

# The Effects of Credit and Debit Cards on the Currency Demand\*

*Forthcoming in Applied Economics*

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June 2007

## Abstract

We analyze the effects of credit and debit cards on the currency in circulation by using GMM estimation. Instead of using the data obtained by surveys, we use monthly data obtained by an interbank institution that keeps the statistics of all credit and debit cards usage of a small open economy, Turkey, for the period over 2002M1-2006M10. As expected from the theory, we find that an increase in the usage of credit and debit cards leads to a decrease in the currency demand. Moreover, the usage of the debit cards has a bigger effect on the money demand, compared to the usage of the credit cards. We also find that the effect of credit cards is mostly through purchases and the effect of debit cards is mostly through withdrawals.

**JEL Classification:** E41

**Key Words:** Credit cards; Debit cards; Currency demand; GMM estimation; Turkey.

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\* We thank Mototsugu Shintani and Ali Sina Onder for their helpful comments and suggestions. All errors are our own responsibility. This is a preprint of an article submitted for consideration in Applied Economics. Applied Economics is available online at <http://journalonline.tandf.co.uk/>.

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## 1. Introduction

There is now an old and enormous literature on the money demand and its empirical analysis<sup>1</sup>. Due to its implications on selecting the appropriate monetary policy actions in the modern world, the importance of the money demand analysis has raised recently. In this respect, the opening of the economies, the globalization of the capital markets and, thus, the flexible exchange rate rule play the primary roles in showing way to the existing literature. This may be the primary reason for the central banks and the researchers to keep their interest on the money demand analysis active.

However, modeling and estimating the demand for money are not free of problems. The main difficulty can be named as the variable selection and the representation. In this sense, the most significant results are obtained by the proper specification of the opportunity cost variables. The interest rates on the domestic and foreign assets are usually the most accepted and used variables in the literature of such analysis.

Recently, the introduction of credit and debit cards has moved the attention from the traditional money demand theories to the modern time empirical analysis. Two important questions are raised accordingly: 1) *Will the expanding use of credit and debit cards lead to the evaporation of cash?*<sup>2</sup> 2) *How will the increasing use of these cards affect the policy?* Stix (2004) provides an answer to both questions by referring to the seigniorage income: although the impact of credit and debit cards on the seigniorage income may seem to be limited, when the discounted sum of the loss of future seigniorage incomes are taken into account, the loss of seigniorage income may become quite substantial. Another answer, given by Markose and Loke (2003), considers the magnitude of these questions: the degree of effect of credit and debit cards on cash

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<sup>1</sup> See Sriram (2001) and Knell and Stix (2006) for comprehensive surveys on empirical money demand studies.

<sup>2</sup> See Drehmann et al. (2002), and Markose and Loke (2003).

demand can be magnified if the network coverage of these cards improves. Supporting a positive answer to the first question, De Grauwe et al. (2000) find that the average cost of card payment is around 1.3 percent of the transaction value while it is around 9 percent of the transaction value when cash is used. Finally, related to the second question, Knell and Stix (2006), among others, state that it is necessary to employ some sort of money demand relation in order to correctly interpret movements of monetary aggregates.

As a simple example, consider the monetary exchange equation given by:

$$M \times V = GDP \quad (1)$$

where  $M$  is the equilibrium amount of money,  $V$  is velocity and  $GDP$  is the gross domestic product. Assuming that  $GDP$  is constant,  $V$  can change according to the movements in  $M$ . And  $M$  can change in two ways: a) movement along the money demand curve (i.e., a change in money supply), b) a shift in money demand (holding money supply constant). In such a case, a currency substitution (i.e., the usage of credit and debit cards, checks, foreign currency, etc.) leads to a shift in money demand which, in turn, may lead to lower interest rate together with unpredictable velocity values. Even this basic example is enough to show how effective can credit and debit cards be on the monetary policy.

In this paper, we attempt to answer those two questions that we introduce above by analyzing the effects of credit and debit cards on currency in circulation (the currency demand) of a small open economy, Turkey. The main contribution of our paper is the usage of data obtained by an interbank institution that keeps the statistics of all credit and debit cards usage of Turkey. Using such a macroeconomic data has many benefits compared to the survey analysis, which are open to several problems, such as capturing the real facts of the economy. The main problem with survey data is that, no matter how

many people are involved on those surveys, the data collected (i.e., sample) can never be as accurate as the macroeconomic data (i.e., population) of a country.

We use the GMM method for the estimation of our currency demand function. However, recently, the GMM estimators have been severely criticized on the ground that inference based on the fact that these estimators are inconclusive. The related econometric literature indicates that there has been considerable evidence that the asymptotic normality provides a poor approximation to the sampling distributions of the GMM estimators. Particularly, the GMM estimator becomes heavily biased (in the same direction as the ordinary least squares estimator), and the distribution of the GMM estimator is quite far from the normal distribution (e.g. bimodal). Stock and Wright (2000) attribute this problem to “weak identification” or “weak instruments”, that is, instruments that are only weakly correlated with the included endogenous variables. Stock, Wright and Yogo (2002) and Dufour (2003) provide a comprehensive survey on weak identification in GMM estimation. We also address this issue in our estimators by using recently developed statistics that are immune to weak identification<sup>3</sup>.

The rest of the paper is organized as follows: Section 2 makes a literature review. Section 3 gives the details of card usage in Turkey. Section 4 introduces the basic model that we use to analyze the effects of credit and debit cards on the currency demand. Section 5 describes the methodology that we use in our estimation. Section 6 depicts the estimation results for the basic model. Section 7 extends the basic model and compares the individual effects of the purchases and the withdrawals made by credit and debit cards. Section 8 concludes. The data are described in Appendix.

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<sup>3</sup> Among others, this approach has been used in applied studies such as Yazgan and Yilmazkuday (2005, 2007), and Yilmazkuday (2007).

## **2. Literature Review**

As it is well known now, the credit cards have mainly two functions, namely medium of borrowing and alternate transaction medium. For the former, the credit card usage is related to the number of ATMs. Regarding the latter, the ratio of the firms that accept credit cards as a payment method are important. Here, the effect of the credit cards comes into the picture: if an economy has a developed credit card service, the amount of money demanded will be affected negatively by the credit card usage. This is due to the fact that people will shift all types of their demand for money (namely transactions, precautionary, and, maybe, also speculative) to the credit cards.

On the other hand, just like the credit cards, the debit cards are also alternate transaction mediums, but, besides, they are also used as mediums of liquidity. Although one cannot use them as a medium of borrowing, they can be used to withdraw the money in the checking accounts. In this sense, just like the usage of credit cards, the usage of debit cards depends on the number of ATMs and the ratio of the firms that accept debit cards as a method of payment. Here, the effect of debit cards on the money demand comes into the picture: if an economy has a developed banking system in terms of the bank cards, the amount of currency in circulation will be affected negatively by the debit card usage.

In the literature, the idea of the credit card as an alternate transaction medium is introduced in a model of money demand by Akhand and Milbourne (1986). They find that the credit cards allow agents to hold less in money balances and more in bonds than in the normal Baumol-Tobin model. Nevertheless, there have been few empirical studies of the effects of credit and debit cards on the money demand. For instance, Mandell (1972), by using the 1970 Survey of Consumer Finances, found an insignificant difference between the demand deposit balances of families with and without the credit cards. Similarly, White (1976), by using data from only one bank, found that the credit cards significantly reduce the household demand deposits.

Duca and Whitesell (1995) criticize these papers and list the following problems. First, there is a self-selection bias that arises when only deposit owners are sampled and the potential simultaneity bias if credit card ownership depends on money demand. Second, the impact of the wealth or assets on the money demand is not controlled. Third, White's data were not based on the total holdings of demand deposits of households at all depositories. Finally, White's findings may not be skewed toward higher-income households, since he had no data on balances at thrift institutions, where low-income families tended to have deposits. In order to avoid these problems, Duca and Whitesell (1995) use newer empirical techniques along with the data on household balances at all depositories and household assets; and they find that the credit card ownership is associated with lower transactions deposits.

Recently, Rinaldi (2001) analyzes the effect of credit and debit cards, number of point-of-sale (POS) machines, and number of automatic-teller-machines (ATMs) on Belgian currency in circulation, and she finds a negative effect of POS terminals and ATMs together with a weak effect of credit and debit cards.

Snellman et al. (2001) and Drehmann et al. (2002) analyze panels of countries. While the former focus on European countries, the latter focus on OECD countries. Snellman et al. (2001) find that the number of cards has an insignificant effect while the number of POS terminals and ATMs have significantly negative effects. Drehmann et al. (2002) also find that the number of POS terminals and ATMs have significant effects on cash demand.

Attanasio et al. (2002) estimates the money demand for Italy and analyzes the welfare cost of inflation for card holders and non-holders. They find that ATM users hold significantly lower cash balances than non-users.

Stix (2004) analyzes the effects of POS payments and ATM withdrawals on the Austrian cash demand. He finds that the cash demand is significantly and sizably affected by debit card usage and that there are significant differences in cash demand for individuals with different debit card usage.

### **3. Card Usage in Turkey**

According to Interbank Card Center of Turkey (BKM<sup>4</sup>), the first credit card issued in Turkey is Diners Club in 1968. Following the Diners Club, “Turk Ekspres Havacilik ve Turizm Limited Company” has entered into the market with "American Express" cards. These two cards have continued their activities without any rival until 1975 when Eurocard, Mastercard and Access credit cards entered into the market. By 1980, banks have also initiated the credit card usage and various types of products have showed up. In 1984, Visa increased the momentum by establishing its office in Turkey. In 1987, the first ATM has entered into service, and again in the same year, other consumer products such as housing and vehicle loans have entered into lives of Turkish consumers. As of 1988, debit cards, invoice payments and investment instruments have started to be presented within the retail banking concept.

In 1990, BKM has been founded and bonus point earning system in respect to the amounts spent and choosing products from the catalogues with these points has been introduced to the customers. The first electronic POS Terminal in Turkey was put into service in 1991. In 1993, offices of Europay/MasterCard in Turkey were opened and card usage gained more pace. In 1997, the first co-branded credit card has been introduced, and in 1999, the first multi-branded cards have been introduced to the market. Again in 1999, the consumers have met the deferred credit cards, and the catalogue and point earning practices have had a new shape and the features such as

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<sup>4</sup> <http://www.bkm.com.tr> is the website of the Interbank Card Center of Turkey.

spending the points earned in contracted shops as cash have been presented to the market.

According to the annual report of BKM (2005), the number of credit cards in Turkey is 30 million by the end of 2005, and they have increased the sales volume of member merchants in the country. In particular, during 2005, the number of purchase transactions has reached 1.2 billion with 77.4 billion YTL (approximately 58 billion U.S. dollars) turnover, and the number of cash withdrawal transactions has reached 58.8 billion with 7.9 billion YTL (approximately 6.3 billion U.S. dollars) turnover occurred. These numbers tell us that, in Turkey, credit cards are mostly used for purchase rather than for cash withdrawal.

The debit cards in Turkey can be used subject to the amount of available balance. The number of debit cards in Turkey has reached 48.2 million by the end of 2005. During 2005, the number of purchase transactions has reached 33.8 billion with 899 million YTL (approximately 692 million U.S. dollars) turnover, and the number of cash withdrawal transactions has reached 482.5 billion with a volume of 87.8 billion YTL (approximately 67.5 billion U.S. dollars). These numbers tell us that, in Turkey, debit cards are mostly used for cash withdrawal rather than for purchase.

By the end of 2005, the total number of POS terminals has been 1,140,957, and the number of ATMs has reached 14,823 where 8,313 of them are located within branch offices (of the banks) and 6,505 of them are located outside.

#### **4. The Basic Model**

Consider the following currency demand equation in first-order (semi) log-linear form:

$$\Delta m_t = \lambda \beta_0 + \lambda \beta_c \Delta c_t + \lambda \beta_d \Delta d_t + \lambda \beta_r E(\Delta r_t) + \lambda \beta_p E(\Delta p_t) + \lambda \beta_w E(\Delta w_t) + (1 - \lambda) \Delta m_{t-1} \quad (2)$$

where  $m_t$  is a (log) measure of currency held at the beginning of period;  $c_t$  is a (log) measure of credit card usage;  $d_t$  is a (log) measure of debit card usage;  $E$  is the expectation operator;  $r_t$  is a measure of interest rate;  $p_t$  is a (log) measure of price level;  $w_t$  is a (log) measure of wealth during period  $t$ ;  $0 \leq \lambda \leq 1$  is a measure of speed of adjustment; and finally,  $\beta_0$  is a constant.

The nuance of this model is the inclusion of credit and debit cards usage. In particular, our basic model attempts to capture the effects of credit and debit cards, separately, on the currency demand. Since the currency demand is measured at the beginning of each period, both cards enter into the model with a negative expected sign. This is due to the currency substitution feature of these cards.

At the beginning of each period, the *within-period* paths of interest rate, price level and wealth are not known by the agents. Thus, the agents form expectations about these variables at the beginning of each period. The expected sign of the interest rate is negative due to the well-known opportunity cost of holding money. The expected sign of the price level is positive due to inflationary adjustments and transaction purposes. The inclusion of wealth into the model is because of the idea that higher levels of wealth allows agents to demand for higher levels of money. So, its expected sign is positive.

Finally, the constant is actually the coefficient of the time trend representing the innovations and improvement in transaction technology. The expected value of  $\beta_0$  is negative due to the fact that individuals demand smaller currency balances as transaction technology improves.

## 5. Methodology

Since we have the expectations of interest rate  $E(r_t)$ , price level  $E(p_t)$ , and wealth  $E(w_t)$  in our currency demand function, we will employ GMM in our analysis. The continuously updating GMM estimator that we use is the Limited Information Maximum Likelihood (LIML)<sup>5</sup>. The version of Equation (2) we estimate is as follows:

$$\Delta m_t = \lambda\beta_0 + \lambda\beta_c\Delta c_t + \lambda\beta_d\Delta d_t + \lambda\beta_r\Delta r_t + \lambda\beta_p\Delta p_t + \lambda\beta_w\Delta w_t + (1-\lambda)\Delta m_{t-1} + \varepsilon_t \quad (3)$$

where  $\varepsilon_t = -\beta_r(r_t - E(r_t)) - \beta_p(p_t - E(p_t)) - \beta_w(w_t - E(w_t)) + \mu_t$ .

In order to obtain the orthogonality condition, let  $\mathbf{z}_t$  be a vector of variables, which are within the information set of the agents at the time they choose the amount of currency to hold (i.e.  $\mathbf{z}_t \in \Omega_t$ ), that are orthogonal to  $\varepsilon_t$ . Since interest rate  $E(r_t)$ , price level  $E(p_t)$ , and wealth  $E(w_t)$  are correlated to  $\varepsilon_t$ ,  $\mathbf{z}_t$  must include the vector of instruments used for these variables. Possible elements of  $\mathbf{z}_t$  include any lagged variables that help to forecast our endogenous variables, as well as any other contemporaneous variables that are uncorrelated with the current currency demand shock,  $\mu_t$ . Then, since  $E[\varepsilon_t | \mathbf{z}_t] = 0$ , Equation (3) implies the following orthogonality condition:

$$E[\Delta m_t - \lambda\beta_0 - \lambda\beta_c\Delta c_t - \lambda\beta_d\Delta d_t - \lambda\beta_r\Delta r_t - \lambda\beta_p\Delta p_t - \lambda\beta_w\Delta w_t - (1-\lambda)\Delta m_{t-1} | \mathbf{z}_t] = 0 \quad (4)$$

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<sup>5</sup> For LIML estimators, we modify the GAUSS code originally used by Stock and Wright (2000).

## 6. Estimation Results

The results are illustrated in Table 1. The estimate of the coefficient on the expected interest rate is negative as we expected, and it is significant at 5% level. It says that if the nominal interest rate increases by one point, the nominal amount of currency held decreases by 0.33 percent, *ceteris paribus*. The estimate of the coefficient on the expected price is positive as we expected, and it is significant at 10% level. It says that when the price level increases by one percent, the currency held increases by 2.70 percent. The high value of this estimate is mostly because it adjusts three nominal variables namely money, credit card usage and debit card usage<sup>6</sup>. The estimate of the coefficient on the wealth says that when the level of wealth increases by one percent, the currency held increases by 0.54 percent. Its sign is positive as expected, and it is significant at 10% level.

**Table 1**

GMM Estimation Results for the Basic Model

$\beta_0$	$\beta_c$	$\beta_d$	$\beta_r$	$\beta_p$	$\beta_w$	$1-\lambda$
-0.0270	-0.4401 <sup>†</sup>	-0.8098**	-0.3320*	2.7000 <sup>†</sup>	0.5355 <sup>†</sup>	0.8773*
(0.0269)	(0.3346)	(0.3194)	(0.1694)	(1.7197)	(0.3439)	(0.4076)
[0.1572]	[0.0942]	[0.0056]	[0.0250]	[0.0582]	[0.0597]	[0.0157]

Notes: <sup>†</sup>, \* and \*\* indicate significance at the 10%, 5% and 1% levels, respectively. Standard errors are in parentheses and p-values are in brackets. The instruments we use for the GMM estimation consist of one lag of interest and price level together with two lags of wealth.

<sup>6</sup> If we take into account the estimates of the coefficients of credit card usage and debit card usage, the estimate of the coefficient of the price level drops to around 1.45 (=2.70-0.44-0.81), which is a reasonable estimate for the effect of price level on the money demand.

The most important results of Table 1 are the estimates of the coefficients on credit card and debit card usage which are both negative as expected. Since we use the credit and debit card usage data obtained by the whole economy, not a survey, it tells us the exact relationship between the card usage and the currency demand in the economy. Notice that the effect of credit card usage on currency demand is less than that of debit card. One possibility for this result is the inevitable usage of the debit cards for withdrawing cash, mostly by using the ATMs. Compared to the cash advances made by the credit cards, the withdrawn made by the debit cards is not due to an interest rate. This factor definitely alters the preferences of the individuals towards using their debit cards. Another reason may be the difference in the acceptance ratios of the credit and the debit cards, while making purchases. Since the firms prefer having the amount of the sale made by the credit or debit cards in their account just after the sale, such firms may only accept debit cards. A final possible reason is the difference between the prevalence ratio of credit and debit cards in the banking system. In order to shed more light on the difference between the effects of credit and debit cards, in the next section, we will analyze the effects of withdrawals and purchases made by credit and debit cards, separately.

Finally, the speed adjustment satisfies  $0 \leq \lambda \leq 1$  and the constant is negative, both as expected. Although the former is highly significant, the latter is significant at only higher significance levels.

Table 2 illustrates the test statistics for the GMM estimation. The Hansen's  $J$ -statistic does not reject the null hypothesis that the overidentifying restrictions are satisfied at conventional significance levels. Despite their significance, one should wary about the GMM-based results that are obtained under the asymptotic normality of the sampling distributions that obtained under conventional asymptotics. Nevertheless, under weak-identification asymptotics, the sampling distributions are quite far from being normally

distributed. In this paper, we address the problem of weak identification by using two different tests.

The first of these tests is the Anderson and Roubin (1949), test (*AR*-test) in its general form developed by Dufour and Jasiak (2001) (see also Dufour 2003). The second test is the *K*-test developed by Kleibergen (2002). These two tests are robust even in the case of nonlinear models (see Dufour, 2003; Stock, Wright and Yogo, 2002), and perhaps more importantly, are robust to excluded instruments (see Dufour, 2003). Since it is rarely possible to use all possible instruments, this latter property is quite important from the applied point of view.

*AR* and *K*-test statistics are used to test the null hypothesis that

$$H_0 : \beta_0 = -0.0270; \beta_c = -0.4401; \beta_d = -0.8098; \beta_r = -0.3320; \beta_p = 2.7000; \\ \beta_w = 0.5355; \lambda = 0.8773$$

*i.e.*, given the instruments that we used, whether the estimated parameters are compatible with the data or not. Since both of these tests are fully robust to weak instruments (see Stock, Wright, and Yogo, 2002, pp.522), a non-rejection of this null hypothesis means that our estimates are also “data-admissible”, even under the case of weak instruments.

The *AR*-statistic, under the above null hypothesis, has an exact Fisher distribution with  $k$  and  $T-k$  degrees of freedom (where  $k$  is the number of instruments, and  $T$  is the number of observations), given that the error terms are *i.i.d.* normal, and the instruments are strictly exogenous.  $k \times AR$  statistic is asymptotically distributed chi-square with  $k$  degrees of freedom even without *i.i.d.* normal errors under standard regularity conditions (see Dufour and Jasiak, 2001, pp. 829, and Dufour 2003, pp.20). As can be

followed from Table 2, given the  $p$ -value of the  $AR$ -test, our parameters estimates cannot be rejected. In other words, our GMM estimates of the currency demand cannot be refuted by the Turkish data.

**Table 2**  
Test Statistics for GMM Estimation of the Basic Model

<i>AR-stat</i>	$\chi^2(4)$	<i>K-stat</i>	$\chi^2(3)$	<i>J-stat</i>	$\chi^2(1)$	<i>Sample Size (n)</i>
$F(4;53)$						
0.4563	1.8255	0.0000	1.8979			57
[0.7673]	[0.7679]	[1.0000]	[0.1683]			

Notes: P-values are in brackets.

However, as argued by Kleibergen (2002), the deficiency of the  $AR$ -statistic is that its limiting distribution has a degrees of freedom parameter equal to the number of instruments. Therefore, the  $AR$ -statistic suffers from the problem of low power when the number of instruments highly exceeds the number of structural parameters. Kleibergen proposed a statistic ( $K$ -statistic) that remedies the drawback of the  $AR$ -statistic. Kleibergen, unlike the  $AR$ -test, does not provide a finite sample theory, but instead shows that his  $K$ -statistic follows an asymptotic  $\chi^2(G)$  distribution (where  $G$  is the number of endogenous regressors) under the null hypothesis in the absence of exogenous regressors<sup>7</sup>. Kleibergen also states that the minimal value of the  $K$ -statistic is attained at the LIML estimate and equals to zero. Since we use LIML estimator, as it

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<sup>7</sup> Since our model has exogenous regressors, in order to calculate  $K$ -statistic, we interpret all data matrices as residuals from the projection on the matrix of exogenous variables. This method is suggested by Kleibergen (2002), pp.1784.

can be seen from Table 2, our calculation for  $K$ -statistic is equal to zero as theory suggests.

## 7. Purchases vs. Withdrawals

In this section, we extend our basic model in order to analyze the difference between the purchases and the withdrawals made by credit and debit cards. Specifically, we consider the following currency demand equation:

$$\begin{aligned} \Delta m_t = & \lambda\beta_0 + \lambda\beta_c\Delta c_t^p + \lambda\beta_c\Delta c_t^w + \lambda\beta_d\Delta d_t^p + \lambda\beta_d\Delta d_t^w \\ & + \lambda\beta_r E(\Delta r_t) + \lambda\beta_p E(\Delta p_t) + \lambda\beta_w E(\Delta w_t) + (1-\lambda)\Delta m_{t-1} \end{aligned} \quad (5)$$

where the notation is the same as before except for  $c_t^p$ ,  $c_t^w$ ,  $d_t^p$  and  $d_t^w$  which denote the log levels of credit card purchases, credit card withdrawals, debit card purchases and debit card withdrawals, respectively.

The estimation results are presented in Table 3. As is evident by Table 3, all the estimates are significant except for credit card withdrawals and debit card purchases. In other words, the effect of credit cards on currency demand is mostly through purchases, and the effect of debit cards on currency demand is mostly through withdrawals. Although these results support the possibility that the inevitable usage of the debit cards for withdrawing cash, we cannot find an exact answer for the difference between the effects of debit and credit cards on the currency demands. A final possibility remains to be acceptance ratios of these cards together with possible commissions taken from purchases made by credit cards.

**Table 3**

GMM Estimation Results for the Extended Model

$\beta_0$	$\beta_c^p$	$\beta_c^w$	$\beta_d^p$	$\beta_d^w$	$\beta_r$	$\beta_p$	$\beta_w$	$1 - \lambda$
-0.0268	-0.3840 <sup>†</sup>	-0.0161	0.0699	-0.8594**	-0.2767*	2.8507*	0.4822 <sup>†</sup>	0.6404 <sup>†</sup>
(0.0256)	(0.2596)	(0.2957)	(0.0950)	(0.3475)	(0.1467)	(1.7098)	(0.3117)	(0.4533)
[0.1477]	[0.0696]	[0.4783]	[0.2308]	[0.0067]	[0.0297]	[0.0477]	[0.0609]	[0.0789]

Notes: <sup>†</sup>, \* and \*\* indicate significance at the 10%, 5% and 1% levels, respectively. Standard errors are in parentheses and p-values are in brackets. The instruments we use for the GMM estimation consist of one lag of interest and price level together with two lags of wealth.

Table 4 illustrates the test statistics for the GMM estimation. The Hansen's  $J$ -statistic does not reject the null hypothesis that the overidentifying restrictions are satisfied at conventional significance levels. As before, we address the problem of weak identification by using the  $AR$  and the  $K$ -test statistics, which test the following null hypothesis:

$$H_0 : \beta_0 = -0.0268; \beta_c^p = -0.3840; \beta_c^w = -0.0161; \beta_d^p = 0.0699; \beta_d^w = -0.8594;$$

$$\beta_r = -0.2767; \beta_p = 2.8507; \beta_w = 0.4822; \lambda = 0.6404$$

As can be followed from Table 4, given the  $p$ -value of the  $AR$ -test, our parameters estimates cannot be rejected. In other words, our GMM estimates of the currency demand cannot be refuted by the Turkish data. Since we use LIML estimator, as it can be seen from Table 4, our calculation for  $K$ -statistic is again equal to zero as theory suggests.

**Table 4**

Test Statistics for GMM Estimation of the Extended Model

<i>AR-stat</i>	<i>K-stat</i>	<i>J-stat</i>	<i>Sample Size (n)</i>
$F(4;53)$	$\chi^2(4)$	$\chi^2(3)$	$\chi^2(1)$
0.1413	0.5651	0.0000	0.6013
[0.9661]	[0.9669]	[1.0000]	[0.4381]

Notes: P-values are in brackets.

**8. Conclusions**

We analyzed the effects of credit and debit cards on the currency demand. Our GMM results based on the Turkish data suggest that both credit and debit cards affect the demand for money negatively, as expected by our specified models. This is mostly due to the fact that credit and debit cards are the modern mediums of exchange that have still increasing usage trends in the contemporary world.

We also found that the effect of the debit card usage on the currency demand is bigger than the effect of the credit card usage. Furthermore, it is interesting to see that the effect of credit cards is mostly due to purchases and the effect of debit cards is mostly due to withdrawals. In other words, the purchases made by debit cards and the cash advances withdrawn by credit cards have insignificant effects on the currency demand. One possible explanation for the difference between the effect of the debit card usage and the effect of the credit card usage is the inevitable usage of the debit cards for withdrawing cash, by using ATMs.

The significant negative effects of credit and debit cards on the currency demand have also policy oriented implications that we mentioned in the text. In particular, the expanding use of credit and debit cards seems to lead to the evaporation of cash,

especially after the ongoing innovations in the transaction technologies and network coverage of these cards. This fact is also captured by our estimation results. As another issue, money has to be redefined by considering the effects of payment cards on it. This is mostly for monetary authorities that care for seigniorage income together with measuring other monetary aggregates accurately.

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## Data Appendix

We estimate the currency demand function of Turkey by using monthly data covering 2002M1–2006M10. This appendix introduces the data we use to estimate Equations (3) and (5). Here are the details.

We use currency in circulation as our measure for  $m_t$ . Data are from the website of the Central Bank of the Republic of Turkey (CBRT)<sup>8</sup> (the data code is TP.PG.P02.1).

We use interest rate on annual demand deposits for  $r_t$ . Data are from CBRT (the data code is TP.FA.F07).

We use consumer price index for  $p_t$ . Data are from IFS Online CDROM (the data code is 18664...ZF...).

We use industrial production index as a proxy for our wealth measure,  $w_t$ . This is mostly due to lack of any other monthly data as a proxy for wealth. Data are from CBRT (the data code is TP.TSY01).

In order to control for the growth of credit and debit card sector (both in terms of individual preferences and in terms of industry), we use the *average* transaction made *per card* for  $c_t$  and  $d_t$ . The data are from The Interbank Card Center of Turkey (there is no data code available).

Since the econometric estimation procedure that we use here (GMM) requires that all the variables (including the instruments) used in the estimation should be stationary, all

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<sup>8</sup> <http://www.tcmb.gov.tr> is the website of CBRT.

of the variables are tested by using the Augmented Dickey-Fuller (ADF) tests, and we find that the null of unit root is rejected in all variables, even at the 1 percent significance level, when tests are applied at different lags<sup>9</sup>.

Finally, the correlations between variables are given in Table A1.

**Table A1**  
Correlations Between Variables

	$\Delta m_t$	$\Delta r_t$	$\Delta p_t$	$\Delta w_t$	$\Delta c_t$	$\Delta c_t^p$	$\Delta c_t^w$	$\Delta d_t$	$\Delta d_t^p$	$\Delta d_t^w$
$\Delta m_t$	1.00	-	-	-	-	-	-	-	-	-
$\Delta r_t$	-0.04	1.00	-	-	-	-	-	-	-	-
$\Delta p_t$	-0.10	-0.03	1.00	-	-	-	-	-	-	-
$\Delta w_t$	-0.33	-0.03	-0.03	1.00	-	-	-	-	-	-
$\Delta c_t$	-0.20	-0.10	-0.15	0.32	1.00	-	-	-	-	-
$\Delta c_t^p$	-0.30	-0.17	-0.03	0.32	0.32	1.00	-	-	-	-
$\Delta c_t^w$	0.43	-0.01	-0.25	-0.28	0.36	-0.14	1.00	-	-	-
$\Delta d_t$	0.35	0.13	-0.11	-0.57	0.07	-0.33	0.68	1.00	-	-
$\Delta d_t^p$	0.30	-0.05	-0.33	-0.15	0.30	-0.05	0.63	0.43	1.00	-
$\Delta d_t^w$	0.36	0.13	-0.12	-0.58	0.05	-0.34	0.69	1.00	0.42	1.00

Notes: The notation is borrowed from text. The data cover 2002:M1-2006:M10.

<sup>9</sup> These results are available upon request.