
Test:   Var(u) = 0
                   chibar2(01) =    62.14
                 Prob > chibar2 =   0.0000
```

We can reject null (as probability is less than 0.05) in favor of the alternative hypothesis so we conclude that the pooled OLS regression is not appropriate and that the random effects is appropriate. Hausman test and Breusch and Pagan Lagrangian multiplier test are both confirming that random effects is appropriate.

Finally, we check the model for the presence of serial correlation. According to this autocorrelation test (Wooldridge test for autocorrelation in panel data), null hypothesis is that there is no serial correlation (no first-order autocorrelation) while alternative hypothesis is that there is serial correlation.

Table 6: Wooldridge test for autocorrelation in panel data for the chosen random effect model

```
F(  1,       8) =     2.421
     Prob > F =      0.1583
```

The probability of 0.1583 (which is greater than 0.05) indicate that there is no first-order autocorrelation.

5. Conclusion

Finally, we summarize the paper as follow. The random effects assumption is that the individual specific effects are uncorrelated with the independent variables. The fixed effects assumption is that the individual specific effect is correlated with the independent variables. Hausman test was used to find out which model is appropriate, fixed effects model or random effects model. The test result indicates that the random effects model is appropriate. By applying Breusch and Pagan Lagrangian multiplier test for random effects, we decided that random effects model is superior to the pooled OLS model. The outcome of these two tests both confirm that the random effects model is appropriate. Based on random effect model, coefficients of LGDP, LEER and LPOS are significant while LGDP and LPOS having positive influence on the dependent variable. Effective exchange rate in logarithm form (LEER) has a negative relationship with money demand in logarithm form (LMOD). For example, 1 percent increase in the level of POS leads to 0.10 percent increase in the level of money demand meaning that the sensitivity of money demand to POS is not very high. In other words, money demand is not elastic with regard to POS. RIR coefficient is positive and insignificant. The coefficient of LATM is positive yet insignificant.

6. References

Amromin, G. & Chakravorti, S. 2009. Whither Loose Change? The Diminishing Demand for Small-Denomination Currency. Journal of Money, Credit and Banking 41(2-3): 315-335.

Attanasio, O., Guiso, L. & Jappelli, T. 1998. The Demand for Money, Financial Innovation, and the Welfare Cost of Inflation: An Analysis with Household Data. National Bureau of Economic Research.

Attanasio, O. P., Guiso, L. & Jappelli, T. 2002. The Demand for Money. Financial Innovation

Bahmani-Oskooee, M. & Malixi, M. 1991. Exchange Rate Sensitivity of the Demand for Money in Developing Countries. Applied Economics 23(8): 1377-1384.

Baltagi, B. (2008). Econometric analysis of panel data: John Wiley & Sons.

Blanchflower, D. G., Evans, D. S. & Oswald, A. J. 1998. Credit Cards and Consumers. National Economic Research Associates, Working Paper

Boeschoten, W. C. & Fase, M. M. 1992. The Demand for Large Bank Notes. Journal of Money, Credit and Banking 319-337.

Boeschoten, W. C. 1998. Cash Management, Payment Patterns and the Demand for Money. De economist 146(1): 117-142.

Columba, F. 2009. Narrow Money and Transaction Technology: New Disaggregated Evidence. Journal of Economics and Business 61(4): 312-325.

Drehmann, M., Goodhart, C. & Krueger, M. 2002. The Challenges Facing Currency Usage: Will the Traditional Transaction Medium Be Able to Resist Competition from the New Technologies? Economic Policy 17(34): 193-228.

Goodhart, C. & Krueger, M. 2001. The Impact of Technology on Cash Usage.

Hancock, D. & Humphrey, D. B. 1997. Payment Transactions, Instruments, and Systems: A Survey. Journal of Banking & Finance 21(11-12): 1573-1624.

Hataiseree, R. & Banchuen, W. 2010. Payment Systems Department.

Humphrey, D. B., Pulley, L. B. & Vesala, J. M. 1996. Cash, Paper, and Electronic Payments: A Cross-Country Analysis. Journal of Money, Credit and Banking 28(4): 914-939.

Lippi, F. & Secchi, A. 2009. Technological Change and the Households' Demand for Currency. Journal of Monetary Economics 56(2): 222-230.

Markose, S. M. & Loke, Y. J. 2003. Network Effects on Cash-Card Substitution in Transactions and Low Interest Rate Regimes. The Economic Journal 113(487): 456-476.

Ramlall, I. 2010. Do Credit and Debit Cards Induce an Evaporation of Cash in Mauritius? International Research Journal of Finance and Economics 36): 16-24.

Rinaldi, L. 2001. Payment Cards and Money Demand in Belgium. Kath. Univ. Leuven, Department Economie.

Safdar, S. & Khan, M. A. Demand for Money, Financial Innovation and Money Market Disequilibrium.

Serletis, A. (2007). The demand for money: Theoretical and empirical approaches: Springer Science & Business Media.

Snellman, J. S., Vesala, J. M. & Humphrey, D. B. 2001. Substitution of Noncash Payment Instruments for Cash in Europe. Journal of Financial Services Research 19(2-3): 131-145.

Sriram, S. S. 2000. A Survey of Recent Empirical Money Demand Studies. IMF Staff papers 334-365.

Stix, H. 2004. The Impact of Atm Transactions and Cashless Payments on Cash Demand in Austria. Monetary Policy & the Economy 1(04): 90-105.
Zilberfarb, B.-Z. 1989. The Effect of Automated Teller Machines on Demand Deposits: An Empirical Analysis. Journal of Financial Services Research 2(1): 49-57.