

The Hysteresis of Dollar Asset Substitution in Ukraine after the
Introduction of the Cash Euro

by

Dmytro Yablonovskyy

A thesis submitted in partial fulfillment of
the requirements for the degree of

Master of Arts in Economics

National University of “Kyiv-Mohyla Academy”
Economics Education and Research Consortium
Master’s Program in Economics

2003

Approved by _____
Ms.Svitlana Budagovska (Head of the State Examination Committee)

Program Authorized
to Offer Degree _____ Master’s Program in Economics, NaUKMA

Date _____

National University of “Kyiv-Mohyla Academy”

Abstract

The Hysteresis of Dollar Asset Substitution in Ukraine after the Introduction
of the Cash Euro

by Dmytro Yablonovskyy

Head of the State Examination Committee: Ms.Svitlana Budagovska,
Economist, World Bank of Ukraine

This paper explores the possibilities of hysteresis of dollar asset substitution in the Ukrainian money market after introduction of cash euro. The euro may be considered as an alternative asset substitute; however, it is hard to predict if it supersedes the dollar entirely, partially or not at all, implying dollar hysteresis. The paper uses an experimental approach to test the presence of such hysteresis. The experimental approach is used because macro data panels are still too short for econometric analysis on the one hand and are unreliable on the other. Among the advantages of an experimental approach is the possibility of observing separately the asset substitution qualities of the dollar, whereas in real economy it also partially fulfills functions of unit of account and medium of exchange. Experimental evidence rejects the hypothesis of the presence of hysteresis of the dollar as an asset when alternative is introduced.

TABLE OF CONTENTS

List of figures	ii
List of tables	iii
Acknowledgments.....	iv
Abbreviations.....	v
Glossary.....	vi
Chapter 1.....	1
Introduction	1
Chapter 2.....	3
Literature review.....	3
Perspectives of euroization	6
Monetary theory in the laboratory	8
Chapter 3.....	11
Theoretical model	11
Money	11
Households	12
Savings.....	15
Periodization and incentives' structure	16
Market	19
Introducing euro to the market.....	20
Chapter 4.....	24
Experimental Evidence.....	24
Preliminary experiments	24
Setup of the final experiment.....	25
Results of the experiment.....	26
Chapter 5.....	32
Conclusions.....	32
Bibliography	35
Appendices	38
Appendix 1	38
Appendix 2.....	39
Appendix 3.....	42
Appendix 4.....	45
Appendix 5.....	46
Appendix 6.....	47
Appendix 8.....	49
Appendix 9.....	50

LIST OF FIGURES

<i>Number</i>	<i>Page</i>
Figure 3-1 Main parameters of foreign currency F market.....	27
Figure 3-2 Main parameters of foreign currency D market.....	28
Figure 3-3. The Shares of investment in currency D out of total investment in foreign currency in periods five through eight.....	29

LIST OF TABLES

<i>Number</i>	<i>Page</i>
Table 3-1. Periodization of the experiment.....	17
Table A1. The shares of volumes of exchanged currency F out of total endowment of currency in the economy.....	45
Table A2. The shares of volumes of exchanged currency D out of total endowment of currency in the economy.....	45
Table A3. The ratio of average exchange rates of currency F to currency D.....	46
Table A4. The shares of investment across currencies and subjects (periods 5-8)	47
Table A5. Descriptive statistics for exchange rates of currency F.....	48
Table A6. Descriptive statistics for exchange rates of currency D.....	48
Table A7. Hypothesis test: exchange rate of currency F equal to 10.....	49
Table A8. Hypothesis test: exchange rate of currency D equal to 10	49
Table A9. Aggregate balances of domestic currency not invested in foreign currency in periods when income was received.....	50

ACKNOWLEDGMENTS

The author wishes to acknowledge the supervisor professor Jonathan Willner for patience, support and useful comments, also research workshop conductors: instructor Mylovanov, professor Bowe, professor Coupe for being scrupulous in commenting on the drafts and providing good pieces of advice, pr. Gardner for help with literature search and valuable comments on presentation.

I would like to thank my classmates for volunteer participation in the preliminary experiments and professor Krasnikova for the help in organization of the final experiment.

All the errors remain author's responsibility.

ABBREVIATIONS

AS	Asset Substitution
bn	Billion
CB	Central Bank
CS	Currency Substitution
EMU	European Monetary Union
FSU	Former Soviet Union
mln	Million
NBU	National Bank of Ukraine

GLOSSARY

Asset Substitution. The use by residents of foreign currency as a store of value, without the use of it as a medium of exchange in domestic transactions .

Currency Substitution. The use by residents of foreign currency as a medium of exchange in domestic transactions.

Dollarization. The holding by residents of foreign currency and foreign currency-denominated deposits at domestic banks. As in the theoretical model and experiments I want to differentiate between dollarization and euroization the dollarization is defined for the holdings of cash dollars and dollar deposits at domestic banks. The usage in the latter context is accompanied by the special comments.

Euroization. The holding by residents of cash euros and euros deposits at domestic banks.

Ratchet Behavior. Unrestricted movements of the indicators upward with restricted movements downward.

Hysteresis. Ratchet behavior of the agents, who did not reduce dollar holdings after introduction of cash euro.¹

¹ Previous research tested the hysteresis against inflation stabilization policies. I observe introduction of the cash euro in January 2002 as a new kind of an exogenous shock challenging dollar's role of an asset substitute. Note that ratchet behavior and hysteresis are synonyms in the context of my work.

Chapter 1

INTRODUCTION

January 1, 2002 can be considered the official birthday of a new currency euro that may become a competitor for the current leading international currency – the US dollar. From this day the euro substituted completely for all the official currencies of the countries, which were members of the European Monetary Union.

Introduction of the euro will have a direct impact on the EMU states. It will influence the money markets of other European countries, including Ukraine as well. Throughout the nineties the Ukrainian economy was significantly dollarized. The newly issued euro may become another alternative currency and asset substitute. If it does not, then there is some ratchet behaviour, implying the presence of dollar hysteresis. Hysteresis was previously investigated in terms of backward rigidity of dollarization to substantial stabilization policies. The introduction of the euro may become another challenge leading to de-dollarization of the Ukrainian economy. Will we still observe backward rigidity of dollarization? Using data from an experiment I test the presence of hysteresis of dollar as an asset substitute after introduction of the euro.

In theory dollarization is usually analyzed from two angles: from the point of view of asset and currency substitution. In my research I focus on asset substitution. The theoretical model and experimental environment are organized so as to isolate this specific function of money from others.

Using the data received from the experiment I test for the presence of hysteresis of dollar as an asset substitute after introduction of the euro.

The work is organized as follows. The second chapter contains literature review. I first discuss literature on currency and assets substitution and then analyze the methodology of conducting monetary and financial experiments. In the third chapter I build a parsimonious theoretical model of the foreign exchange markets based on the presence of the foreign asset substitute in the economy. Chapter four is devoted to experimental evidence on testing the hysteresis hypothesis using the theoretical model developed in the preceding chapter. Chapter five contains conclusions and policy implications.

Chapter 2

LITERATURE REVIEW

In my thesis I investigate euroization in Ukraine using an experimental approach. The phenomenon under study evolved recently, in the context of cash euroization, and has not yet been analyzed econometrically due to scarcity and unreliability of data. The experimental approach can be a solution to the absence of data allowing not only modeling of the situation, but also decomposing into specific effects.

First, I examine some theoretical models of currency and asset substitution. Then I focus on dollarization, which can impact the further circulation of euro in the following two ways. On the one hand, it creates some special preconditions for euroization. On the other hand, many researchers define dollarization not only as the fraction of dollars in money supply, but as the fraction of all foreign currencies that circulate in the domestic money market. Thus, the dollarization ratio change will signify not only the changes in circulation of dollars, but in the euro as well. In this section both theoretical models and survey articles are reviewed. Then I proceed with the examination of laboratory tests of monetary and international economic theories.

Dollarization: theory and empirical evidence

Accepting foreign currency in the domestic market is referred to as currency or asset substitution depending on the role played. This phenomenon is observed in transitional and in developing countries. Calvo and Vegh (1992) summarize the surveys done on currency substitution in developing countries. They make conclusion that dollarization has positive and negative influence on a given economy. Full dollarization can be an effective policy tool against inflation but on the other hand it does not leave any possibilities for other policy tools as, for example, “lender of last resort”. Thus, according to the authors

there are no simple answers for assessment of the dollarization. They also mention the problem of the lack of data of foreign currency in circulation.

In the same year Agenor (1992) published a theoretical study devoted to the existence of parallel currency markets in developing countries. The parallel currency markets are illegal markets that appear due to ineffective exchange rate restrictions. In the paper he chronologically observes the emergence and spread of parallel currency markets, then develops a theory for the determinants of parallel exchange rates and finally concludes with policy implications. Agenor (1992) states that unification of official and parallel markets cannot be achieved by relying exclusively on devaluation of the official exchange rate. To be a success, it must be accompanied by a relaxation of exchange restrictions and by supportive fiscal and monetary policies.

Mishkin (2002) claims the experiences of Latin America could be good policy lessons for transition economies and Ukraine in particular. Based on Latin American cases he concludes that a monetary policy strategy will not be successful in maintaining low inflation over the medium term in emerging market countries unless government policies create the right institutional environment in the economy, i.e. CB with transparent and consequent monetary policy and well-regulated banking system.

There is a number of empirical researches done on dollarization. One was conducted by Freitas (2000) for the cases of Bolivia, Turkey and Indonesia. In his paper Freitas estimates the determinants of dollarization and accepts the hypothesis of the hysteresis presence in all three countries. Hysteresis in the context is defined, as a ratchet behavior of the agents, which after substantial stabilization and with low inflation and interest rates did not shift back to the domestic currency.

There is also some research using data for transition economies. Vetlov (2001) looked at dollarization in Lithuania and Heimonen (2001) studied currency substitution in Estonia. Vetlov uses VAR and VECM to establish relationships between dollarization ratios, and domestic and foreign deposits interest rate fluctuations. He makes a conclusion that *ceteris paribus* a rise of the interest rates paid on domestic currency deposits relatively to the one paid on foreign currency deposits tends to lower dollarization in Lithuania. Heimonen

evaluates the possibility of the substitution of euro for dollars in Estonia. Long run dynamics did not support any asymmetries between currencies. In the short run, there was some evidence of a ratchet effect favoring the euro. Thus in the short run euro may substitute a previous asset substitute – dollar. Feige, Faulend, Sonje, and Susic (2000) examine the Croatian case of currency substitution. The role of substitute there is played not by the dollar but by DM, which by now has to be fully offset by euros. Feige uses Argentinean data to make approximations of substitution in Croatia. They use a denomination displacement method and a demand for foreign currency method to determine the unknown amounts of DM in circulation. According to the authors the methods for determining the amounts of non-dollar co-circulating currencies can be used to obtain estimates of the amounts of Euros that may be required when ‘dmarkization’ becomes ‘euroization’. Hence, Feige et al (2000) conclude that such estimates should help to facilitate a timely and smooth transition. Successfully monitored transition will result in gain from this unique historical experiment for researchers, policy makers and national accountants.

A series of the researches was devoted to dollarization in Ukraine. Below I observe briefly those that are most relevant to my thesis focus.

In the paper by Piontkivsky (2000) two hypotheses are empirically tested on Ukrainian data. The first is that portfolio balance considerations, i.e. differences in real rate of returns, drive the level of dollarization. The second is the existence of hysteresis in the context rigidity against stabilization policies. The results of the tests confirm the first hypothesis, but reject the second.

In my own paper (Yablonovskyy (2000)) I make theoretical analysis of the impact of the dollarization on the effectiveness of monetary policy in Ukraine coming to the conclusion that such policy may be substantially weakened by the presence of the dollars in circulation, which are the part of uncontrolled by the CB money supply.

Bondarenko (2000) in his thesis explores the dollar asset and currency substitution in Ukraine using VAR methodology using money, exchange rate and prices as variables. He

founds currency substitution in Ukraine is significant with bias towards foreign cash in circulation relative to foreign deposits.

Perspectives of euroization

With the introduction of the cash euro the members of the European Monetary Union switched from one legal, broadly accepted monetary unit to the new common euro. The introduction of a cash euro, however, raises many questions for non-member countries. Deutsch Mark previously played some role as a currency and asset substitute in those countries. So will it be replaced one for one by euro in the internal currency market of non-member countries or it will result in increasing dollarization? Will the euro substitute for the dollar as an asset and/or as a medium of exchange currently used illegally in the money market? The answers must be based on previous evidence concerned with dollarization in Ukraine (which by definition includes all hard currencies).

One of the most recent papers focusing on dollarization specifically in Ukraine is Curtis, Gardner and Waller (2002). The authors divide the modern monetary history of Ukraine into two periods. The first covers the period of ruble and coupons' circulation and the second starts with issuing hryvnias. Dollars acquired a significant role in the economy early in the first period, and with time played all three standard roles of money: unit of account, medium of exchange and store of value. Hyperinflation led to an increase in dollarization despite limitations introduced by the CB.¹ The introduction of hryvnya in the second period was accompanied by imposing additional restrictions on dollar circulation and tougher enforcement of the previously introduced. These restrictions affirmed the dollar's role in servicing operations in the shadow economy.² According to Soller and Waller (2000), such restrictions may have a positive correlation with the degree of dollarization. Finally, the authors conclude that due to the staggering lack of reforms in Ukraine, joining

¹ Dollar cannot be used for transactions within the economy, though it is used in shadow sector of the economy.

² The introduction of hryvnya was accomplished by tough stabilization monetary policies. One of the achievements was the enforcement of the unique exchange rate for all the market players. As before that official CB rate, the rate of street exchanges and rates used for inter firms illegal transactions would differ substantially. See Curtis, Gardner and Waller (2002) for detailed description.

the EU will require a long period, which in turn will postpone introduction of the euro to the domestic money market.

Despite pessimistic forecasts by Curtis and her colleagues Ukraine asserted its intent to join the EU (and consequently EMU). Thus, it would be useful to analyze what the first steps of the Ukrainian government should be as it starts a more active EMU accession policy. According to the Maastricht criteria, an accession country must run an average inflation rate of no more than 1.5% above countries already in EMU and the nominal exchange rate must remain within “normal fluctuation margins” for at least two years prior to the adoption of the euro (Feige and Dean 2002). If Ukraine fixed its exchange rate towards the euro to fulfill the exchange rate conditions, then it is possible that euroization may start even earlier. Rational agents will convert their monetary holdings into the most stable currency. Thus, it is likely that they will prefer the unfluctuating euro to dollar, which exchange rate for hryvnya is floating. Usage of such strategy would allow agents to hedge against foreign exchange risks.

There is also a scarcely conceivable scenario in which Ukraine implements unilateral euroization when national currency is substituted by the euro. Wojcik (2000) investigates such a scenario for the Polish economy and comes to the conclusion that it is not a desirable path. While unilateral euroization would reduce exchange risk, the default risk due to failure of the CB to keep enough foreign reserves would mitigate these gains. Among the other costs of unilateral euroization are the loss of seigniorage and elimination of the monetary authorities' lender-of-last-resort function. In addition, the European Union has made it very clear that unilateral euroization does not constitute a viable option for the monetary integration of candidate countries. In this case, then for Ukraine, having weaker prospects of entering EMU than Poland has, without developed banking and financial sector, the unilateral euroization scenario is even more unattractive.

By now few attempts were done to analyze possible euroization (either partial or full) scenarios for Ukraine. Last year I presented a paper at annual EERC conference (Yablonovskyy (2002)) in which conducted qualitative analysis of impact of some degree of euroization on Ukrainian economy. I conclude that despite it is not likely that euro will

entirely substitute dollar in the internal money market, still it will spread to certain degree in nearest future. The CB optimal policy would be neither speeding up euroization nor limiting it. Rapid increase of euros in circulation will increase money supply which cannot be influenced by monetary policy. On the other hand, limitations on euro may have negative impact on trade development and capital mobility between Ukraine and countries of the European Union.

Monetary theory in the laboratory

As a rule monetary theories are tested using aggregate macroeconomic data. However, there are some cases where field data is either unavailable or extremely unreliable. Economic experiments can be a method to gather empirical data where standard methods fail. Though experiments are primarily used by microeconomists to test theories of economic agents' strategic behavior, they may be applicable to macroeconomic analysis. One obstacle to using experiments in a macroeconomic context is that the scale of macro phenomena is too big to be tested in laboratory experiments. Most macroeconomic models today are built on explicit microeconomic foundations, in some cases with such restrictions on individuals' behaviour that are not embodied in any available empirical data. Hence, as Duffy (1998) argues, there must be fewer objections to using experiments to test macroeconomic theories. For example, in my study I would like to focus only on the asset substitution role played by cash foreign currency. However, even with the available rough estimates of the amounts of dollar cash in hands of the public it will be impossible to decompose them into fractions depending on the functions fulfilled. Creating a special experimental environment is a plausible solution for conducting analysis.

Duffy (1998) gives a general overview of laboratory tests of monetary theories. He points to four general directions in monetary theory that were tested in the laboratory. The first deals with testing backward induction. The other three correspond to the classical roles of money: a store of value, a medium of exchange and a unit of account.

The ability of money to store value is of particular interest in my research. This defines the asset qualities of money. In times of inflation money loses its ability to store value. Duffy

(1998) investigates the particular case of self-fulfilling inflationary expectations. He tests whether individuals behave adaptively or rationally. The agents in the laboratory are assumed to live for several periods, thus facing an intertemporal consumption maximization problem with some disposable consumption in each period and monetary endowments. The role of the government is played by the experimenter, who makes a decision to intervene by creating money in the economy. With continuing growth of the money supply agents in the economy start to form inflationary expectations. The evidence from several different experiments suggests that the expectations are adaptive as opposed to rational. Laboratory investigation of the store of value role for money was analyzed in the context of an overlapping generations model by Bernasconi and Kirchkamp (1999) and determinacy of Equilibria by Marimon and Sunder (1993).

Bernasconi and Kirchkamp (1999) constructed an experimental economy based on overlapping generations model, in which inflation is determined by the monetary policy and by the amount of average saving within each period. Among their findings is that subjects 'over-save' for precautionary reasons and as a result monetary policies which are equivalent in static equilibrium exhibit different levels and different volatility of inflation in the experiment. In Bernasconi and Kirchkamp's experiment over-saving led to lower than equilibrium inflation level under the real deficit regime, but approximately equal to equilibrium level under the money growth regime.

Marimon and Sunder (1993, 1994, 1995) constructed a series of experiments involving a version of the overlapping generations model where the stock of fiat money is allowed to grow over time. In these experiments, a government (the experimenter) seeks to purchase a constant per capita amount of the consumption good in every period. The government makes purchases at current prices by expanding the money supply, which results in inflation. As inflation persists, subjects formulate certain inflationary expectations, which are adaptive according to Marimon and Sunder.

Duffy (1998) also explores the role of money as a medium of exchange, which has application to Ukraine described in the section devoted to the review of works on Ukrainian dollarization. Curtis, Gardner, Waller (2002) in their study mention that in

Ukraine, the dollar is often used as a means of payments (medium of exchange role) when buying durable goods, such as computers, cars, and real estate.

There are also several experiments on exchange rate behavior and investigations of patterns of international trade. Noussair, Plot, Riezman (1997) use a two “country” model to test the law of one price and the flow of funds theory of exchange rate determination and obtained supporting experimental evidence.

As the above review show there have been no experiments devoted to euroization scenarios. However, there are several related to exchange rate and currency theories. Given the lack of data and limited research focus on asset substitution, investigating Euroization using the experimental approaches to gain insight about perspectives of the euro as an asset fills a void in the literature.

Chapter 3

THEORETICAL MODEL

Money

There are three kinds of money in the experiment. The first kind of money is domestic currency. The second and third kinds of money are foreign currencies, which are perfect substitutes. Domestic money is denoted by M , first foreign currency is denoted by F and second by D . The time subscript denotes the date of issuance of the particular sum of money.

In my experiment, I introduce a hyperinflation index for domestic currency equal to μ . Note that μ is not an analogue of CPI, but is just a coefficient used to depreciate nominal money stock due to inflation. Thus, real money stock M_t is transferred through time $M_t = M_0$, $M_t = \mu M_{t-1}$, $M_t = \mu^2 M_{t-2}$. The general formula will be:

$$M_t = \mu^j M_{t-j} \tag{3.1}$$

The power of μ indicates for how many periods the specific money was kept. In my experiment μ equals 0.5. Thus in real terms money stock (e.g. 100) received at period t will be worthy half of its initial value (50) at period $t+1$. There is no inflation the F and D currencies. The choice of μ at the level of 0.5 is justified by two arguments. The motivation for this particular number is that subjects in the experiment would be able to use simpler calculations to depreciate their holdings on the one hand and that it is big enough to create incentives for foreign exchange trade on the other hand.

Foreign currency F is issued at period one, foreign currency D is issued at period q . Domestic currency M is issued in equal amounts M every period beginning from the first

one and distributed equally to the households as an income. Foreign currencies are issued only once and are used for exchange purposes between two groups of households.

Regular issuance of money does not imply seigniorage by the CB. Issuing money is just distributing wages earned by households which are then absorbed in exchange for consumption goods, whose role will be played in the experiment by real money payoffs.

In recent years due to substantial stabilization policies output in Ukraine began to grow and inflation rate reduces.¹ However, not to mix up the additional impact of other macroeconomic factors and keep the model reasonably parsimonious I keep the output and inflation constant throughout the experiment. For the same reasons no information on economic growth in the countries where the asset substitutes were originally issued is not given to agents in the economy.

Households

There is a group of households in the economy, who maximize individually utility.

$$\max u_i, i = 1, \dots, N \quad (3.2)^2$$

N is the size of two groups together, with K individuals in first group and L individuals in the second group. For simplicity I assume K=L. Second group enters the economy with domestic currency income in the first period. First group enters economy in the first period with certain amount of the foreign currency F. At period q (q=4) first group receives endowments of currency D. Thus the experiment is divided in two equal parts: before and after introduction of the currency D. This is done to give subjects equal time for learning about the properties of currencies F and D, so that valid comparisons could be made.

¹ But the data is still unreliable and thus must be treated with caution.

² I use subscript to indicate specific period and/or individual, absence of the subscript implies that the vector/matrix including values for all periods or/and all individuals is used. I use capital letters for aggregate values (sum of individual values).

Since I observe dynamic process the problem must be stated intertemporally.

$$u_i = f(c_i), \text{ for } T \text{ periods} \quad (3.3)$$

Every second period households receive income, which equals the amount of money issued divided by the number of households receiving the income as follows:

$$m_{it} = \frac{M_t}{K} \quad (3.4)$$

for t corresponding to even periods for members of group K

$$m_{it} = 0 \quad (3.5)$$

for t corresponding to even periods for members of group L

$$m_{it} = \frac{M_t}{L} \quad (3.6)$$

for t corresponding to odd periods for members of group L

$$m_{it} = 0 \quad (3.7)$$

for t corresponding to odd periods for members of group K

A households' income is spent as follows:

$$m_t \equiv c_t^c + s_t^c \quad (3.8)^1$$

¹ Superscript "c" stands for "current".

m_t is a monetary income vector of households receiving income in a given period, c_t^c is a vector of consumption from current income and s_t^c is a vector of savings from current income. s_t is used for future consumption. Subscript t indicates the period.

For simplicity I assume that consumption from current income is fixed in real terms across time and individuals. Since the individuals cannot change (i.e. improve) their performance of current consumption they will focus their efforts on optimizing future consumption. The real money payoffs are the same for each period and are distributed according the following formula:

$$P_{it} = \frac{c_{it} \cdot Y}{C_t} \quad (3.9)$$

Intuitively, we introduce assumption about fixed aggregate output by fixing Y .¹

In the experiment I ignore the fixed part of current consumption. The payoffs are distributed among the group of the players, who consume their savings. For example, the first group receives income in period one. Then it saves using either domestic or foreign currency and in the following period reveals the claim on consumption of the output (real money payoffs) constrained by the savings amount.

I assume that the level of utility is identically represented by the level of pay off, as the more money an individual gets in terms of payoff the happier he/she is. Thus,

$$P_{it} = u_{it} \quad (3.10)$$

The level of individual consumption at given period t equals:

$$c_{it} = \beta_{it}' s_i \quad (3.11)^2$$

s_i is a row vector of savings including T elements. β_{it} is the T -elements row vector of fractions of savings used for consumption in the current period, and all $j \geq t$ elements are equal to zero, as individuals cannot borrow in this model.

In my preliminary experiments I tested the impact of additional constraints that only savings from the previous period can be used for the current consumption and infinitely high inflation between the periods. The former means that for the elements of $\beta_t \forall j: j \neq t$, $b_{ij}=0$. The latter implies that monetary holdings that were not transferred into foreign currency have zero value in the next period. But these assumptions appeared to be too excessive as they narrow down the decision making to an obvious choice of investing all savings above current consumption in foreign currency under any exchange rate. For more details see the section devoted to the preliminary experiments.

Savings

Each period when individual receives income he/she spends some fixed part of it on consumption. The part which is not consumed is saved. It can be either saved in domestic currency or foreign currency F (and/or currency D beginning from the period q). In the period following the one in which the income is received part of the savings can be consumed. In order to consume the individuals must use domestic currency. Then they must exchange some of the foreign currency endowment back into domestic money at the beginning of this period.

Notice, that here I introduce a simplifying assumption of zero interest rate for both domestic and foreign currency. If all the agents invest money in interest bearing assets with the same market interest rate their relative performance will not change. And since in my experiment payoffs are based on relative performance, the incentive structure will not be distorted by using a zero interest rate.

¹ It is a parsimonious assumption used for ceteris paribus purposes.

The savings in the domestic currency equal the amount of savings accumulated in all previous periods minus the amount of the endowment of foreign currency.

The individual endowment of foreign currency at the end of period t equals:

$$f_{it} = \sum_{j=1}^t s_{ij} \gamma_{ij} e_{fd} - \sum_{j=1}^t f_{ij} \lambda_{ij} i \quad (3.12)$$

e_{fd} is the vector of exchange rates of foreign currency for domestic with 20 elements (integers from 1 to 20).² In the experiment the exchange rate is assumed to be an integer ranging from one to twenty. This assumption is used to simplify the calculations by subjects to make them spend more time on the development of the optimal strategy. In practice, policies designed to limit the exchange rate fluctuations are typical for CB of Ukraine. Despite declared floating exchange rate CB continuously intervenes to the market to sustain the exchange rate.

γ_{ij} is the row vector indicating the fraction of total savings in period j exchanged for foreign currency under each of the possible exchange rates by i -th individual. λ_{ij} is the row vector indicating the fraction of foreign currency holdings in period j exchanged for domestic currency by i -th individual. i is a 20 elements vector of ones.

Periodization and incentives' structure¹

There are two groups of subjects with K and L member respectively $K=L$. For simplicity:

$$K=L \quad (3.13)$$

¹ Consumption of current income is neglected.

² The competitive equilibrium exchange rate in the experiments is equal to ten.

In first round, the supply of foreign currency is given exogenously by the external sector. There is one more simplifying assumption that all individuals receive the same income:

$$m_{it}^Y = m_{jp}^Y, \forall j, p : i \neq j, t \neq p \quad (3.14)$$

The structure of the life cycle of experimental subjects is summarized in the following table.

Table 3-1. Periodization of the experiment

	Period 1				Period 2		
1st group (K)	Receives the endowment of foreign currency F	Holds foreign currency F	Sells foreign currency F	Buys consumption goods	Gets income in domestic currency	Buy foreign currency	Holds foreign currency
2nd group (L)		Gets income in domestic currency	Buys foreign currency F	Holds foreign currency F	Holds foreign currency F	Sells foreign currency F	Buys consumption goods

Every period the individuals make savings. These savings are consumed in subsequent periods. The subjects face two options: either keep savings in the domestic currency or exchange them into foreign currency. Since the exchange rate values are limited, thus, their deviations from competitive equilibrium levels are limited as well. It is always better to buy foreign currency, which is strictly dominant strategy. Note that if no one buys foreign currency the relative performance in terms of savings will be the same for all individuals, but if one of them starts to exchange he is better off. Thus, everybody is expected to exchange and individuals end in Nash equilibrium, in which they exchange all

¹ The basic setup of the exchange partially mimics the one used by Lim, Prescott, and Sunder (1994).

their foreign currencies' holdings. Note that it is not optimal to keep foreign currency for more than one period, as then the opportunity for consumption (getting real money payoffs) is lost. If an individual does not exchange foreign currency in period when can consume the savings then cannot consume anything in this period, but the consumption is divided between other members of the group depending on their claims. According to the consumption those subjects receive real money payoffs.

In period 1 individual's consumption is equal to some part of income. Suppose:

$$c_{it} = \bar{c}_{it} \quad (3.15)$$

The bar above c_{it} means that that consumption in the first period is set exogenously at some constant level. This is parsimonious assumption and is introduced explicitly in experimental setup.

In the first period individuals also decide which currency to use for saving. Suppose that τ is the share of the savings invested in foreign currency. Then consumption in the second period equals:

$$c_{t+1} = \tau \cdot \mu \cdot s_{it} + (1 - \tau) \cdot e_t \cdot s_{it} \cdot \frac{1}{e_{t+1}} \quad (3.16)^1$$

For simplicity I make the analysis within two periods' framework, which can further be extended without loss of generality to n periods. Maximization of utility implies maximization of the consumption stream or the sum of the consumption level in two periods. For simplicity I assume that individual does not have any intertemporal preferences. The maximization problem with respect to the share of savings in the domestic currency can be formulated as follows:

¹ In this setup e is the competitive equilibrium exchange rate (fc/dc)

$$\max_{\tau} c_i = \bar{c}_i + \tau \cdot \mu \cdot s_i + (1 - \tau) \cdot e_t \cdot s_i \cdot \frac{1}{e_{t+1}} \quad (3.17)$$

Suppose the equilibrium exchange rate is constant through time, which corresponds to competitive equilibrium outcome, then the ratio of exchange rate is equal to one, μ is less than one, then consumption will decline with the increase of τ .

$$FOC : \frac{\Delta c_i}{\Delta \tau} = s_i \left(\mu - \frac{e_t}{e_{t+1}} \right) < 0 \quad (3.18)$$

To maximize consumption τ must be minimized to 0, since $0 \leq \tau \leq 1$.

The investors do not have incentive to hold foreign currency for longer than two periods as they thus will create relative scarcity of this currency in the periods they decide not to exchange, allowing others to get more of the payoff pie.

Market

The aggregate supply of domestic currency at period 1 is given by M_1^Y . The supply of foreign currency is given by F_1^E (superscript E indicates that it is exogenous). The equilibrium exchange rate for the competitive market is given by:

$$E_1^C = \frac{F_1^E}{M_1^Y} \quad (3.19)^1$$

The demand for domestic currency is revealed by subjects by making offers at the market.

¹ Here superscript “c” stands for “competitive”. Note F and M is equal to total endowment of these currencies at a given period.

Of course, in practice competitive outcome will not always occur. Among the reasons can be simple mistakes, lack of time and analytical skills for developing the optimal strategy, impact of accumulated in previous periods' wealth etc. The most reasonable explanation will be the expectation of some extra profits in future using speculation. But since the experiment has only eight number of periods and budgets of the individuals are relatively small, the possibility of gaining market power enough for speculation is very small.

According to the conditions of the experiments the residuals of foreign currency are exchanged at competitive equilibrium level which would occur if period nine was conducted.

Introducing euro to the market

The euro is introduced to the market at some period q . Note that the subjects are given information not about the euro but simply foreign currency D. The amount of D issued is the same as the amount of F, the rules of the exchange are identical, and hence, the two foreign currencies are perfect substitutes. The subjects are not told explicitly that currencies are identical, but it follows from the similarity of the description and trading rules and endowments they are given. According to my hypothesis it will take some learning before individuals will be equally confident in F and D. Although two currencies are identical the subjects will prefer the one they already used. If this proposition is true then indeed there is a learning effect, which will support hysteresis hypothesis. The hypothesis of learning presence is accepted if the shares of purchased foreign cash are biased towards F or/and the number of F per unit of domestic currency used in the contracts was less than D quantity per unit of M. The presence of learning will support the hypothesis of hysteresis.

The presence of learning (experience) variable can be formulated formally in the following way:

$$s_{it+1}^f = (1 - \tau^F(t) - \tau^D(t-q))\mu \cdot s_{it} + \tau^F(t) \cdot e_{it}^F \cdot s_{it} \cdot \frac{1}{e_{t+1}^F} + \tau^D(t-q) \cdot e_{it}^D \cdot s_{it} \cdot \frac{1}{e_{t+1}^D} \quad (3.20)$$

The formula above is the extension of the model described in the previous section. Here we have two foreign currencies. Besides, the τ is now the function of time, which is done to model hysteresis. As the number of periods increases the subjects learn about the currency (receive experience on trading it).

$$0 \leq \tau(t) \leq 1 \quad (3.21)$$

$$\lim_{t \rightarrow \infty} \tau(t) = \tau' \quad (3.22)$$

That is as the time horizon increases due to learning the share of currency approaches some fixed value τ' .

$$1 \geq \tau'_i > 0, \tau''_i < 0 \quad (3.23)$$

Note that previously introduced equation with one foreign currency could be reformulated for the case of τ depending of time as follows:

$$\max_{\tau} c_i = \bar{c}_{ii} + \tau(t) \cdot \mu \cdot s_{ii} + (1 - \tau(t)) \cdot e_i \cdot s_{ii} \cdot \frac{1}{e_{t+1}} \quad (3.24)$$

Then differentiating with respect to time gives:

$$FOC : \frac{\Delta c_i}{\Delta t} = \frac{\Delta c_i}{\Delta \tau} \frac{\Delta \tau}{\Delta t} = s_{ii} \left(\mu - \frac{e_t}{e_{t+1}} \right) \frac{\Delta \tau}{\Delta t} < 0 \quad (3.25)$$

For this equation hysteresis will imply that in case derivative of τ with respect to t is positive and converges 1 (i.e. τ grows with time and has 1 as an upper bound). But since both domestic currency and currency F were issued at the same period no hysteresis can be present.

The maximization problem with two foreign currencies with the first introduced in period one and the second in period q , can be formulated as follows.

$$\max_{\tau} c_i = \bar{c}_i + (1 - \tau^F(t) - \tau^D(t))\mu \cdot s_{ii} + \tau^F(t) \cdot e_{ii}^F \cdot s_{ii} \cdot \frac{1}{e_{t+1}^F} + \tau^D(t-q) \cdot e_{ii}^D \cdot s_{ii} \cdot \frac{1}{e_{t+1}^D} \quad (3.26)$$

Ceteris paribus individuals will prefer the currency with higher value of τ which positive relates to the number of periods the given currency is in circulation.

In case τ for currency D is lower than its competitive equilibrium level but increases with the number of periods it is in the circulation then the hysteresis is present. Besides, as D is introduced q periods after F, I expect the shares of investment in D to be lower than in D ($\tau^F(t) > \tau^D(t-q)$) in case the hysteresis is present.¹

Numerically, under hysteresis hypothesis the exchange rate of currency F must be higher than exchange rate of currency D. As it was mentioned before, the dominant strategy is to exchange entire endowment of them. After introduction of D the endowment of foreign currencies in the economy increases twice. According to the conditions of the experiment the two foreign currencies are identical. Thus, I expect the exchange rate to decrease by two times from previous competitive equilibrium level ten to five.

Since the competitive equilibrium may not occur due to some imperfections, then the expected numerical estimate of the ratio of average exchange rates of F to D must be higher than one under hysteresis.

Under hysteresis I expect the shares of trade of currency F higher than of D. When the players invest entire amount of savings in foreign currencies then share of investment in currency F will be higher than of D if hysteresis is present. However, due to market

imperfections, simple mistakes by the subjects there may be still some investment in domestic currency. Then for comparison it would be more representative to compute fractions of investment in a given foreign currency out of total investment in foreign currencies. Mathematically both indicators give the same relative results. That is, if the fraction of F investment out of total savings is higher then the fraction of F investment out of total investment in foreign currencies will be higher as well. Numerically I expect the shares of investment in F out of total investment in foreign currencies must be more than 0.5.

¹ The idea of the introduction of the learning into the model of hysteresis is taken from Uribe (1997)

Chapter 4

EXPERIMENTAL EVIDENCE

Preliminary experiments

I have conducted three preliminary experiments. The description of the experimental environment can be found in appendices 1, 2 and 3 respectively. The first experiment was conducted mainly for testing how method works. The second experiment had excessive assumptions with infinite inflation, no more than two period savings, and there was no trade actually. The subjects just filled the forms so the problem of optimization was trivial. The third preliminary experiment was a prototype of the final experiment and allowed to see some technical drawbacks in the design of instructions and conditions.

In the preliminary experiments I started with extreme assumptions of infinite inflation and savings allowed to be kept for not longer than two periods. Then I relaxed the assumptions to allow more decision-making. The final experiment was designed using lessons from preliminary experiments in such a way as to contain enough room for decision making but to preserve a limited information set of the agents. As the focus of the research is on hysteresis of asset substitution due to learning by doing at the financial market I did not conclude the information about the economies where currency substitutes were issued. Besides, trying to keep model parsimonious I did not incorporate many of the dynamic features of the Ukrainian economy, hence output and inflation were fixed throughout the experiment.

Among the distinguishing features of Ukrainian economy during last years are economic growth and reduction of inflation. However, these statements are made based on Derzhkomstat data, which unreliability led me to using experimental approach. Besides, the macroeconomic stabilization did not result in complete dedollarization of the economy. For some reason economic agents do not trust completely national currency and prefer

dollars. The hryvnya is more stable now, but no one can assure stability in future. Hence the analysis of possible euroization does not lose its validity. What needs to be done in further research is to test the impact of other sources of instability in the economy, not just inflation. This can be done via inclusion of different kinds of expectations about money supply growth, trust to the government and to the banking sector etc.

The impact of further relaxing the assumptions is subject to a future research which was not implemented in my thesis due to time and budget constraints.¹

Setup of the final experiment

The final experiment was conducted in class on 8th of April 2003 with 10 students² (five in each of the groups: $K=L=5$) from bachelor program of “Kyiv-Mohyla Academy”. It lasted for three hours. The experiment included eight periods ($T=8$) based on the theoretical model described in the previous chapter (first four with currency F and from fifth through eighth using F and D currencies ($q=4$)). At the first period one group received endowment of currency F, 100 units each player, and the other received their first income in domestic currency, 1000 units each player. At the fifth period the first group received endowment of foreign currency D, 100 each player. Thus, the total endowment of F throughout the game was 500. The total endowment of D in periods five through eight was 500 as well. Every period of one the groups in turn received 5000 units of domestic currency in total. Based on the individual performance in terms of the maximization of the consumption students received real money payoffs.

The subjects were paid 10 UAH for participation plus bonus depending on the performance. The mean total payoff was 28 UAH, the median 28.46 UAH, the maximum 34.82 UAH and the minimum 21.97 UAH. According Derzhkomstat data average hourly wage in April 2003 in Ukraine was 2.92 UAH³, multiplying by time of the experiment – 3.5

¹ All subjects in the experiment received real money payoffs (in hryvnya).

² The number of subjects in the experiments usually ranges from 8 to 16, for examples see: Noussair, Plott, Riezman (1995, 1997).

³ <http://www.ukrstat.gov.ua/>

hours we receive 10.22 UAH. Hence, the average payoff was 2.74 times higher of that the average employee would earn in Ukraine according to official statistics.

The trades were conducted via an exchange person, who documented all the deals. I also supervised the correctness of the documentation. Only registered deals were taken into account. The subjects were instructed about the rules and were allowed to train by conducting trade. They were told that each deal, which sum exceeds their available endowment will be automatically cancelled. Each subject carried his own accounting of the budget. Every second period subjects made decisions on consumption. The exchange person documented the volume of consumption. Each period lasted for fifteen minutes. After each period the subjects had some time to check the correctness of the registration of the deals, however no new deals could be done.

Results of the experiment

I would like to start my analysis with the overview of the foreign exchange market for currency F. As can be seen from the graph below the volumes of trade from the very beginning did not include all F available in the economy F cash ($F_t^E > F_t^T$)¹, and declined substantially after the introduction of the second foreign currency D. In the periods one through four the shares of traded volumes of total endowment of F in the economy were 0.908, 0.856, 0.902, and 0.918 correspondently. After introduction of D the shares declined approximately twice and had the values 0.544, 0.39, 0.558, 0.492 in periods five through eight correspondently.²

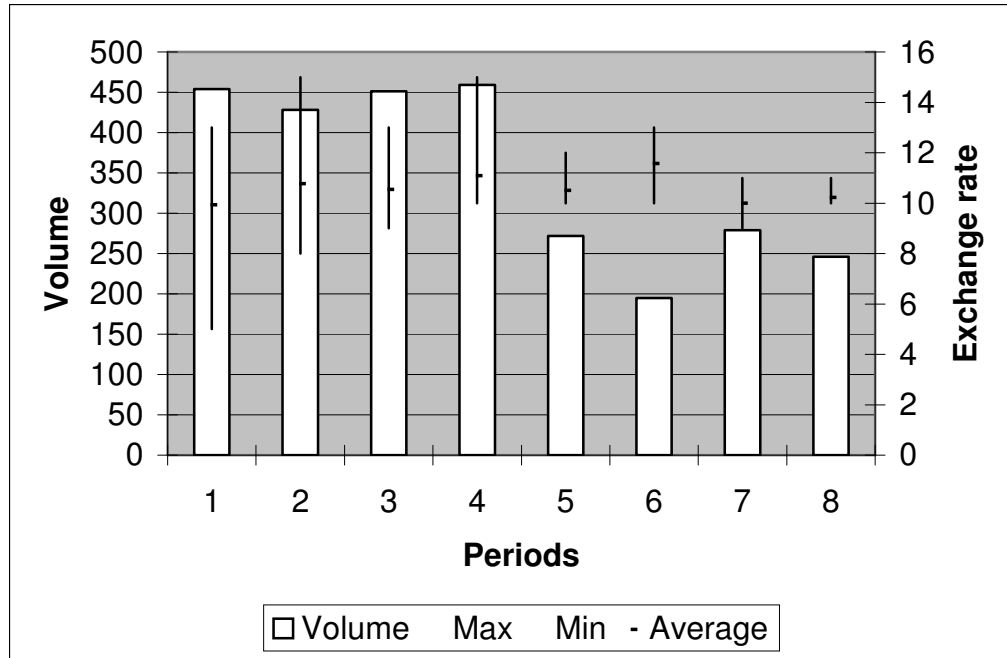
The volatility of the exchange rate of F decreased with the time. The average exchange rate of F did not change even after decline in trade volumes. The possible explanation is that the exchange rate can driven by its previous historical values rather than volumes of foreign currency in the economy ($e_t^F = f(e_{t-1}^F, \dots, e_{t-i}^F)$). Individuals do not care about the value of the

¹ Superscript “T” stands for “traded”, consequently the letter with such superscript indicates the volume actually traded in the market.

² See also appendix 4.

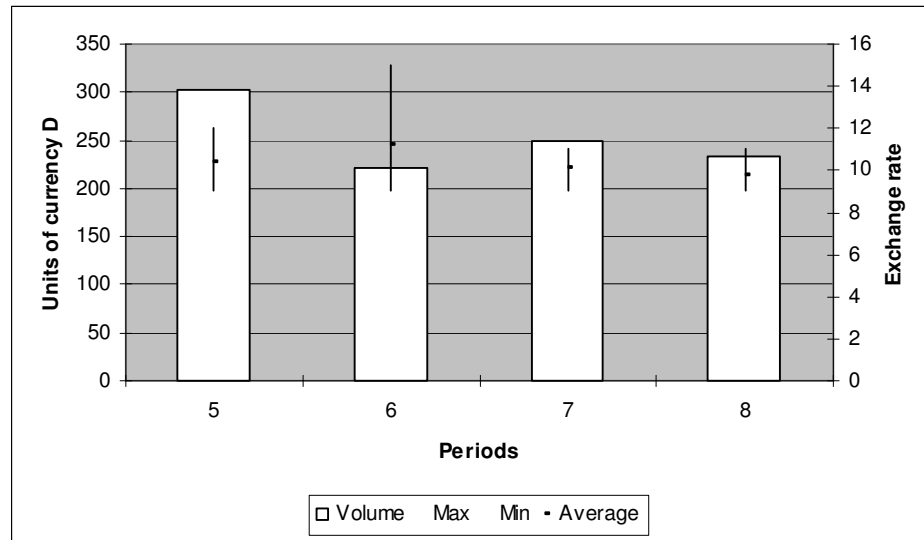
exchange rate but only about its stability as they want to retain purchasing power of their savings.

Figure 3-1 Main parameters of foreign currency F market.



Now look at the graph below, which provides the information on the market of second foreign currency D. The biggest trade occurred when D was first introduced; in the second period the volume of trade was less but higher exchange rate signifies presence of high demand for this foreign currency. After the subjects got some fractions of newly introduced currency into their wealth portfolios the volumes of trade and exchange rate stabilized being approximately at the same levels in the seventh and eighth periods. The shares of trade volumes out of total endowment in the economy in periods five through eight were 0.606, 0.442, 0.498, and 0.468 correspondently.

Figure 3-2 Main parameters of foreign currency D market.

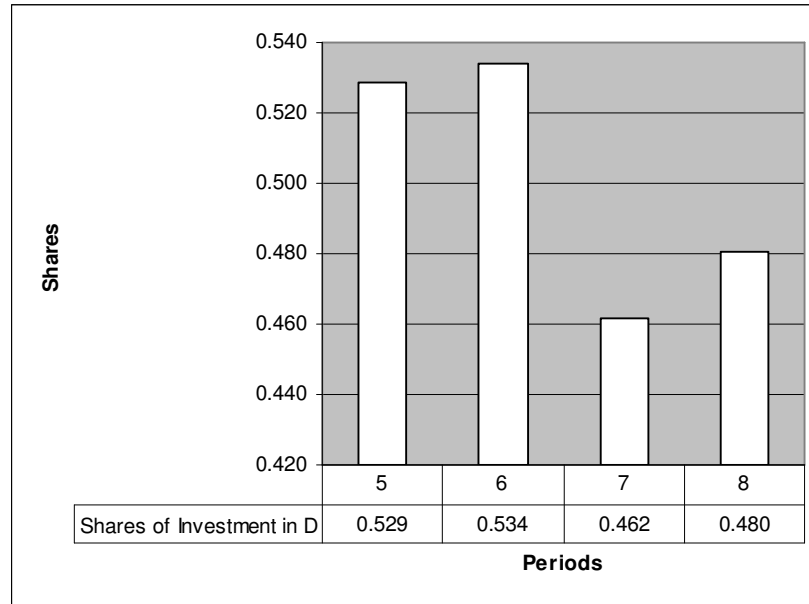


According to the results of the experiment the exchange rate did not decrease after introduction of a second currency. This can be explained by the dominance among subjects of the adaptive expectations, which are based on previous values of the exchange rate. As it was mentioned in the theoretical part, then the ratio of the average exchange rates must be used for analysis of the bias. The ratio for the periods five through eight was 1.05, 0.96, 1.02, 1.02 respectively, which is close to one.¹ Hence the hypothesis of hysteresis is not supported by exchange rate dynamics.

Below is the graph, which illustrates the shares of the investment in currency D of total investment in foreign currency in periods in which it was traded.

¹ See also appendix 5.

Figure 3-3. The Shares of investment in currency D out of total investment in foreign currency in periods five through eight.



Based on the values from the graph a conclusion can be made of no hysteresis of dollar substitution. The conditions for accepting the hysteresis hypothesis formulated in the theoretical model were the increase of τ with time and $\tau^F(t) > \tau^D(t-q)$.¹ From the graph above it can be seen that τ^D does not exhibit expected pattern as it is neither monotonically increasing with the time nor smaller than share of investment in currency F. Numerically, the fractions of currency D investment are approximately equal to 0.5. Thus, the hysteresis hypothesis is rejected.

The subjects spent more purchases of the currency D than they did on currency F after the introduction of the former. This may signify the use of diversification strategy, as agents decided to add new currency to their portfolio.

¹ To be precise it must be mentioned that from the graph it can be seen that in periods 5, 6 the fractions of investment in D out of investment in foreign currencies is larger, but it is clear that these fractions will be also larger for the investment in D out of total savings, which will include also domestic currency savings in the denominator.

Although the dominant strategy was not to keep any wealth in foreign currency for longer than two periods¹ until it can be exchanged back into domestic currency and then consumed, the subjects continued to keep foreign currency for longer periods, which can be explained by speculative motives. They knew that in the last period their endowments would be exchanged into domestic with further consumption, even though the expected exchange rate would not be favorable. Given the above mentioned argument the interest to a newly issued additional asset substitute is then rational and will result in high share of investment in the latter currency. In the seventh and eighth period, when the wealth was diversified the subjects put more investment in currency F.

More detailed decomposition of the shares of investment across subjects and assets is presented in the appendix 6. There are also tables with descriptive statistics on exchange rates in appendix 7 and tests for average value of F and D exchange rates equal to 10 in appendix 8. In most periods the results of tests do not reject the hypothesis, thus, confirming the historical formation of the exchange rates, based on previous values.

The subjects also had some parts of their income in the domestic currency not exchanged. Thus, this residual was subject to inflation. The residual appeared because of limited duration of the period. Thus, some subjects were too slow to manage all the possible deals. Besides, some of the improperly conducted deals were abated after the experiment. Note that the share of not exchanged domestic currency income declined after introduction of currency D from average 30% in periods one through four to 9% in periods five through eight. Hence, the experimental economy started to use more foreign currency for operations.²

¹ If the foreign currency is not exchanged back into domestic currency in the next period, the opportunity for consumption in one period is lost (the subject does not use the possibility to get money payoff in the corresponding period).

² See appendix 9 for details.

To conclude this section it must be mentioned that in general the experimental evidence does not support the hypothesis of hysteresis as the subjects invest approximately equal shares of their wealth in two assets substitute. Relaxing the assumption of equal substitutability between F and D may result in bias towards one of the asset. As the experimental evidence did not support the presence of the hysteresis, its presence in real life thus will be a consequence of the assets not being perfectly substitutable.

CONCLUSIONS

Cash euro is already playing a role as a new asset substitute in a dollarized economy of Ukraine. Exchange offices accept euros as dollars; banks offer deposits in euros. However, due to the lack of data it is hard to implement econometric test in terms of perspectives of the euro on the Ukrainian money market.

In my work I used an experimental setup as an alternative to analyze the impact of the introduction of the euro on asset substitution. Experimental analysis allows generating data in the laboratory, thus overcoming data scarcity and unreliability. Although experiments cannot provide complete information on the observed phenomenon but they can build a background for further theoretical models and testing those models as soon as enough data becomes available.

In my thesis I tested experimentally for the presence of the hysteresis of dollarization after the introduction of cash euro. I constructed a theoretical model according to which there can be alignment to using dollars as an asset substitute after the euro comes to the market. The hypothesis of the presence of such hysteresis was rejected. The subjects purchased substantial shares of experimental currency, which was an equivalent of euro in the market. The total investment in an equivalent of euro was about 50% out of total investment in foreign currencies. The exchange rates for two currencies were approximately the same. According to the results of the statistical tests the values of the exchange rates were close to ten for both currencies. Hence there was no bias towards experimental equivalent of dollar. Such behavior can be explained by diversification and speculation motives, which dominated risk aversion against new currency.

Further tests of hysteresis must be extended to currency substitution, when substitutes will fulfill not only function of store of value, but also medium of exchange. In experimental setup it will imply that consumption will be bought using not only domestic but foreign currencies. Besides information set of the agents may be increased by giving them the information about the development of economies of the home country and countries where asset substitutes were issued. As time horizon increases enough the econometric models for the test of the hypothesis of hysteresis as well as more general tests of behavior of euro in the Ukrainian money market can be worked out and implemented.

The next two paragraphs are devoted to some policy implications of the results obtained from both theoretical analysis and experimental test.

Asset and currency substitution substantially limits CB possibility to conduct monetary policies, making traditional tools ineffective. For example, increasing money supply in dollarized economy may result in high inflation, since agents have additional ways to escape from additionally issued domestic money, increasing holdings of foreign currency. At the same time increased demand for foreign currency will cause the depreciation of the domestic currency. Previously major asset substitute in Ukraine was dollar. But as the results of the experiment suggest diversification strategies of the agents in the economy may result in some degree of euroization in the nearest future. Hence, euro may become another asset substitute which may further increase the share of foreign currencies in the money supply of the economy making monetary policies more inefficient. On the other hand the role of regulation of the money market using foreign exchange policy tools increases. The CB may conduct not only dollar but euro interventions. Besides, it would be optimal to diversify its foreign reserves by increasing share of euro.

Ukraine claimed its intentions to become the member of the EU in future (hence, EMU as well). In this context circulation of euro in the internal money market may have some special implications. Adopting euro as a domestic currency will not be accepted as a positive step by EMU authorities as there must three preceding steps made. The applicant

must first join the EU, enter the exchange rate mechanism of the EU and fulfill Maastricht inflation criteria. On the other hand, changing the bias in money substitution from dollar to euro may imply more economic and financial tightness with the EU members, creating favorable preconditions for becoming a member of the latter union.

BIBLIOGRAPHY

- Agenor Pierre-Richard. *Parallel Currency Markets In Developing Countries: Theory, Evidence and Policy Implications*. Essays In International Finance, No. 188, November 1992.
- Antweiler Werner. *Is the Canadian Dollar in Cecular Decline? Empirical Evidence on Purchasing Power Parity and the Links Between Rate Volatility, Transborder Capital Flows, and News*.
- Arifovic J. *The Genetic Algorithm for Exchange Rate Determination: Experimental Evidence*. The Journal of Political Economy, Volume 104, Issue 3 (Jun. 1996), 510-541.
- Bernasconi M., Kirchkamp. *Why do monetary policies matter? An experimental study of saving and inflation in an overlapping generations model*. November 1999. <http://www.sfb504.uni-mannheim.de/~kirchkamp/noi.html>
- Bondarenko S. *Currency Substitution in a Dollarized Economy: the Case of Ukraine*. EERC MA Thesis. 2000.
- Calomirtis W. Charles, Domovitz Ian. *Asset Substitution, Money Demand, and the Inflation Process in Brazil*. Journal of Money, Credit and Banking, Volume 21, Issue 1 (Feb., 1989), 78-89.
- Calvo A. Guillermo, Carlos A. Vegh. *Currency Substitution In Developing Countries: An introduction*. IMF Working Paper 92/40 (May 1992).
- Curtis S. Elizabeth, Gardner Roy, Waller J. Christopher. *Dollarization in Ukraine: 1991 to the Present*. Prepared for presentation at the Fordham/CEPR New York City Conference “Euro and Dollarization: Forms of Monetary Union in Integrating Regions”, April 5-6, 2002.
- Duffy J. *Monetary Theory in Laboratory*. Review. September/October 1998. p. 9-26.
- Feige E.L., Dean J.W. *Dollarization and Eurorization in Transition Countries: Currency Substitution, Asset Substitution, network Externalities and Irreversibility*. Presented at the Fordham University International Conference on “Euro and Dollarization: Forms of Monetary Union in Integrating Regions”, April 5-6, 2002, New York.

- Feige E.L., M. Faulend, Velimir Sonje, Vedran Sobic. *Currency substitution, Unofficial Dollarization and Estimates of Foreign Currency Held Abroad: The Case of Croatia*. Paper prepared for the Sixth Dubrovnik Conference.
- Freitas M.L. *Dollarization Hysteresis: Further Empirical Evidence*. [Unpublished paper] Universidade de Aveiro. 2000.
- Heimonen K. *Substituting a Substitute Currency – the Case of Estonia*. BOFIT Discussion Papers 2001. No 11.
- Lim, Suk., Edward C. Prescott, and Shyam Sunder. *Stationary solution to the Overlapping Generations Model of Fiat Money: Experimental Evidence*. *Empirical Economics* 19(2), 1994, pp. 255-77.
- Merimon R. Sunder Sh. *Indeterminacy of Equilibria in a Hypoinflationary World: Experimental Evidence*. *Econometrica*, Volume 61, Issue 5 (Sep., 1993), pp. 1073-1107.
- Mishkin S. Frederic. *Monetary Policy Strategies For Emerging Market Countries: Lessons From Latin America*. Prepared for the Seventh Dubrovnik Conference, “Current Issues in Emerging Market Economies”, Dubrovnik, Croatia, June 28-30, 2001.
- Noussair Ch.N, Plott Ch. R., Riezman R.G. An Experimental Investigation of the Pattern of International Trade. *The American Economic Review*, volume 85 Issue 3 (June., 1995), 462-491.
- Noussair Ch.N, Plott Ch. R., Riezman R.G. *The Principles of Exchange Rate Determination in an International Finance Experiment*. *The Journal of Political Economy*, Volume 105, Issue 4 (Aug., 1997), 822-861.
- Piontkivsky R. *Dollarization Effects on the Macroeconomic Policy in Transitional Economies: the Case of Ukraine*. EERC International Conference: “International Capital Flows in Countries in Transition”. Kyiv, Ukraine, April 12-13, 2000.
- Soller V. Elisabeth, Waller J. Christopher. *A Search Theoretic Model of Legal and Illegal Currency*. *Journal of Monetary Economics* 2000, Vol. 45:155-184.
- Tsesliuk S. *Exchange Rate and Prices in an Economy with Currency Substitution: the Case of Belarus* EERC Ma Thesis. 2002.
- Uribe M. *Hysteresis in a Simple Model of Currency Substitution*. *Journal of Monetary Economics* 40 (1997) 185-202.

Vetlov I. *Dollarization in Lithuania: an Econometric Approach*. BOFIT Discussion Papers. 2001. No 1.

Wojcik C. *A Critical Review of Unilateral Euroization Proposals: The Case of Poland*.

Focus on Transition, 2/2000, pp.48-76.

Yablonovskyy D. *Dollar Money Flows and Monetary Policy in Transitional Economies*.

EERC International Conference:

“International Capital Flows in Countries in Transition”. Kyiv, Ukraine, April 12-13, 2000.

Yablonovskyy D. *Dollarization in Transition Economy of Ukraine: History and Perspectives*.

Sixth Annual EERC International Academic Conference. Kyiv, Ukraine, 2002.

APPENDICES

Appendix 1

Preliminary experiment no 1

The goal: to imitate the work of the market of consumer goods. Two groups: producers and consumers. The producers have simple production function, according to which they produce each period. The consumers have utility function, according to which they consume every period.

Instructions:

1. Producers.

You produce good X, which you want to exchange the consumers for their money. On the production of a unit of a good you spend 5 dcus. For the production you need money, which you got as a credit with zero interest rate – maximum 100 dcus.

For participation in the exchange fill the following table.

After analysis of supply and demand (filling of the similar tables by consumers), there will be identified prices and corresponding volumes of trade with this prices.

2. Consumers.

You consume good X, which you want to get from producers for your money, maximizing its consumption. For consumption you have money – 100 dcus, which you want to spend completely, you want to consume as much as possible units of X.

To participate in exchange you have to fill in the following table. After analysis of supply and demand (filling of the similar tables by consumers), there will be identified prices and corresponding volumes of trade with this prices.

Appendix 2

Preliminary experiment no 2

Part 1

Rules:

Your income for the month constitutes 200 dcus²³. 100 dcus you spend on current consumption (food, clothes, housing etc)²⁴. 100 dcus you save. But inflation in the country is so high, that in the next period your savings will have zero real value. To protect your savings from complete depreciation you convert them into foreign currency – fcu1.

Fcu1s can be exchanged for new dcus in the next period. New dcus in the next period are denominated old ones, that is, they the same value as the old ones. Your task is to maximize future consumption. Hence, by saving 100 dcus each time, you first try to exchange them for as more as possible amount of fcu1s, and then all (!) fcu1s you exchange for dcu1s according to market exchange rate (this happens automatically in every even period).

Thus, in odd periods you receive income in dcus, 100 from which you must save, by buying fcu1s. Even periods you begin with certain endowment of fcu1s, which you exchange for dcu1s. The latter are summed to get your score (this you are supposed to maximize).

Example:

You received income 200 dcus, 100 of them you consumed (you can't change this sum), 100 you must save. You fill the table with the data on your demand on fcu1s depending on exchange rate (fcu1s for 100 dcus). Then according to the market exchange rate in accordance with your demand tables the fcu1s are installed on your account. In the next period fcu1s are exchanged for dcus. The amount of dcus exchanged for fcu1s (not received as an income) is summed up in every period. The sum is you score for the game. Your goal is to receive the highest possible scores.

Rules for filling the table:

You fill every empty cell in the demand column. In this cell, taking into consideration the endowment of dcus you put the amount of the other currency you want to by at this exchange rate.

Exchange rate = fcu1s for 100 dcus.

The answers must be given in decimal fractions up to the second digit after the point.

²³ Domestic currency units

²⁴ Expenditures on current consumption do not change over time

Table:

Period 1											
Exchange rate	50	60	70	80	90	100	110	120	130	140	150
Demand											
Period 3											
Exchange rate	50	60	70	80	90	100	110	120	130	140	150
Demand											
Period 5											
Exchange rate	50	60	70	80	90	100	110	120	130	140	150
Demand											
Period 7											
Exchange rate	50	60	70	80	90	100	110	120	130	140	150
Demand											
Period 9											
Exchange rate	50	60	70	80	90	100	110	120	130	140	150
Demand											

Part 2**Rules:**

In general rules remain the same, but now you have two foreign currencies for saving: besides fcu1 you have also fcu2. The exchange rate = fcu2s for 100 dcus. General demand on two foreign currencies is limited by the available amount of the dcus.

Example:

You have 100 dcus. You decided to exchange x of this money for fcu1s and y for fcu2s. Then based on those fractions you fill the table.

The rules of filling the table:

First you mention which fraction of you savings you will convert in each currency. You fill in each empty cell in the demand table. In this cell, taking into consideration the endowment of dcus you put the amount of the other currency you want to by at this exchange rate.

Exchange rate = fcu1s for 100 dcus.

Exchange rate = fcu2s for 100 dcus.

The answers must be given in decimal fractions up to the second digit after the point.

Table:

According to the formulated above rules fill the table.

<i>Period 1</i>		Fraction of fcu1s:					Fraction of fcu2s:				
Exchange rate	50	60	70	80	90	100	110	120	130	140	150
Demand on fcu1s											
Demand on fcu2s											
<i>Period 3</i>		Fraction of fcu1s:					Fraction of fcu2s:				
Exchange rate	50	60	70	80	90	100	110	120	130	140	150
Demand on fcu1s											
Demand on fcu2s											
<i>Period 5</i>		Fraction of fcu1s:					Fraction of fcu2s:				
Exchange rate	50	60	70	80	90	100	110	120	130	140	150
Demand on fcu1s											
Demand on fcu2s											
<i>Period 7</i>		Fraction of fcu1s:					Fraction of fcu2s:				
Exchange rate	50	60	70	80	90	100	110	120	130	140	150
Demand on fcu1s											
Demand on fcu2s											
<i>Period 9</i>		Fraction of fcu1s:					Fraction of fcu2s:				
Exchange rate	50	60	70	80	90	100	110	120	130	140	150
Demand on fcu1s											
Demand on fcu2s											

Appendix 3

Preliminary experiment no 3

Period 1

Instructions

General description

There are two groups of people in the economy. That save part of the income in one period and consume the next period. Inflation rate from current to the next period is 100%. The output (payoff available for each period) for consumption is constant. There is domestic currency (dc) in the economy and foreign (fc). Income is received in the dc. Then it can be saved either in dc or exchanged for fc from the other group. In the next period you can either consume you saving receiving pay off (individual payoff is equal to the total payoff divided by the payoff claims in the domestic currency and multiplied by the individual claim in dc) or keep on saving. To consume fc savings you need first to convert them into domestic currency at the beginning of that period.

Suppliers' individual instructions:

In this period (1) you have 100 of the fc. You can either keep it or convert to the dc. Converted dc will be used to get payoff, according to mentioned above formula. For exchange open the file:

Kitty\public\permanent\exp_3.1

Then open sheet S*

There you can only fill gray cells. There you have three tables:

Initial endowment (fc)	Current Balance (fc)
100	0

Gives your endowment at the beginning of the period and current balance after trade.

There is also table with suppliers' offers for you to know the situation at the market.

And there is main table, where you can insert up to ten bids. You insert quantity and exchange rate; bids cannot be changed after accepted. You must confirm all bids (i.e. put the amount equal to the number in cell accepted to the cell confirmed).

Pay off is counted based on the numbers from column accepted.

Trade is completed on Friday, 21 of March, 12 am.

Demanders' individual instructions:

In this period (1) you have 1000 of the dc. You can either keep it or convert to the fc. Converted fc will be used to get payoff in the next period, according to mentioned above formula.

For exchange open the file:

Kitty\public\permanent\exp_3.1

Then open sheet D*

You have the table with the bids.

Pay off is counted based on the numbers from column confirmed. You insert accepted offers in the corresponding column. If the total accepted number is more than 1000, all bids are automatically marked as unaccepted. Only confirmed bids are counted.

Trade is completed on Friday, 21st of March.

General program instructions

By no there are no additional password for the program, so thus please use only your own sheets to proceed.

No changes in the formulas in your sheet can result in improvement of you results. But you can only lose the opportunity of getting information necessary for making decisions.

Let me know about any problem you face while using the program.

The changes will be seen by other users only after you save the file.

Training file

Task:

Payoff:

Suppliers:

1. You can make up to ten offers.
2. The exchange rate must be an integer; it can range from 1 to 20.
3. Your total bid can not be more than initial endowment. All bids above that limit automatically will not be revealed to demanders.
4. Offers cannot be changed after they are accepted. In case of revealed at the end of the game any imbalances, both of the sides that made a deal will get zero pay offs. You

Demanders:

Description of the program

All the information available for demanders and suppliers is presented through the formulas that refer to the administrator's sheet. Thus, non of the players can change the information available to other players. Exchange rate is exogenously set to be integer and belong to the interval from 1 to 20 (with predicted competitive market value equal to 10).

In the final experiment the agents will have their own files. Thus, only there own data will be available to them.

Cheating

Neither suppliers nor demanders can have overdraft, in which case their offers are not seen to the other side. The results of the suppliers' trade are computed using "accepted" column, filled by the demanders. The results of the demanders' trade are computed using column "confirmed" filled by suppliers.

Besides, excel allows keeping records from changes, done by different users, which allows for additional control of validity of the results. The subjects will be

informed that all of them will get zero pay offs in case of any kind or attempt of cheating.

Suppliers:

Suppliers have information on their initial endowments, current balance (endowment minus accepted offers). Suppliers do not know about the domestic money supply in the economy. They have information about other offers, which is summarized in the table.

Appendix 4

The shares of volumes of exchanged currency out of total endowment of currency in the economy

Table A1. The shares of volumes of exchanged currency F out of total endowment of currency in the economy

Periods	1	2	3	4	5	6	7	8
Fractions	0.908	0.856	0.902	0.918	0.544	0.39	0.558	0.492

Table A2. The shares of volumes of exchanged currency D out of total endowment of currency in the economy

Periods	5	6	7	8
Fractions	0.606	0.442	0.498	0.468

Appendix 5

The ratio of average exchange rates of currency F to currency D.

Table A3. The ratio of average exchange rates of currency F to currency D

Periods	5	6	7	8
DC/F	10.50	11.57	10.20	10.22
DC/D	10.00	12.00	10.00	10.00
D/F	1.05	0.96	1.02	1.02

Appendix 6

Decomposition of shares of investment

Table A4. The shares of investment across currencies and subjects (periods 5-8)

		5	6	7	8
F	1	0,382	0,000	0,961	0,343
	2	0,599	0,249	0,630	0,533
	3	0,682	0,546	0,414	0,482
	4	0,541	0,516	0,573	0,596
	5	0,000	0,514	0,027	0,224
D	1	0,618	0,772	0,033	0,456
	2	0,337	0,673	0,366	0,459
	3	0,311	0,269	0,582	0,482
	4	0,456	0,245	0,421	0,065
	5	0,996	0,010	0,966	0,592

Appendix 7

Descriptive statistics for exchange rates

Table A5. Descriptive statistics for exchange rates of currency F

Period	1	2	3	4	5	6	7	8
Mean	9.93	10.76	10.55	11.09	10.50	11.57	10.20	10.22
Median	10.00	10.00	10.00	11.00	10.00	12.00	10.00	10.00
Maximum	13.00	15.00	13.00	15.00	12.00	13.00	11.00	11.00
Minimum	5.00	8.00	9.00	10.00	10.00	10.00	9.00	10.00
Std. Dev.	1.23	1.73	1.18	1.34	0.71	0.98	0.79	0.44
Skewness	-1.68	0.67	0.77	1.65	0.99	-0.21	-0.34	1.34
Kurtosis	10.77	2.94	2.64	5.08	2.78	2.27	1.85	2.79
Observations	30	21	22	22	10	7	10	9

Table A6. Descriptive statistics for exchange rates of currency D

Period	5	6	7	8
Mean	10.40	11.25	10.09	9.75
Median	10.00	11.00	10.00	10.00
Maximum	12.00	15.00	11.00	11.00
Minimum	9.00	9.00	9.00	9.00
Std. Dev.	0.74	1.54	0.54	0.71
Skewness	0.35	0.96	0.13	0.32
Kurtosis	2.92	4.04	3.62	2.22
Observations	15	12	11	8

Appendix 8

Tests for average values of exchange rates of foreign currencies equal to 10

Table A7. Hypothesis test: exchange rate of currency F equal to 10

Period	1	2	3	4	5	6	7	8
P-value	0.7687	0.0571	0.0425	0.0010	0.0522	0.0053	0.4433	0.1690

Table A8. Hypothesis test: exchange rate of currency D equal to 10

Period	5	6	7	8
P-value	0.0541	0.0172	0.5884	0.3506

Appendix 9

Aggregate balances of domestic currency not invested in foreign currency in periods when income was received

Table A9. Aggregate balances of domestic currency not invested in foreign currency in periods when income was received

Absolute (dc)	497	2024	1298	2219	102	975	31	768
Percentage of total income, %	10	40	26	44	2	20	1	15
Average percentage for four periods, %				30				9

