Currency Substitution in the Economies of Central Asia: How Much Does It Cost?*

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Abstract

Underdeveloped financial markets and periods of high inflation stimulated dollarization and currency substitution in the economies of Central Asia. Some authors argue that the latter can pose serious obstacles for an effective conduct of monetary policy and affect households' welfare. This study proposes to use a model with money-in-the-utility function to estimate the elasticity of substitution between domestic and foreign currencies in three economies of Central Asia – Kazakhstan, the Kyrgyz Republic and Tajikistan. Utility derived from holding money balances is represented by a CES function with money holdings denominated in two currencies. The residents are assumed to diversify their monetary holdings due to instability of the domestic currency. The steady state analysis reveals that though currency substitution decreases governments' seigniorage revenue, holding foreign money can be welfare generating if domestic currency depreciates vis-a-vis the currencies in which households' foreign balances holdings are denominated.

Key words: currency substitution, dollarization, monetary policy, seigniorage, welfare, transition economies

JEL classification: E58, P2, E41

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1 Introduction

Currency substitution or use of a foreign currency to finance transactions by domestic residents has been a widespread phenomenon in emerging market and transition economies. During the 1990s, currency substitution and dollarization had started to increase rapidly in former centrally planned economies, and has characterized these economies for most of the 1990s and 2000s.[1] This study investigates the importance of currency substitution in a group of transition economies in Central Asia and estimates the degree of substitutability between domestic currency and foreign currency in these economies. This empirical analysis contributes to understanding of economic importance of currency substitution in three economies - Kazakhstan, the Kyrgyz Republic and Tajikistan. Moreover, the study examines implications of currency substitution for the seigniorage revenues of the government and its welfare cost.

The countries in Central Asia have experienced important structural socioeconomic and political transformation related to demolition of the old administrative systems and building institutions of the free market.[2] Implementing principles of the market economy required economic liberalization, including price liberalization and gradual capital markets decontrol. Price liberalization had resulted in an accelerated pace of inflation and rapid depreciation of newly introduced national currencies. Weak positions of domestic legal tenders and their decreasing purchasing power had led to a flight from national money and an increase in foreign currency holdings by residents. Currency substitution was a result of general economic instability and undermined credibility towards domestic money.[3] Moreover, rudimentary financial sector institutions were not able to provide households with reliable financial instruments for saving in domestic currency. Holding foreign currency (mostly U.S. dollars) had become a way to hedge against the risk of inflation and depreciation of the local currency.

Macroeconomic stabilization in Central Asian economies in the end of 1990s had brought down inflation rates and thus helped local currencies regain more credibility. This has not however reversed the process of dollarization. There is important evidence that foreign currency is still being used by the population.[4] The data on foreign currency denominated

[1] See, for example, Balino, Bennett and Borenzstein (1999), Feige (2003)

[2] See Gurgen, Snoek, Craig, McHugh, Izvorski, van Rooden (1999)

[3] Currency substitution and dollarization phenomena are faced by most of developing and transition economies. For example, Sahay and Vegh (1995), Savastano (1996), Feige (2003), Havrylyshyn and Beddies (2003) studied groups of countries in Latin America, Central and Eastern Europe, former Soviet republics and provided an evidence that macroeconomic instability and high rates of inflation had become major reasons of currency substitution and dollarization in these economies.

[4] Foreign currency is often used in purchasing big ticket items and in fixing the price for such items (cars, real estate, technical equipment, etc.). Households still also use foreign money as a savings instrument keeping certain amounts in cash.

assets, foreign capital flows, and inflows of remittances from abroad witness that there is a significant inflow of foreign currency in the economies of Central Asia. [5] The issue of currency substitution and its policy implications thus remains of interest for researchers and economists.

In the present study the elasticity of substitution between domestic and foreign currencies in Central Asian economies is estimated. For this purpose an empirical estimation of an optimizing model with money-in-the-utility function is performed. The nonlinear Euler equations that characterize the first-order-conditions of optimization by a representative consumer are estimated using General Method of Moments (GMM) procedure as proposed by Hansen (1982). After the key parameters are estimated, they are used for further comparison of steady states with different degrees of dollarization and different inflation rates in order to examine the implications for seigniorage revenues and the welfare loss incurred by households due to holding foreign money balances.

The paper is organized as follows. Section 2 discusses the literature on currency substitution. Section 3 briefly presents economic background and recent developments in the economies of Central Asia. Section 4 presents a theoretical model. Section 5 discusses the data used in the study. Section 6 presents the empirical results. Sections 7 and 8 examine the seigniorage losses and welfare implications of currency substitution in Central Asia. Section 9 concludes.

2 Currency Substitution: Theoretical Background and Empirical Evidence

The problem of currency substitution and dollarization has been extensively studied in economic literature. Many developing economies have experienced high levels of dollarization following the periods of macroeconomic instability.[6] In the literature on dollarization, authors make a distinction between dollarization and currency substitution. Currency substitution describes a situation when a foreign currency is used by local agents for different transactions, i.e. foreign currency is used as a medium of exchange. [7] Dollarization usually describes a situation when agents use foreign currency as a store of value and a unit of account. In this study, no formal distinction is made between dollarization and currency substitution since these two phenomena are interconnected and correlated in these countries.[8]

[5] See Table B 1 in the Appendix B.

[6] See, for example, Rennhack and Nozaki (2006) who discuss the magnitude and trends in dollarization in different developing regions.

[7] For definition, see Balino et al. (1999), Havrylyshyn and Beddies (2003).

[8] Calvo and Végh (1992) discuss that currency substitution is very often referred to as dollarization in economies with high inflation episodes.

Dollarization in transition economies is an important question to study due to several reasons. First, dollarization might pose obstacles for an effective monetary policy through affecting the monetary transmission mechanism. Sahay and Vegh (1995), Balino, Bennett, and Borensztein (1999), Havrylyshyn and Beddies (2003) and other authors argue that dollarization makes the conduct of monetary policy more challenging as it influences the stability of the money demand and makes exchange rate more volatile. Hovarth and Maino (2006) study transmission mechanism of the monetary policy in Belarus, and discuss the ways in which dollarization affects different channels of monetary policy transmission. On one hand, high level of dollarization brings more volatile exchange rates and a stronger pass through from exchange rates to prices. On the other hand, the interest rate channel might become weaker as holding foreign currency denominated assets makes local economic agents less sensitive to changes in interest rates on domestic currency assets.

Furthermore, dollarization affects the ability of governments to earn revenue from seigniorage. Bufman and Leiderman (1993) study dollarization in Israel, and find that dollarization and currency substitution may affect the ability of government to finance its budget deficit. They show that small increases in dollarization have resulted in large seigniorage losses in Israel. Harrison and Vymyatnina (2007) argue that currency substitution can also preclude government from using an inflationary tax to finance its expenditure programs as the spending power is limited by the willingness of domestic residents to hold domestic currency. They claim that foreign currency cash transactions can encourage tax evasion and shift the economy to the underground activities.

Finally, authors argue that currency substitution might affect the ability of central banks to provide accurate macroeconomic forecasts. Thus, in the context of dollarization and currency substitution effective implementation of an inflation targeting regime might be affected as well. Though Leiderman, Maino and Parrado (2006) find that in Latin American economies dollarization can still allow implementing an inflation targeting regime, the latter might still be an important argument against dollarization in the economies in Central Asia due to their underdeveloped financial sectors and weak transmission channels of the monetary policy. The effect of dollarization on monetary stability and monetary policy depends on its importance and substitutability between foreign and local currencies, and development of financial sectors.

Numerous studies have attempted to examine currency substitution in developing and transition economies. Some authors base theirs studies on the so called portfolio balance model, where agents allocate their wealth in domestic and foreign money, and domestic and foreign bonds. A linear demand for domestic money and foreign money is then estimated using a simple Ordinary Least Squares (OLS) regression or other appropriate empirical methodology. The demand for foreign currency as a measure of currency substitution is represented as a function of interest rates on domestic and foreign bonds and other variables. Komarek and Melecky

(2003) apply this approach to study the case of the Czech Republic. Mongardini and Mueller (1999) examine currency substitution in the Kyrgyz economy. Recently Harrison and Vymyatnina (2007) used this methodology to study currency substitution in the Russian economy. This framework allows investigating the factors driving dollarization through estimating how demand for foreign money or the level of dollarization react to changes in inflation, interest rate differentials and foreign exchange depreciation.

Another group of authors employ a dynamic optimization framework with a money-in-the-utility model with two currencies. In this literature, estimation of the structural parameters is based on estimating the Euler equations derived from the optimality conditions. This approach allows explicit estimation of the main model parameters such as efficiency of foreign currency in providing monetary services, the elasticity of substitution between the domestic and foreign currency as well as the magnitude of relative risk aversion and intertemporal substitution. Estimation of the non-linear equations is performed using a Generalized Method of Moments (GMM) framework. This approach was employed by Imrohoroglu (1994) who examines currency substitution in Canada, Bufman and Leiderman (1993) who investigate currency substitution in Israel. Transition and emerging market economies were studied by Friedman and Verbetsky (2001) who consider the economy of Russia, and Selçuk (2003) who investigates currency substitution in some economies of Central and Eastern Europe – the Czech Republic, Hungary, Poland and the Slovak Republic. The authors find a rather high degree of substitutability between local and foreign currencies in the economies with unstable economic situation, high inflation and volatile exchange rates.

In the present study, the second methodology is used. This approach allows estimating explicitly the parameters of the model and analyzing implications of dollarization for seigniorage revenues and households' welfare. This study will follow methodology proposed by Eckstein and Leiderman (1992) who study seigniorage and welfare effects of inflation in Israel. A similar approach can be employed to examine the effects of dollarization. Verbetsky and Friedman (2001) follow this approach to study the seigniorage loss and changes in welfare due to dollarization in Russia. Bufman and Leiderman (1993) study how changes in the level of dollarization affect seigniorage revenue of the government in Israel. The findings of these studies allow concluding that dollarization affects significantly the ability of the governments to earn the seigniorage. The welfare implications are not straightforward. In the present investigation, the framework proposed by Verbetsky and Friedman (2001) is applied.

3 Institutional Framework and Currency Substitution in Central Asia

The dissolution of the Soviet Union in the beginning of 1990s led to a deep socio-economic crisis in the economies of Central Asia: a severe output decline, general macroeconomic instability, and hyperinflation. Economic relations with other republics in the FSU were demolished. This caused a deep recession in the economies of the region and had a negative impact on living standards.[9]

Although the very beginning of the transformation process appeared to be a painful experience for the economies in Central Asia, they have managed to restore positive economic growth in the late 1990s and have even demonstrated impressive growth rates in 2000s. High prices for hydrocarbons, rapid structural reforms, large inflows of foreign investments, and political stability have spurred the economy of Kazakhstan and improved considerably the living standards in this country in recent years. High energy prices and increasing investments in the oil and gas sectors were the main factors that drove economic growth in Kazakhstan.[10] Two other economies have experienced relatively modest developments in comparison to their big neighbor. Kyrgyzstan's growth was driven mainly by the gold production and investments in the gold sector, while the economy of Tajikistan could only start to recover from the recession in the end of the last decade due to the civil war that had lasted even after the peace accord was signed in 1997. Actual economic recovery could only start in 2000.[11]

A period of hyperinflation in the first half of 1990s was a consequence of price liberalization and overall economic decontrol in Central Asian countries. Moreover, newly established central banks were heavily financing state enterprises' losses and government deficits. Rapid growth in money supply had contributed to high levels of inflation in all countries. With the introduction of national currencies, the central banks in the region have gradually taken control over the prices and could achieve price stability by the end of the 1990s. Economic developments of 2000s stimulated rapid developments in the financial markets in the region. Large inflows of capital and foreign exchange into these economies in the form of export receipts, remittances, foreign direct investment, and external borrowing by banks have supported economic growth and financial markets developments. Remittances have recently developed into an important source of foreign exchange for the Kyrgyz Republic and Tajikistan.[12] They have contributed to growth and poverty reduction, but also have turned into a policy challenge. One

[9] See Pomfret (2006)

[10] IMF Staff estimates that in Kazakhstan oil accounts for more than 50 percent of exports and 40 percent of government revenues. (IMF Country Report, 2009)

[11] See Pomfret (2006)

[12] IMF Country Report (2007) estimates that Tajikistan has one of the highest remittances to GDP ratio among former FSU economies

of the issues arising from large inflows of remittances is that the latter contribute to growing inflow of foreign currency in the Central Asian economies that is beyond the control of monetary authorities.[13]

Central banks in the region have recently gained more importance and control and the framework of monetary policy has experienced important evolution over the period of transition in these economies. In the earlier period, central banks' policies were characterized by targeting money growth by means of conducting a tight monetary policy to take control over inflation through managing money supply. As local currencies continued depreciating in the late 1990s, the countries' policy makers became concerned with the external balances and the stability of local money relative to major currencies (mainly the U.S. dollar). Gradual liberalization of exchange rate regimes and capital account have caused higher volatility of the exchange rates. An important tool to support stable exchange rates has proved to be foreign exchange interventions. Thus, the monetary policy framework became more concerned with the exchange rate stability. The instruments employed by central bankers and the monetary policy framework have been evolving over the last several years, the most effective instrument remains interventions in the foreign exchange markets and control over money supply. At this stage of development, currency substitution might largely impede the effects of the monetary policy in Central Asian economies as large amounts of foreign currency in circulation increase the part of money supply that is not under control of central banks. As this affects domestic money demand, exchange rates become more volatile.[14] Such instruments as official interest rates have limited efficiency due to thin financial sectors and underdeveloped financial intermediation.

4 A Model of Currency Substitution

The model presented in this section is based on a traditional money-in-the-utility function model with two currencies. This framework was employed by several authors to study substitution between domestic and foreign currencies in different countries.[15] There are different motives to hold foreign currency alongside local currency. In some countries, using foreign

[13]IMF Regional Outlook (September 2006) analyzes remittances inflows in the region of Central Asia. The IMF staff states that remittances are generally used to finance consumption and housing construction rather than investment in productive capacity, and therefore they can discourage domestic saving. Moreover, due to difficulty to measure foreign exchange inflows monetary management might be inefficient. Remittances inflows can contribute to exchange rate appreciation and fuel inflation.

[14]One might argue that money growth targeting and exchange rate interventions are not considered to be important instruments of monetary policy in developed and advanced transition economies. Today, central bankers can use interest rates setting and inflation targeting frameworks to achieve their goals. The practice show, however, that the monetary authorities in the economies of Central Asia continue to rely heavily on foreign exchange interventions to provide price and exchange rate stability.

[15]see Imrohoroglu (1994), Bufman and Leiderman (1993), Verbestki and Friedman (2001), Selcuk (2006)

money decreases transaction costs, for example, in the regions geographically close to the country in which currency these holdings are denominated. This makes trade relations less costly. In other countries, holding foreign currency provides a simple and natural hedge against local inflation. Holding different currencies is a way to diversify monetary assets in the context of limited access or availability of financial instruments denominated in either currency. This describes the situation in the countries of Central Asia.

In the model presented, the economy consists of a continuum of infinitely lived identical individuals with total measure one. A representative agent is assumed to derive utility from the consumption of a single good and from the liquidity services provided by holdings of domestic and foreign money. Thus, an agent maximizes the expected value of the discounted utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, x_t), \tag{1}$$

where β is the discount factor, c is consumption of goods and x denotes liquidity holdings. Residents choose to diversify their monetary balances by holding money denominated in domestic and foreign currency. The money services are produced by using a combination of domestic and foreign real balances in a CES production function:

$$x = [(1-\alpha)m^{-\rho} + \alpha m^{*-\rho})]^{-\frac{1}{\rho}} \tag{2}$$

where m denotes domestic real money balances and m^* denotes foreign money balances. Coefficient α is a share of foreign money balances in producing money services or efficiency of foreign money. Parameter ρ reflects the elasticity of substitution between domestic and foreign currency. The money services part of the utility function reflects willingness of residents to diversify the money holdings portfolio to lower the risk of losing their monetary assets due to economic instability and inflation in home country. The foreign country is assumed to have stable price level while domestic currency is under inflationary pressure and thus the exchange rate of the domestic currency to foreign currency is unstable.

The budget constraint of a resident household is represented as follows:

$$c_t + m_t + m_t^* + b_t = y_t + \tau_t + \frac{m_{t-1}}{(1+\pi_t)} + \frac{m_{t-1}^*(1+\epsilon_t)}{(1+\pi_t)} + \frac{b_{t-1}(1+r_{t-1})}{(1+\pi_t)}, \tag{3}$$

where r_t is a nominal interest rate on one period bonds between period $t-1$ and t. Variables π_t and ϵ_t represent inflation rate and rate of depreciation of the national currency, respectively. The nominal exchange rate is the ratio between the domestic price level and foreign price level: $E_t = \frac{P_t}{P_t^*}$. The residents care about the stability of the exchange rate and the relative value of the domestic currency to foreign currency. As they assume that foreign currency is more

stable, holding it gives them certain confidence about their wealth. Each period every individual receives an endowment y_t, and a lump-sum transfer from the government τ_t.Moreover, agents hold financial assets b_t, that give the nominal interest rate r_t between period t and $t+1$.

Rearranging the first order conditions we can get the following Euler equations:

$$\beta E_t \left[\frac{u_{c_{t+1}}}{u_{c_t}} \frac{1+r_t}{(1+\pi_{t+1})} \right] = 1, \tag{4}$$

$$\frac{u_{m_t}}{u_{c_t}} = 1 - \beta E_t \left[\frac{u_{c_{t+1}}}{u_{c_t}} \frac{1}{(1+\pi_{t+1})} \right], \tag{5}$$

$$\frac{u_{m_t^*}}{u_{c_t}} = 1 - \beta E_t \left[\frac{u_{c_{t+1}}}{u_{c_t}} \frac{1+\epsilon_{t+1}}{(1+\pi_{t+1})} \right] \tag{6}$$

Euler equation (4) is the standard condition for optimal allocation of consumption between periods t and $t+1$. It equates the marginal utility cost of giving up one unit of consumption in period t to the expected utility gain from shifting that unit to consumption in the next period. Equations (5) and (6) equate the expected utility costs and benefits of reducing consumption in the current period by one unit and allocating that unit to money holdings and then to consumption in the next period.

To estimate the model and analyze the implications for seigniorage revenue and welfare cost of dollarization, the following utility function specification is used:

$$U(c_t, x_t) = \frac{(c_t^{1-\gamma} x_t^{\gamma})^{1-\sigma} - 1}{1-\sigma}, \tag{7}$$

where x_t is represented by the equation 2.

It is assumed that the coefficient γ lies in the interval between 0 and 1, and reflects the transaction requirement of money, and parameter σ represents the coefficient of relative risk aversion (RRA) and should be positive. The situation when $\sigma = 1$ is considered as a logarithmic specification of the utility function. The parameter ρ measures the degree of currency substitution and should be more than -1. Then the elasticity of substitution between domestic and foreign money is computed as $1/(1+\rho)$.

Using the specified utility function, the following optimality conditions are derived:

$$\beta E_t \left(\frac{c_{t+1}}{c_t} \right)^{\sigma(\gamma-1)-\gamma} \left(\frac{x_{t+1}}{x_t} \right)^{\gamma(1-\sigma)} \frac{1+r_t}{1+\pi_{t+1}} = 1 \tag{8}$$

$$(1-\alpha)\frac{\gamma}{1-\gamma}\frac{c_t}{x_t} \times [(1-\alpha)m_t^{-\rho} + \alpha m_t^{*-\rho}]^{-\frac{1}{\rho}-1} \times m_t^{-\rho-1} + \tag{9}$$
$$+\beta E_t \left\{ \left(\frac{c_{t+1}}{c_t}\right)^{\sigma(\gamma-1)-\gamma} \left(\frac{x_{t+1}}{x_t}\right)^{\gamma(1-\sigma)} \frac{1}{(1+\pi_{t+1})} \right\} - 1 = 0,$$

$$\alpha\frac{\gamma}{(1-\gamma)}\frac{c_t}{x_t} \times [(1-\alpha)m_t^{-\rho} + \alpha m_t^{*-\rho}]^{-\frac{1}{\rho}-1} m_t^{*-\rho-1} + \tag{10}$$
$$+\beta E_t \left\{ \left(\frac{c_{t+1}}{c_t}\right)^{\sigma(\gamma-1)-\gamma} \left(\frac{x_{t+1}}{x_t}\right)^{\gamma(1-\sigma)} \frac{(1+\epsilon_{t+1})}{(1+\pi_{t+1})} \right\} - 1 = 0.$$

The optimality conditions are transformed into the following estimation equations:

$$d_{1,t+1} = \beta \left(\frac{c_{t+1}}{c_t}\right)^{\sigma(\gamma-1)-\gamma} \left(\frac{m_{t+1}}{m_t}\right)^{\gamma(1-\sigma)} \times$$
$$\left[\frac{1-\alpha+\alpha\left(\frac{m^*_{t+1}}{m_{t+1}}\right)^{-\rho}}{1-\alpha+\alpha\left(\frac{m^*_t}{m_t}\right)^{-\rho}}\right]^{\gamma(\sigma-1)/\rho} \frac{1+r_t}{1+\pi_{t+1}} - 1, \tag{11}$$

$$d_{2,t+1} = \frac{\gamma(1-\alpha)\left(\frac{c_t}{m_t}\right)}{1-\alpha+\alpha\left(\frac{m^*_t}{m_t}\right)^{-\rho}} - (1-\gamma)\times$$
$$\left\{\left[1-\beta\left(\frac{c_{t+1}}{c_t}\right)^{\sigma(\gamma-1)-\gamma}\left(\frac{m_{t+1}}{m_t}\right)^{\gamma(1-\sigma)}\right]\times \right. \tag{12}$$
$$\left. \times \left[\frac{1-\alpha+\alpha\left(\frac{m^*_{t+1}}{m_{t+1}}\right)^{-\rho}}{1-\alpha+\alpha\left(\frac{m^*_t}{m_t}\right)^{-\rho}}\right]^{\gamma(\sigma-1)/\rho} \times \frac{1}{1+\pi_{t+1}}\right\},$$

$$d_{3,t+1} = (1-\alpha)\left(\frac{m_t^*}{m_t}\right)^{1+\rho} - \alpha - \beta\left(\frac{c_{t+1}}{c_t}\right)^{\sigma(\gamma-1)-\gamma}\left(\frac{m_{t+1}}{m_t}\right)^{\gamma(1-\sigma)} \times$$
$$\times \left[\frac{1-\alpha+\alpha\left(\frac{m_{t+1}^*}{m_{t+1}}\right)^{-\rho}}{1-\alpha+\alpha\left(\frac{m_t^*}{m_t}\right)^{-\rho}}\right]^{\gamma(\sigma-1)/\rho} \times$$
$$\times \left((1-\alpha)\left(\frac{m_t^*}{m_t}\right)^{1+\rho}(1+\epsilon_{t+1}) - \alpha\right) \times \frac{1}{(1+\pi_{t+1})}. \tag{13}$$

The utility function in equation (7) can be considered as a special case of the utility function with habit formation in consumption:

$$U(c_t, x_t) = \frac{[(c_t - \delta c_{t-1})^{1-\gamma} x_t^{\gamma}]^{1-\sigma} - 1}{1-\sigma}; \tag{14}$$

where an introduced parameter δ measures the intensity of habit persistence in the consumption decision of the agent. If $\delta > 0$, the model exhibits habit formation in a traditional sense. In this case, the larger the δ, the less pleasure from a given amount of consumption, and the larger must be the purchases to generate the same utility. In the case when $\delta < 0$, household's decisions are subject to durability in the sense that not only current, but also past consumption generates utility. c_{t-1} is the "habit stock", i.e. the reference level to which the consumer compares her current consumption level. When $\delta = 0$, habits do not play any role and the consumer cares only about present consumption level. If $\delta = 1$, habits are very strong and consumer derives utility only from consumption growth rate. Under habit persistence, an increase in current consumption lowers the marginal utility of consumption in the current period and increases it in the next period. The derived estimation equations for the case when $\delta \neq 0$ are presented in the Appendix C.

5 Data and Estimation Procedure

The GMM procedure is applied to estimate the system if equations derived in the previous section. This procedure was developed by Hansen (1982) who formulated the estimation problem as follows.[16] Let w_t be an $(h \times 1)$ vector of variables that are observed at date t, let θ denote an unknown (a$\times$1) vector of coefficients, and let $h(\theta, w_t)$ be an $(r \times 1)$ vector-valued function, h: $(\mathbb{R}^a \times \mathbb{R}^h) \rightarrow \mathbb{R}^r$. Since w_t is a random variable, so as $h(\theta, w_t)$. Let θ_0 denote the true value of θ, and the true value is characterized by the property that

$$E\left\{h(\theta_0, w_t)\right\} = 0. \tag{15}$$

[16]Procedure description is taken from Hamilton (1994)

Further, denote $Y_T \equiv (w'_T, w'_{T-1}, ..., w'_1)'$ be a $(Th \times 1)$ vector containing all the observations in a sample of size T, and suppose that $g(\theta; Y_T)$ is the sample average of $h(\theta, w_t)$:

$$g_T(\theta; Y_T) \equiv \frac{1}{T} \sum_{t=1}^{T} h(\theta, w_t). \tag{16}$$

The basic idea of the GMM is to choose θ so as to make the sample moment $g(\theta, Y_{\mathrm{T}})$ as close as possible to the population moment of zero. Thus, the GMM estimator $\hat{\theta}_T$ is the value of θ that minimizes the scalar:

$$Q(\theta; Y_T) = [g(\theta; Y_T)]' \, W_T \, [g(\theta; Y_T)] \, , \tag{17}$$

where $\{W_T\}_{T=1}^{\infty}$ is a sequence of $(r \times r)$ positive definite weighting matrices which may be a function of Y_T. Hansen (1982) describes this procedure for obtaining a consistent and efficient estimator for W_T.[17]

In the present study, the unknown parameters to be estimated are denoted as $\theta_1 = (\alpha, \beta, \gamma, \sigma, \rho)'$ or $\theta_2 = (\alpha, \beta, \gamma, \sigma, \delta, \rho)'$. To account for endogeneity a set of instruments is used. The instruments used include the lagged values of the variables in the estimated equations:

$$I_t = \left\{ 1, \frac{m_{t-p+1}}{m_{t-p}}, \frac{m^*_{t-p}}{m_{t-p}}, \frac{c_{t-p+1}}{c_{t-p}}, \frac{c_{t-p}}{m_{t-p}}, 1 + r_{t-p} \right\}.$$

The monthly data are used for estimation. The period covered spans from 2000 to 2008 in case of Kazakhstan and Kyrgyzstan, and from 2002 to 2008 for Tajikistan.

The variables employed include consumer price indices (CPI), nominal exchange rates of national currencies to the U.S. dollar, interest rates, industrial production volume or average real wages as a proxy for consumption and the data on deposits in the second-tier banks. The data on deposits include deposits denominated in foreign and local currencies and is used as a proxy for foreign and domestic money balances respectively.

The data on interest rates include the official rates of central banks, deposit rates, lending rates, money market rates, and a Federal Funds rate of the Fed. The main sources of the data are central banks and statistical offices of the countries, and the IMF International Financial Statistics database.[18]

[17] The GMM estimates are obtained using TSP with a standard procedure that is automatically performed. The weighting matrix is first assumed to be an identity matrix to obtain initial estimates of the estimated parameters. Further, the initial values of the parameters are used to obtain an estimate of the optimal weighting matrix W_T.

[18] More detailed desciption of data can be found in Table A 1 in Appendix A.

6 Empirical Results

The estimation results for each country are reported in Tables 1. Results are reported for different interest rates. In each case, the minimal value of the objective function J_T is presented in the tables as well. This is a chi-square test statistic for the validity of the model's overidentifying restrictions.

Table 1 presents estimation results. The parameter estimates for β are below unity for each country. This implies that households in these economies value future consumption less than consumption in the present period. In Tajikistan, β is less than 0.9 for the cases when refinance and interbank rates are used in the estimation. This result might tell that the residents in these economies are very "present-oriented" and put less value on future consumption.

The values of the estimates for γ vary from 0.01 to 0.18 among countries depending on the choice of the interest rate. Thus, the share of money in providing utility is significantly lower than the share of consumption. The share of foreign money holdings in providing monetary services α is estimated between 0.46 and 0.59. This implies quite high efficiency of foreign money and therefore explains the high level of currency substitution in all three economies.

For Kazakhstan, the parameter ρ could be estimated in the restricted range of values only when the the second specification (with habit formation) of the utility function is assumed. The values lie between -0.7 and -0.87. In the cases of Kyrgyzstan and Tajikistan, ρ was estimated between -0.47 and -0.81. The elasticity of substitution between the currencies is computed as $s = \frac{1}{(1+\rho)}$ and is assumed to lie between 0 and ∞. In the present case, the estimated elasticity is between 2 and 5. These numbers imply good substitution between the domestic and foreign currencies These results show that the two currencies are good substitutes in the Central Asian states and residents can easily switch from one currency to another.

Finally, the RRA parameter σ could not be estimated precisely in most of the cases and its estimates were sometimes negative. Negative parameter of relative risk aversion implies non-convexity of preferences what poses a difficulty to interpretation of the model. Imprecise estimation in some cases helps justify that this parameter could not be estimated due to certain reasons. The issue of negative values of RRA parameters and imprecision of its estimates was studied and largely debated in the economic literature.[19] This discussion is however beyond the subject of the present study.

The J-test statistic for testing the over identifying restrictions of the model show that the

[19]Negative and sometimes statistically insignificant values of the estimated parameter of Relative Risk Aversion (RRA) and intertemporal elasticity of substitution (IES) were obtained and discussed to different extent by some authors who studied consumption behavior through estimating the Euler equations by GMM. See, for example, Hansen and Singleton (1982), Hall (1988), Mao (1990), Holman (1998) and others. In his study on this issue, Pozzi (2002) proposed an explanation for the imprecision in estimating these pramater and its estimates negative values.

data provide support for the considered model, or in other words the over identifying restrictions are valid.[20] Hence, the instruments chosen proved to be valid.

[20]Since the number of orthogonality conditions exceeds the number of parameters, the validity of overidentifying restrictions should be tested. The test suggested is a J_T test, where J_T statistics is a minimized value of the objective function times the number of observations. Under the null hypothesis the overidentifying restrictins are valid, the J_T-statistics is asymptotically distributed as χ^2 with degress of freedom equal to the number of overidntifying restrictions.

Table 1. GMM estimates

a)Kazakhstan

	Refinance rate	Treasury Bill	Deposit Rate	FFR
β	0.92***(0.00)	0.95***(0.00)	0.96***(0.00)	0.98***(0.00)
α	0.49***(0.00)	0.50***(0.00)	0.50***(0.00)	0.50***(0.00)
γ	0.10***(0.00)	0.12***(0.01)	0.10***(0.01)	0.07***(0.01)
σ	-0.12***(0.01)	-0.13***(0.01)	-0.11***(0.01)	-0.08***(0.01)
δ	0.79***(0.00)	0.78***(0.01)	0.78***(0.03)	0.78***(0.01)
ρ	-0.70***(0.06)	-0.87***(0.02)	-0.85***(0.02)	-0.87***(0.02)
$J-statistics$	8.49 [0.75]	7.28 [0.84]	7.28 [0.84]	7.85 [0.80]
$No.obs$	103	103	103	103

b)Kyrgyzstan

	Repo rate	MMR	Deposit Rate	FFR
β	0.95*** (0.00)	0.96***(0.01)	0.94***(0.00)	0.99***(0.00)
α	0.55***(0.01)	0.56***(0.01)	0.56***(0.01)	0.62***(0.03)
γ	0.05*** (0.00)	0.06***(0.00)	0.06***(0.00)	0.02***(0.00)
σ	0.02 (0.03)	0.03 (0.08)	0.005 (0.03)	-0.04 (0.01)
ρ	-0.76***(0.08)	-0.72*** (0.08)	-0.67***(0.06)	-0.31*(0.17)
$J-statistics$	5.87 [0.75]	6.60 [0.68]	6.16 [0.72]	5.91 [0.75]
$No.obs$	94	90	95	95

c)Tajikistan

	Refinance rate	Interbank Rate	Deposit Rate	FFR
β	0.89***(0.00)	0.89***(0.00)	0.92***(0.00)	0.98***(0.00)
α	0.54***(0.00)	0.53***(0.00)	0.53***(0.01)	0.47***(0.01)
γ	0.08***(0.00)	0.07***(0.00)	0.06***(0.00)	0.01***(0.00)
σ	0.05 (0.04)	0.07** (0.03)	0.01 (0.03)	-0.02 (0.00)
ρ	-0.69*** (0.01)	-0.68*** (0.02)	-0.70*** (0.01)	-0.94***(0.03)
$J-statistics$	5.63 [0.86]	5.26 [0.87]	4.97 [0.89]	5.78 [0.83]
$No.obs$	71	61	71	71

Notes: a) Standard errors are in parentheses; P-values are in brackets; b) $\beta-$discount factor, $\alpha-$ share of foreign money balances in producing money services; s=$\frac{1}{(1+\rho)}-$elasticity of currency substitution

Table 1 provides results for the utility function with habit formation for Kazakhstan, where the parameter of habit persistence appears $\delta \neq 0$. In case of Kazakhstan, this specification helped restore the meaningful values of the parameter ρ. For the other two countries, introduction of the habit persistence has not changed the magnitude of the major parameters in most of the cases. In Kazakhstan, consumption exhibits a strong persistence with the values of $\delta = 0.78$.

In the case of Kyrgyzstan, the value of the parameter α was estimated at a lower level than in the first model specification. A strong habit persistence was found in this country as well. The parameter measuring habit formation $\delta = 0.7$. The elasticity of substitution between the currencies remains high. In Tajikistan, the habit formation parameter values vary from negative to positive numbers depending on the interest rate chosen.

Empirical results in this section provide a strong support to the presence of currency substitution in the economies of Central Asia, and an important role of foreign currency as a substitute for domestic money in economic transactions.

7 Implications for Seigniorage Revenue

One of the major concerns for policy makers related to currency substitution is its effect on the seigniorage revenue of central banks. Official dollarization, or full replacement of the domestic currency by some foreign currency (for example, U.S. dollar), thus, directly affects the ability of the government to earn revenue from issuing money. Partial, or unofficial dollarization, can however affect the seigniorage revenue as well. Some authors argue that this effect can be of a large magnitude.[21] In the context of transition and developing economies, the loss of seigniorage revenue might be an important issue.[22]

In this study, the implications for seigniorage revenue are derived from analyzing a hypothetical steady state of the model. Steady states with different inflation rates (π) and dollarization (α) are compared. In the steady state, consumption and real money balances holdings

[21] Bufman and Leiderman (1993) studied currency substitution in Israel and showed that even small increases in dollarization can have significant effect on the seigniorage income of the monetary authorities. Verbetsky and Friedman (2001) examined seigniorage loss for the case of Russia

[22] Fischer (1982), for example, calculates average seigniorage rates during the 1960s and 1970s for a cross-section of countries and finds that seigniorage accounts for more than 10% of total government revenue in many less developed countries, especially those with high inflation rates. Click (1998) reports average seigniorage as a share of government spending for a set of 90 countries. He finds that the seigniorage revenue share ranges from 5% in Honduras to 62% in Argentina. Lange and Sauer (2005) calculated the seigniorage for the period from 1995 till 2000 for 15 Latin American countries, and found out that seigniorage accounts for almost 12 % of government revenue in these economies even though inflation rates have been reduced in 1990s.

grow at some constant rate $\phi > 0$. The population grows at the rate $n = 0$. The real return on the market portfolio, R, is invariant with respect to both time and inflation rate. Under this conditions, the steady state demand for domestic real money balances can be derived using the optimality conditions from the equations 8 to 10. First, the expression for the ratio between foreign and domestic real money balances in terms of model parameters, inflation and dollarization can be computed following the expression:

$$h = \left(\frac{(1-\alpha)}{\alpha} \frac{1 - \beta \frac{(1+\epsilon)(1+\phi)^{-\sigma}}{(1+\pi)}}{1 - \beta \frac{(1+\phi)^{-\sigma}}{(1+\pi)}} \right)^{-\frac{1}{1+\rho}} \tag{18}$$

Further, the demand for domestic money balances in terms of model parameters is derived as follows:

$$m = \frac{\gamma}{1-\gamma} \frac{R_b c}{(R_b - R_m) + (R_b - R_{mf}) \left(\frac{\alpha}{1-\alpha} \frac{R_b - R_m}{R_b - R_{mf}} \right)^{1/(1+\rho)}}, \tag{19}$$

where the notations from Verbetsky and Friedman (2001) are used for simplification: $R_b = (1+R)/(1+\pi)$, $1+R = (1+\pi)(1+\mu)^{\sigma}/\beta$, $R_m = 1/(1+\pi)$ and $R_{mf} = (1+\epsilon)/(1+\pi)$.

In the case with habit formation in consumption there is a slight difference in the money demand equation:

$$m = \frac{\gamma}{1-\gamma} \frac{(1+\phi-\delta) R_b c}{(R_b - R_m) + (R_b - R_{mf}) \left(\frac{\alpha}{1-\alpha} \frac{R_b - R_m}{R_b - R_{mf}} \right)^{1/(1+\rho)}}, \tag{20}$$

where δ is a parameter of habit persistence.[23]

The money growth rule is assumed as follows:

$$M_t = (1+\mu) M_{t-1}, \tag{21}$$

where μ is a growth rate of the domestic money supply.

For simplicity, the government budget constrain is assumed to be:

$$M_t = M_{t-1} - T_t, \tag{22}$$

The fiscal policy assumed implies that the government rebates seigniorage revenues to the public through lump-sum transfers T_t.

[23]The results of the simulated seigniorage-to-GDP ratio for the case of habit formation are presented in the Appendix C.

To compute the seigniorage, different approaches can be found in literature. Here the monetary concept of seigniorage computation is used due to the fact that dollarization affect to an important extent the ability of the central bank to receive revenue from increasing the money supply. Furthermore, this approach is suitable for calculating seigniorage revenue in the framework of the present model setup and is simple in computation.[24]

The monetary concept determines seigniorage as follows:

$$\frac{S_t}{Y_t} = \frac{M_t - M_{t-1}}{M_t} \frac{M_t}{P_t Y_t}, \tag{23}$$

where M_t is a monetary base, S_t is a seigniorage revenue and Y_t is GDP. Therefore, the seigniorage ratio to GDP is:

$$\frac{S_t}{Y_t} = \mu \frac{M_t}{P_t Y_t},$$

where μ is a growth rate of money supply and

$$\frac{M_t}{P_t Y_t} = \frac{M_t / p_t N_t}{Y_t / N_t} = \frac{m}{y},$$

where m is the steady state per capita real money balances and y is the per capita GDP. The seigniorage revenue to GDP ratio can be computed as follows:

$$\frac{S}{Y} = \mu \frac{c}{y} \frac{m}{c}. \tag{24}$$

For the calculation of the seigniorage loss the values of the parameters are chosen from the estimation results in the previous section. The following values are assumed: $\gamma = 0.07$ and

[24]Though monetary definition of seigniorage is the most widespread concept of seigniorage, other definitions can be found in recent literauture. Fiscal seigniorage refers to the yield on the counterparts of the monetary base after deduction of costs. Lange and Sauer (2005) distinguish an opportunity cost seigniorage that can be computed as follows:

$S = i\frac{M}{P}$,

where i is a market interest rate, M is a monetary base and P is a price level.

Under rational inflation expectations, the Fischer equation implies the opportunity seigniorage can be calculated as follows:

$S = (\pi + r)\frac{M}{P}$,

where π is inflation rate, and r is a real rate of interest. This definition of seigniorage can be related to the monetary seigniorage:

$S = \frac{dM}{P} = \frac{dM}{M}\frac{M}{P} = \mu\frac{M}{P}$,

where μ is the growth rate of base money. Assuming that velocity and the money multiplier are constant, the quantity theory of money implies that money growth equals the sum of the inflation rate (π) and the real economic growth rate (g):

$S = (\pi + g)\frac{M}{P}$.

Hochreiter and Rovelli (2002) add to these two concepts a concept of inflation tax seigniorage:

$S = \pi\frac{M}{P}$.

$\beta = 0.98$.The parameter α will be given values from 0.4 to 0.7, and ρ is assumed to be -0.7. The ratio of consumption over income is assumed to be 0.8. This an average ratio from the annual data on GDP and consumption during the period covered in the empirical investigation. The RRA parameter σ is assumed to be 0, since it was not estimated precisely and its estimated value was negative in some cases.[25] In the steady state, the growth rate of money μ is equal to the steady state inflation rate π.The underlying assumption of the Purchasing Power Parity (PPP) is used to consider two scenarios of the domestic currency depreciation. In the first scenario, I assume that the foreign inflation rate $\pi^* = 0$ while domestic inflation rate changes from 0.2 to 50 percent. In this scenario, the depreciation rate, ϵ_t is moving together with the domestic inflation rate and $\epsilon = \pi$. In the second scenario, foreign inflation rate is constant but equals 5 percent. This scenario implies that the domestic currency depreciates at a slower rate than the domestic inflation rate.

Table 2 presents the results of the seigniorage revenue simulation. The simulated values are presented as the ratio to GDP in percent. This ratio was calculated for different values of the domestic inflation rate π and different values of the share of foreign money balances α.

The results in the table 2 (a) show that the ratio of seigniorage to GDP increases with the rate of inflation, but only till certain level of inflation rate. The seigniorage revenue reaches its peak when the inflation rate is 2 percent in the case when dollarization level $\alpha = 0.4$. After that it gradually decreases. This result is similar to the results obtained by Verbetsky and Friedman (2001) who found that the government achieves the highest seigniorage revenue at the inflation rate of 1-3 percent depending on the level of dollarization. More important is the relation between dollarization and seigniorage revenue. The results show that the latter is a decreasing function of dollarization. The higher α is, the lower is the ratio of seigniorage revenue to GDP.

In scenario 2, if dollarization level is 0.4, the seigniorage revenue increases till inflation rate reaches 5 percent. In this scenario, the ratio of government revenue from seigniorage to GDP is higher than in the first scenario for each level of dollarization and each inflation rate. The agents prefer holding more domestic money when there is inflation abroad. Moreover, they hold more domestic currency when domestic inflation rate is lower than the foreign inflation rate. From equation 18, it can be seen that if consumption is constant, the demand for domestic money balances will be higher when there is inflation in the foreign country. The results in the second scenario support the previous finding that seigniorage revenue is a decreasing function of the level of dollarization. In this scenario, however, the seigniorage to GDP ratio is less sensitive to the increases in dollarization.

[25] To check whether assumption of $\sigma = 0$ is robust, the parameter was set to zero in the estimation. This did not distort the results for the estimated values of other parameters.

Table 2. Simulated Seigniorage (SE)/GDP ratios (%)

a) Scenario 1: $\epsilon = \pi(\pi^* = 0\%)$

$\pi, \%$	α			
	0.4	0.5	0.6	0.7
0.2	0.48	0.28	0.11	0.03
0.5	0.98	0.53	0.19	0.05
1.0	1.42	0.67	0.22	0.05
2.0	1.58	0.61	0.18	0.04
3.0	1.41	0.48	0.14	0.03
4.0	1.19	0.38	0.10	0.02
5.0	0.98	0.30	0.08	0.02
6.0	0.82	0.24	0.06	0.014
8.0	0.59	0.16	0.04	0.010
10	0.44	0.12	0.03	0.007
20	0.16	0.04	0.01	0.003
30	0.09	0.02	0.006	0.001
50	0.05	0.01	0.003	0.0008

b) $Scenario2 : \pi^* = 5\%$

$\pi, \%$	α			
	0.4	0.5	0.6	0.7
0.2	0.62	0.59	0.49	0.28
0.5	1.36	1.27	1.01	0.52
1.0	2.25	2.03	1.48	0.66
2.0	3.30	2.75	1.67	0.60
3.0	3.83	2.91	1.51	0.48
4.0	4.07	2.81	1.28	0.37
5.0	4.15	2.61	1.07	0.29
6.0	4.11	3.37	0.90	0.24
8.0	3.86	1.91	0.65	0.16
10	3.51	1.53	0.48	0.12
20	2.03	0.65	0.18	0.04
30	1.31	0.38	0.10	0.02
50	0.76	0.21	0.06	0.01

Note: $\beta = 0.98, \gamma = 0.08, \rho = -0.7, \sigma = 0, c/y = 0.8$

Introduction of a habit formation in the consumption changes the numerical results of the seigniorage computation, since the demand for real domestic money balances is represented by equation 21. If the estimated value of δ is positive and $\phi > 0$ but $\phi < \delta$, then in the habit formation economy the seigniorage to GDP ratio will be lower for every level of dollarization and each inflation rate than in the economy with no habit formation. The results of the simulated ratio of seigniorage revenue to GDP for the utility function with habit formation are presented in the Appendix C.

The findings in this section provide a support to the hypothesis about the decreasing seigniorage revenue due to increasing dollarization.

For further analysis, actual seigniorage to GDP ratios were calculated using the data from the central banks of the countries examined in the study. The actual seigniorage-to-GDP

ratio was calculated using the data on the monetary base following the monetary seigniorage concept. Results are presented in Table 3. Both simulated and actual ratio of seigniorage to GDP decrease when dollarization level α increases. There is however no significant variation in the actual annual seigniorage revenue over time.

Table 3. Actual and simulated seigniorage (SE)/GDP ratios (in %)

a)Kazakhstan

Period	Inflation rate (in%)	Dollarization level, α	Simulated SE/GDP ratio	Actual SE/GDP ratio
2000	13	0.51	0.07	0.05
2001	8	0.64	0.02	0.05
2002	6	0.60	0.06	0.05
2003	6	0.47	0.35	0.06
2004	7	0.43	0.48	0.08
2005	8	0.42	0.46	0.06
2006	9	0.35	0.94	0.096
2007	11	0.32	1.07	0.07

b)Kyrgyzstan

Period	Inflation rate (in%)	Dollarization level, α	Simulated SE/GDP ratio	Actual SE/GDP ratio
2000	19	0.58	0.02	0.014
2001	7	0.59	0.06	0.005
2002	2	0.62	0.14	0.002
2003	3	0.64	0.08	0.003
2004	4	0.70	0.02	0.005
2005	4	0.73	0.01	0.005
2006	6	0.66	0.03	0.009
2007	10	0.52	0.09	0.0016

c)Tajikistan

Period	Inflation rate (in%)	Dollarization level, α	Simulated SE/GDP ratio	Actual SE/GDP ratio
2002	12.3	0.49	0.10	0.01
2003	16.3	0.49	0.07	0.01
2004	7.1	0.60	0.05	0.003
2005	7.1	0.56	0.09	0.003
2006	10	0.70	0.007	0.004
2007	13.1	0.75	0.002	0.015

This implies that actual seigniorage revenues were quite stable over the period considered. Time aggregation in calculating the seigniorage revenue might generate more variability in the seigniorage revenues of the local governments. Nevertheless, the results of the present section support the negative relationship between the revenue that central banks derive from money issuance and the amount of foreign money holdings by the residents. A simple correlation analysis shows that the correlation between dollarization level α and simulated and actual seigniorage to GDP ratios is around -0.82 and -0.71 respectively.

8 Economic Welfare and Dollarization

Through affecting seigniorage revenues of the government and thus the amount of the lump-sum transfers to the public, currency substitution affects the welfare of households. It is important to note that dollarization itself arises due to several factors that affect economic welfare, i.e. high rates of inflation, rapid depreciation of domestic money, etc. These factors stimulate dollarization because economic agents aim to hedge the value of their financial assets and money holdings by switching to foreign currency. Holding foreign money, thus, becomes a way for households to preserve their wealth.

In this section, potential implications of dollarization and currency substitution for welfare are discussed. These implications involve different channels through which foreign balances holding by households can affect their welfare. This analysis, though cumbersome, give some important insights on the economic role of dollarization transition economies.

The baseline assumption is that the welfare of a household changes if dollarization α increases, i.e. $\alpha_0 < \alpha_1$ and $u(\alpha_0) > u(\alpha_1)$. To calculate the welfare costs of dollarization in a steady state with a given rate of inflation, one needs to compute the percentage decrease in consumption per capita that would generate the same welfare change as that from moving from original level of dollarization α_0 to a higher level of dollarization α_1. Or it is necessary to find such Δc that would return the household to the original level of utility: $u(c, \alpha_0) = u(c+\Delta c, \alpha_1)$. For this purpose, the utility function in equation 7 is rewritten in the following way:

$$u(c_t, x_t) = \frac{\left(c_t^{1-\gamma} m^{\gamma} \left(1 - \alpha + \alpha h^{-\rho}\right)^{-\frac{\gamma}{\rho}}\right)^{1-\sigma}}{1-\sigma} - 1, \tag{25}$$

where $h = \frac{m^*}{m}$. Plugging in the expression for h from equation 17, and equating utilities for different levels of dollarization through including consumption compensation, the following equality is obtained:

$$c^{(1-\gamma)} m_1^{\gamma} \left(1 - \alpha_1 + \alpha_1 \left(\frac{1-\alpha_1}{\alpha_1} \left(\frac{1 - \beta \frac{(1+\epsilon)(1+\phi)^{-\sigma}}{(1+\pi)}}{1 - \beta \frac{(1+\phi)^{-\sigma}}{(1+\pi)}}\right)^{\frac{\rho}{1+\rho}}\right)\right)^{-\frac{\gamma}{\rho}} - 1 =$$

$$= (c + \Delta c)^{(1-\gamma)} m_2^{\gamma} \left(1 - \alpha_2 + \alpha_2 \left(\frac{1-\alpha_2}{\alpha_2} \left(\frac{1 - \beta \frac{(1+\epsilon)(1+\phi)^{-\sigma}}{(1+\pi)}}{1 - \beta \frac{(1+\phi)^{-\sigma}}{(1+\pi)}}\right)^{\frac{\rho}{1+\rho}}\right)\right)^{-\frac{\gamma}{\rho}} - 1, \Leftrightarrow$$

$$\Leftrightarrow \quad c\left(\frac{m_1}{c}\right)^{\gamma}\left(1-\alpha_1+\alpha_1\left(\frac{1-\alpha_1}{\alpha_1}\left(\frac{1-\beta\frac{(1+\epsilon)(1+\phi)^{-\sigma}}{(1+\pi)}}{1-\beta\frac{(1+\phi)^{-\sigma}}{(1+\pi)}}\right)^{\frac{\rho}{1+\rho}}\right)\right)^{-\frac{\gamma}{\rho}} = \tag{26}$$

$$= \quad (c+\Delta c)\left(\frac{m_2}{c+\Delta c}\right)^{\gamma}\left(1-\alpha_2+\alpha_2\left(\frac{1-\alpha_2}{\alpha_2}\left(\frac{1-\beta\frac{(1+\epsilon)(1+\phi)^{-\sigma}}{(1+\pi)}}{1-\beta\frac{(1+\phi)^{-\sigma}}{(1+\pi)}}\right)^{\frac{\rho}{1+\rho}}\right)\right)^{-\frac{\gamma}{\rho}}$$

Defining the expression in the parentheses as $f(\alpha)$, a simpler representation of the previous equality is as follows:

$$c\left(\frac{m_1}{c}\right)^{\gamma} f(\alpha_1) = (c+\Delta c)\left(\frac{m_2}{c+\Delta c}\right)^{\gamma} f(\alpha_2), \Longleftrightarrow \tag{27}$$

$$\Longleftrightarrow \left(\frac{c+\Delta c}{c}\right) = \frac{\left(\frac{m_1}{c}\right)^{\gamma} f(\alpha_1)}{\left(\frac{m_2}{c+\Delta c}\right)^{\gamma} f(\alpha_2)}, \Longleftrightarrow$$

$$\Longleftrightarrow \frac{\Delta c}{c} = \frac{\left(\frac{m_1}{c}\right)^{\gamma} f(\alpha_1)}{\left(\frac{m_2}{c+\Delta c}\right)^{\gamma} f(\alpha_2)} - 1$$

As a ratio of GDP per capita, the consumption compensation is:

$$\frac{\Delta c}{y} = \frac{c}{y}\left[\frac{\left(\frac{m_1}{c}\right)^{\gamma} f(\alpha_1)}{\left(\frac{m_2}{c+\Delta c}\right)^{\gamma} f(\alpha_2)} - 1\right]. \tag{28}$$

To compute consumption compensation, the money demand expression from equation 18 is plugged into equation 26. Derived consumption compensation in equation 27 consists of two parts: a decrease in the lump-sum transfer from the government due the loss of the seigniorage revenue and the direct changes in households utility due to holding foreign money.

Using the same parameter values as in the calculation of seigniorage loss in the previous section, the consumption compensation is calculated using equation 27. The welfare loss is computed for a change in dollarization α from 0.5 to 0.6 for different rates of inflation. Two scenarios from the previous section are analyzed. Table 4 presents the results of the simulated changes in welfare represented as percentage in GDP. Negative values of the consumption compensation imply welfare gains, while positive values on the contrary imply welfare loss.

Table 4. Consumption compensation for increasing dollarization

$\pi, \%$	**ΔC/GDP, %**	
	Scenario 1: $\epsilon = \pi$	*Scenario 2*: $\pi^* = 5\%$
0.2	-0.56	1.56
0.5	-0.77	1.42
1	-1.01	1.17
2	-1.28	0.68
3	-1.42	0.24
4	-1.49	-0.11
5	-1.53	-0.40
6	-1.56	-0.62
8	-1.59	-0.93
10	-1.61	-1.12
20	-1.639	-1.47
30	-1.644	-1.56
50	-1.647	-1.61

Notes: α changes from 0.5 to 0.6, $\beta = 0.98, \rho = -0.7, \gamma = 0.08, c/y = 0.8$

The results in Table 4 show that dollarization in fact brings gain in welfare that can be as large as 1.65 percent of GDP if domestic inflation rate reaches 50 percent. The welfare gain is an increasing function of inflation. This finding can be explained by the fact that an increase in foreign money holdings hedges households from incurring loss due to depreciating domestic money. The higher the inflation rate, the higher is the gain from an increase in foreign currency holdings. This also implies that the loss in seigniorage revenue due to increasing dollarization is exceeded by the gains from holding foreign currency. In the second scenario, holding foreign money brings welfare loss if domestic inflation is lower than inflation in the foreign economy. In this scenario, holding dollars is not optimal as domestic currency is more powerful when foreign inflation exceeds inflation at home. Thus, the welfare loss will occur due to uncertainty about the foreign inflation rate and thus the exchange rate between local and foreign currencies. The seigniorage loss is greater than the gain in consumption by households due to switching to foreign currency. Hence, dollarization in the inflationary environment with depreciating local currency vis-a-vis foreign currency becomes welfare generating. Currency substitution thus is a transitory phenomenon that might result in negative as well as positive changes in welfare. The welfare cost thus depends on the ability of resident households to diversify their money holdings in a way to avoid a risk of sudden depreciation of either currency.

9 Conclusion

In the present study currency substitution in the transition countries of Central Asia was examined. The findings of this investigation show that foreign and domestic currencies are good substitutes in all three economies - Kazakhstan, the Kyrgyz Republic and Tajikistan. The elasticity of substitution between the two currencies is more than unity in all the cases. The share of the foreign currency in providing money services exceeds 0.5 for all three economies. Currency substitution and dollarization turned to be of significant magnitude and importance in these transition countries. A study was conducted using a simple dynamic model of money-in-utility function with two currencies, where holding money balances denominated in different currencies serves as a hedge against domestic instability and inflation. The steady state implications for seigniorage revenues of the government and households welfare were analyzed. Seigniorage revenue was found to be a decreasing function of dollarization. An increase in dollarization index from 0.4 to 0.5, will decrease seigniorage revenue to GDP ratio by almost half. Seigniorage revenues will however depend on the inflation rate abroad. The higher the inflation rate abroad, the higher is the seigniorage ratio in a domestic economy due to increasing local demand for domestic real money balances. Increasing dollarization will still result in loss of seigniorage revenue for each dollarization level and inflation rate.

The welfare analysis comprises the loss of seigniorage and a change in welfare due to switching to a foreign currency. The findings of the welfare analysis are sensitive to the scenario of the domestic currency depreciation. If foreign inflation is zero, then switching to holding dollars is a welfare generating decision. Though the government loses its revenues from money issuance, the overall effect of currency substitution can be positive. In the second scenario, where foreign inflation rate was fixed at 5 percent, holding dollars would decrease households' wealth if inflation in home country is lower than inflation abroad. The residents choose holding foreign currency which is in fact has less purchasing power and depreciates at higher rate than domestic currency. Once domestic inflation rate outpaces foreign inflation, switching to dollars starts bringing gains in welfare. Dollarization thus affects households wealth from two sides: decreasing lump-sum transfers from the government and hedging motives against domestic inflation. It is important as well to consider inflation in a foreign economy to properly analyze welfare implications of currency substitution and dollarization.

Currency substitution and dollarization thus constitute transitory phenomena that do not necessarily bring welfare loss. Governments willing to dedollarize local economies should be concerned with stability of local currencies rather than restricting directly foreign money holdings.

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Appendix A Data Description

Table A 1. Data Sources

Series	Time span	Source
a) Kazakhstan		
Consumer Price Index	2000:1 - 2008:12	IMF
Deposits denominated in domestic and foreign currency (in mln tenge)	2000:1 - 2008:12	NBK
Industrial Production (in mln. tenge)	2000:1 - 2008:12	Statistical Agency of Kazakhstan
Refinancing Rate of the National Bank (in percent)	2000:1 - 2008:12	IMF
Treasury bill rate (in percent)	2000:1 - 2008:12	IMF
Average deposit rate (in percent)	2000:1 - 2008:12	NBK
Nominal exchange rate (tenge to US dollar) (in tenge)	2000:1 - 2008:12	IMF
b) Kyrgyzstan		
Consumer Price Index	2000:1 - 2008:3	IMF
Deposits denominated in domestic and foreign currency (in mln som)	2000:1 - 2008:3	NBKR
Industrial Production (in mln. som)	2000:1 - 2008:3	Statistical Agency of Kyrgyzstan
Rate on repo operations of the NBKR	2000:1 - 2008:3	NBKR
Money market rate	2000:1 - 2008:3	IMF
Deposit rate	2000:1 - 2008:3	IMF
Nominal exchange rate (tenge to US dollar) (in som)	2000:1 - 2008:3	IMF
c) Tajikistan		
Consumer Price Index	2002:1 – 2008:2	IMF
Deposits denominated in domestic and foreign currency (in mln somoni)	2002:1 – 2008:2	NBT
Industrial Production (in mln. somoni)	2002:1 – 2008:2	NBT
Wages (in somoni)	2002:1 – 2008:2	NBT
Official Rate of the NBT (in percent)	2002:1 – 2008:2	NBT
Interbank Rate (in percent)	2002:1 – 2007:3	NBT
Deposit Rate (in percent)	2002:1 – 2008:2	IMF
Nominal exchange rate (tenge to US dollar) (in tenge)	2002:1 – 2008:2	IMF

Notes: NBK -National Bank of Kazakhstan, NBKR - National Bank of the Kyrgyz Republic, NBT - National Bank of Tajikistan

Appendix B. Inflation and Dollarization

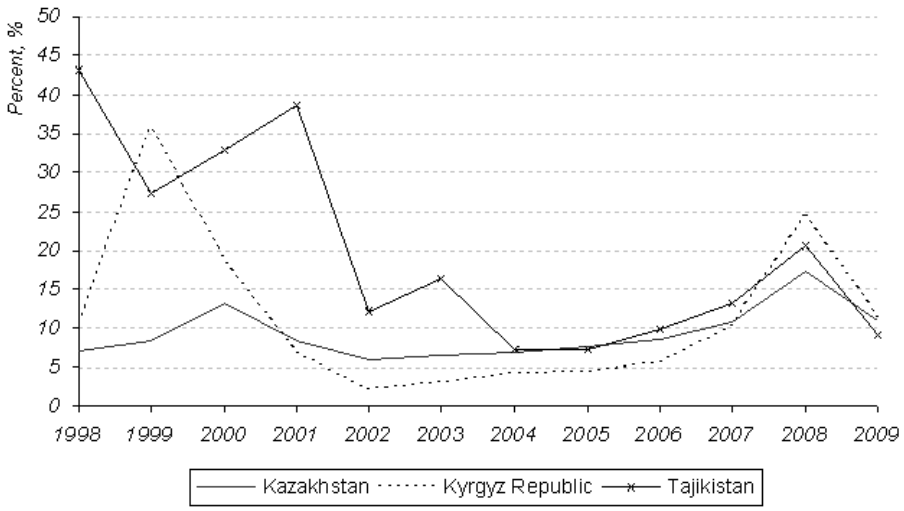
Table B 1. Capital Inflows in Central Asia

	2000	2001	2002	2003	2004	2005	2006	2007	2008 estim.
Remittances* (mln. USD)									
Kazakhstan	122	171	205	147	166	178	187	223	250
Kyrgyzstan	9	11	37	78	189	322	481	715	715
Tajikistan	...	...	79	146	252	467	1019	1691	1750
FDI (mln. USD)**									
Kazakhstan	1278	2861	2164	2213	5436	2123	6630	6900	10732
Kyrgyzstan	-7	-1	5	46	132	43	182	208	265
Tajikistan	24	10	36	32	272	55	66	160	190

Source: * World Bank Migration and Remittances Factbook, 2008

** EBRD Transition Report, 2008

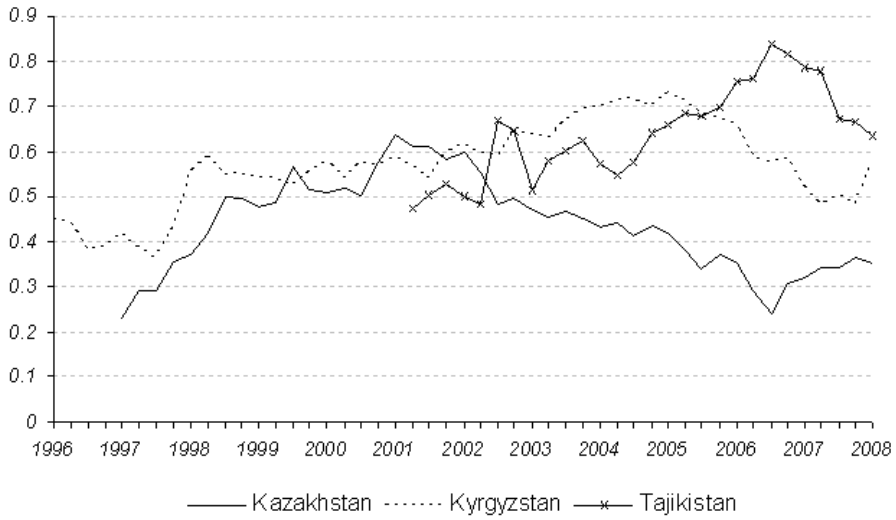
Figure B 1. Inflation in Central Asia



Note: Figures for 2009 are estimates

Source: EBRD Transition Report, 2008

Figure B 2. Dollarization in Central Asia



Note: Dollarization Index is computed as a ratio of foreign currency denominated deposits to total deposits

Appendix C. Habit Formation in Consumption

Derived estimation equation for the case with habit formation are as follows:

$$d_{1,t+1} = \begin{array}{c} \beta \left\{ C_t^{\sigma(\gamma-1)-\gamma} \left(\frac{C_{t+1}-\delta}{C_t-\delta}\right)^{\sigma(\gamma-1)-\gamma} M_{t+1}^{\gamma(1-\sigma)} \right. \\ \left. \left(\frac{1-\alpha+\alpha H_{t+1}^{-\rho}}{1-\alpha+\alpha H_t^{-\rho}}\right)^{\frac{\gamma}{\rho}(\sigma-1)} \left(\frac{1+r_t}{1+\pi_{t+1}} + \delta\right) \right\} - \end{array} \tag{eq. B1}$$

$$-\delta\beta^2 \left\{ C_t^{\sigma(\gamma-1)-\gamma} C_{t+1}^{\sigma(\gamma-1)-\gamma} \left(\frac{C_{t+2}-\delta}{C_t-\delta}\right)^{\sigma(\gamma-1)-\gamma} M_{t+1}^{\gamma(1-\sigma)} \right\} \times$$

$$\times \left\{ M_{t+2}^{\gamma(1-\sigma)} \left(\frac{1-\alpha+\alpha H_{t+2}^{-\rho}}{1-\alpha+\alpha H_t^{-\rho}}\right)^{\frac{\gamma}{\rho}(\sigma-1)} \left(\frac{1+r_t}{1+\pi_{t+1}}\right) \right\} - 1,$$

where $C_t = \frac{c_t}{c_{t-1}}, M_t = \frac{m_t}{m_{t-1}}, H_t = \frac{m_t^*}{m_t}$.

$$d_{2,t+1} = \left(\frac{\frac{\gamma}{1-\gamma}(1-\alpha)\frac{c_{t-1}}{m_t}(C_t-\delta)}{(1-\alpha+\alpha H_t^{-\rho})} \right) + \tag{eq. B2}$$

$$+\beta \left\{ C_t^{\sigma(\gamma-1)-\gamma} \left(\frac{C_{t+1}-\delta}{C_t-\delta}\right)^{\sigma(\gamma-1)-\gamma} M_{t+1}^{\gamma(1-\sigma)} \left(\frac{1-\alpha+\alpha H_{t+1}^{-\rho}}{1-\alpha+\alpha H_t^{-\rho}}\right)^{\frac{\gamma}{\rho}(\sigma-1)} \times \right.$$

$$\times \left(1 - \delta\beta C_{t+1}^{\sigma(\gamma-1)-\gamma} \left(\frac{C_{t+2}-\delta}{C_{t+1}-\delta}\right)^{\sigma(\gamma-1)-\gamma} M_{t+2}^{\gamma(1-\sigma)} \left(\frac{1-\alpha+\alpha H_{t+2}^{-\rho}}{1-\alpha+\alpha H_{t+1}^{-\rho}}\right)^{\frac{\gamma}{\rho}(\sigma-1)} \right) \frac{1}{1+\pi_{t+1}} -$$

$$\left. - \left(1 - \delta\beta C_t^{\sigma(\gamma-1)-\gamma} \left(\frac{C_{t+1}-\delta}{C_t-\delta}\right)^{\sigma(\gamma-1)-\gamma} M_{t+1}^{\gamma(1-\sigma)} \left(\frac{1-\alpha+\alpha H_{t+1}^{-\rho}}{1-\alpha+\alpha H_t^{-\rho}}\right)^{\frac{\gamma}{\rho}(\sigma-1)} \right) \right\},$$

$$d_{3,t+1} = (1-\alpha)H_t^{1+\rho} - \alpha - \tag{eq. B3}$$

$$-\beta \left\{ C_t^{\sigma(\gamma-1)-\gamma} \left(\frac{C_{t+1}-\delta}{C_t-\delta}\right)^{\sigma(\gamma-1)-\gamma} M_{t+1}^{\gamma(1-\sigma)} \left(\frac{1-\alpha+\alpha H_{t+1}^{-\rho}}{1-\alpha+\alpha H_t^{-\rho}}\right)^{\frac{\gamma}{\rho}(\sigma-1)} \times \right.$$

$$\times \left(1 - \delta\beta C_{t+1}^{\sigma(\gamma-1)-\gamma} \left(\frac{C_{t+2}-\delta}{C_{t+1}-\delta}\right)^{\sigma(\gamma-1)-\gamma} M_{t+2}^{\gamma(1-\sigma)} \left(\frac{1-\alpha+\alpha H_{t+2}^{-\rho}}{1-\alpha+\alpha H_{t+1}^{-\rho}}\right)^{\frac{\gamma}{\rho}(\sigma-1)} \right) \frac{1}{1+\pi_{t+1}} \times$$

$$\times \left(1 - \delta\beta C_t^{\sigma(\gamma-1)-\gamma} \left(\frac{C_{t+1}-\delta}{C_t-\delta}\right)^{\sigma(\gamma-1)-\gamma} M_{t+1}^{\gamma(1-\sigma)} \left(\frac{1-\alpha+\alpha H_{t+1}^{-\rho}}{1-\alpha+\alpha H_t^{-\rho}}\right)^{\frac{\gamma}{\rho}(\sigma-1)} \right) \times$$

$$\left. \times \left((1-\alpha)H_t^{1+\rho}(1+\epsilon_{t+1}) - \alpha \right) \right\}.$$

Table C 1. Simulated Seigniorage/GDP ratios (%)

a) Scenario 1: $\epsilon = \pi(\pi^* = 0\%)$

$\pi, \%$	α		
	0.4	0.5	0.6
0.2	0.14	0.08	0.03
0.5	0.29	0.16	0.06
1.0	0.43	0.20	0.07
2.0	0.47	0.18	0.05
3.0	0.42	0.14	0.04
4.0	0.36	0.11	0.03
5.0	0.30	0.09	0.02
6.0	0.25	0.07	0.019
8.0	0.18	0.05	0.012
10	0.13	0.04	0.009
20	0.05	0.01	0.003
30	0.03	0.007	0.002
50	0.01	0.004	0.001

b) Scenario 2: $\pi^* = 5\%$

$\pi, \%$	α		
	0.4	0.5	0.6
0.2	0.19	0.18	0.15
0.5	0.41	0.38	0.30
1.0	0.68	0.61	0.44
2.0	0.99	0.83	0.50
3.0	1.15	0.87	0.45
4.0	1.22	0.84	0.39
5.0	1.24	0.78	0.32
6.0	1.23	0.71	0.27
8.0	1.16	0.57	0.19
10	1.05	0.46	0.15
20	0.61	0.20	0.05
30	0.39	0.12	0.03
50	0.23	0.06	0.02