Rapid Growth and Financial-Market Volatility: the Deposit Boom in Ukraine

Patrick Conway
Department of Economics
University of North Carolina
Chapel Hill, NC 27599-3305
patrick_conway@unc.edu
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Abstract:

Ukraine has experienced both rapid growth and substantial price and financial volatility since its adoption of exchange-rate stability as the primary goal of the National Bank of Ukraine (NBU). The increased financial intermediation of the population is a primary reason for these. I demonstrate that, despite the fixed exchange rate, financial markets remain largely isolated from Eurodollar markets. Inflation has not been pinned down by the fixed exchange rate, as the nominal-anchor literature would suggest, nor has it been proportional to money growth. The reason: a rapidly rising but volatile demand for broad money by the population. I report econometric results that demonstrate the links from deposit formation to credit growth and then to economic growth. I also link this deposit boom to the phenomenon of "excess liquidity", and provide suggestions for credit policies to eliminate this while maintaining the fixed exchange rate.

Keywords: Ukraine, financial markets, nominal anchor, volatility, financial deepening, seigneurage

JEL classifications: E43, F31, F36

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The Russian crisis beginning 17 August 1998 caused an economic crisis for Ukraine as well as for the other economies of the former Soviet Union.[1] While the National Bank of Ukraine (NBU) initially defended the value of its currency, it soon thereafter adopted a more passive stance – and the nominal exchange rate depreciated strongly. The nominal exchange rate of the Ukrainian hryvnia to the US dollar depreciated from 1.86 in September 1997 to 5.66 in December 1999.

In May 1999 the Ukrainian legislature passed the "Law on the National Bank of Ukraine". In that law the NBU is given three main objectives (in decreasing order of importance): the stabilization of the Ukrainian monetary unit, the stability of the banking sector, and price stability.[2] The NBU chose to implement its objective through maintaining a near-fixed exchange rate with the US dollar. The period from the end of 1999 to June 2005 was one of remarkable stability in the exchange rate between the Ukrainian hryvnia and the US dollar.

The macroeconomic outcomes while exchange-rate stability was the goal have been very pleasing, as illustrated in Figure 1. This was a period of rapid economic growth in Ukraine coinciding with a large surplus in the current account. Real economic growth remained at the 5 percent rate in 2000, and then rose to around 10 percent in 2001. It dropped back in 2002 to 5 percent, and then rose to higher rates in 2003. The most rapid growth was observed in mid-2004. The Orange Revolution of December 2004 coincided with a large drop in economic activity, with real growth returning to the still-strong 5 percent level in early 2005. The current account surplus as a percent of

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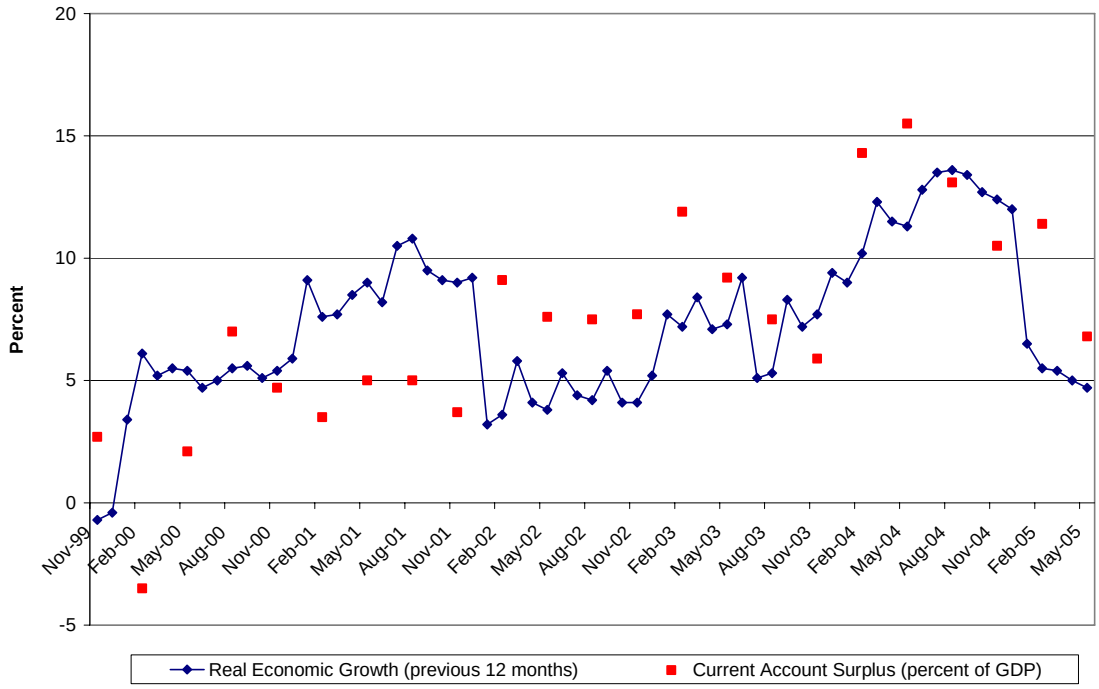
[1] See Conway (2001, chapter 10) for a detailed discussion of the implication of that crisis in three non-Russian FSU countries, including Ukraine.

[2] Source: "The Law of Ukraine on the National Bank of Ukraine", Law 679 signed by President Kuchma on 20 May 1999.

GDP was also strongly positive during this period, with its largest values also observed in 2004.[3]

Figure 1: Economic Growth and Current Account Surplus in Ukraine



Source: National Bank of Ukraine

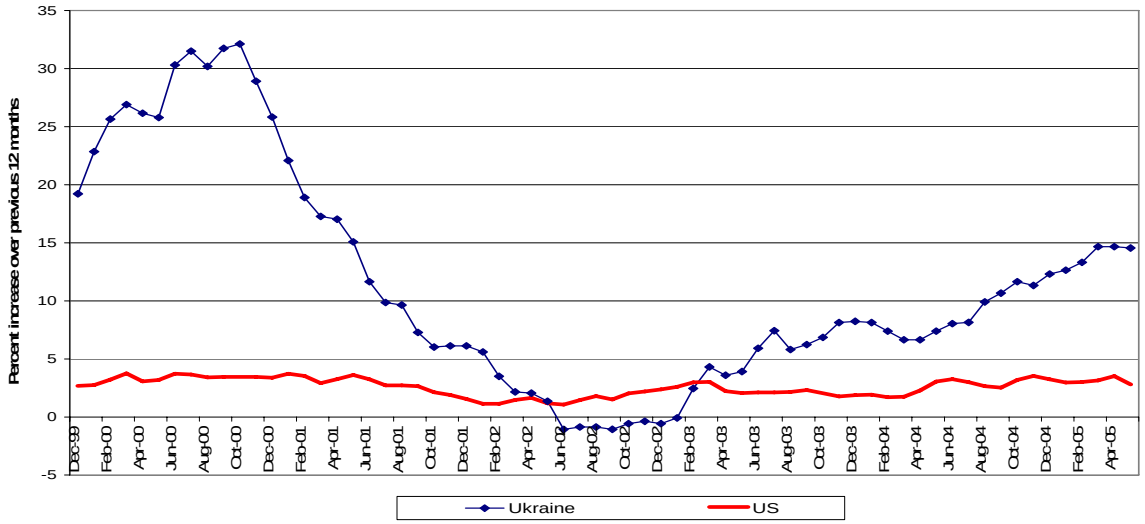
This is seemingly a successful application of the "nominal anchor" use of exchange rates: in this view, fixing the hryvnia's value in terms of US dollars established a stability in prices and interest rates that encouraged an export-led growth episode.[4] There's a weakness in that logic, however, that becomes evident when the inflation record is examined. Annual inflation in the consumer price index has registered rates between -0.6

[3] The strong current-account performance is striking, but perhaps a bit misleading until 2004. There is a stable component of about 5 percentage points of this current account surplus due to current transfers. The remainder is fairly evenly split between the goods balance and the services balance from the beginning of 2002 on.

[4] Corden (1993) provides an explanation of the "nominal anchor" view of stabilization policy, and contrasts it with the "real targets" approach.

percent and 20 percent since 1999. Figure 2 illustrates these wide swings in annualized inflation for the Ukraine relative to that observed in the United States. The stable exchange rate did not have the expected effect in terms of stabilizing the consumer price index.

Figure 2: Consumer Price Inflation in Ukraine

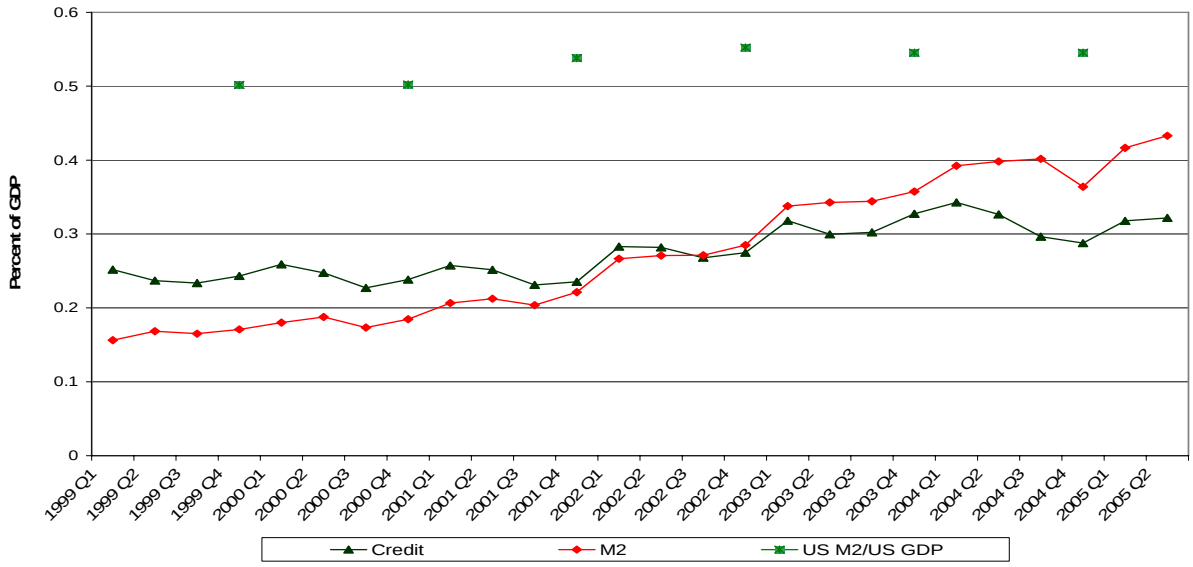


Source: National Bank of Ukraine, Economic Report of the President

Duenwald et al. (2005) has interpreted recent Ukrainian economic history as an example of a "credit boom". It is certainly the case that domestic credit as a share of GDP has grown rapidly in the last five years, but this doesn't tell the entire story. In Figure 3 I plot both credit to GDP and M_2 to GDP ratios for Ukraine during the past decade, as well as an indication of M_2 to GDP ratio for the US over the same time horizon. While there has been rapid credit growth over this entire period leading to a rise in the ratio of credits to GDP, even more striking has been the increase in the ratio of M_2 to GDP. Ukraine has not yet reached the degree of financial deepening in evidence in the US, but it has greatly increased this financial deepening during the stable exchange rate period. The Orange

Revolution at the end of 2004 was associated with temporary disintermediation, as households converted deposits into foreign currency for safety, but the economy was soon on its upward track once again.

Figure 3: The Deposit Boom in Ukraine



Source: National Bank of Ukraine, International Monetary Fund, Economic Report of the President 2004.

This increased financial intermediation has been a blessing in the recent past, but carries a warning for the future. The increase in holdings of currency and deposits has provided the Ukrainian government with substantial seigneurage and has fueled credit expansion at relatively low interest rates. This private-sector decision to hold money, broadly defined, is not irrevocable – as the withdrawal of deposits during the Orange Revolution illustrated. Adoption of a new exchange-rate/monetary policy runs the risk of slowing, or reversing, this process of intermediation.

I. Goods- and financial-sector non-integration in the stable exchange-rate period.

NBU monetary policy had as its primary goal the stabilization of the exchange rate with the US dollar. While this could facilitate integration of Ukrainian and world goods and financial markets, such integration does not necessarily follow. I show in this section that the hypotheses of purchasing power parity and of uncovered interest parity are rejected for Ukraine during this period.

Goods market non-integration. If purchasing power parity holds, the implication will be that commodity prices of traded goods will be equalized. While this extreme form of purchasing power parity has been invalidated in practice, there is evidence of long-term convergence to purchasing power parity in a number of developed countries.[5] Figure 2 provides prima facie evidence against short-term purchasing power parity, but investigation of convergence requires the use of an error-correction estimation strategy.

In Table 1, the null hypothesis of a random walk in quarterly Ukrainian inflation is tested against the alternatives of inertial inflation, systematic effects of monetary and fiscal policy, and pass-through of foreign inflation. The null hypothesis of a random walk in inflation is rejected, as is evident from the F test. Passthrough of contemporaneous US inflation to Ukrainian inflation takes the appropriate sign and magnitude (i.e., close to unity), but is insignificantly different from zero as well as one. There is evidence of an inertial component in inflation, as indicated by the significant coefficients on lagged inflation. Monetary and fiscal policies have no significant independent effects. Finally, long-run convergence is tested by inclusion of the error-

[5] Froot and Rogoff (1995) provides a useful summary of the tests of purchasing power parity up to that time, and draws the conclusion of the text.

correction term ec_{t-1}.[6] The coefficient on the error-correction term, while significant, indicates a very slow (3 percent per month) adjustment of inflation toward the long-run quantity equation.

Table 1: Inflation Determinants.

$\Delta\pi_t$	coefficient	standard error	T statistic
Intercept	-0.08	(0.15)	0.54
$\Delta\pi_{t-1}$	**0.53**	(0.12)	4.59
$\Delta\pi_{t-2}$	-0.25	(0.13)	1.91
$\Delta\pi_{t-3}$	**0.39**	(0.11)	3.43
$\Delta\ \Delta m_{t-1}$	-0.04	(0.04)	1.01
$\Delta\ \Delta m_{t-2}$	-0.05	(0.05)	1.02
$\Delta\ \Delta m_{t-3}$	-0.02	(0.04)	0.50
$\Delta g(y_{t-1})$	0.10	(0.09)	1.04
$\Delta g(y_{t-2})$	0.01	(0.09)	0.11
$\Delta g(y_{t-3})$	0.01	(0.10)	0.10
$\Delta\pi^*_t$	0.92	(0.49)	1.88
ec_{t-1}	**-0.03**	(0.01)	2.19
R^2	0.51		
F(11,63)	**4.92**		

Coefficients in bold are significantly different from zero at 95 percent confidence level.
Source: author's calculations

Financial-market non-integration. The inter-bank credit market provides a useful window on the degree of integration with world financial markets in recent years. Despite the success in maintaining a stable exchange rate and the opportunities for financial capital flows into and out of Ukraine, nominal interest rates on inter-bank credits of the same maturity have not been equalized with those available on European markets. Figure 4 illustrates one such case: nominal annualized 30-day inter-bank

[6] ec_{t-1} is calculated as the residual of the regression $\pi_{t-1} = a + b\ \Delta m_{t-1} + c\ g_{t-1}$, with g_{t-1} the growth in real GDP and Δm_{t-1} the growth rate of M_2 for period t-1. Those results are available on demand.

credits in Kyiv and London market. Both hryvnia and US dollar interest-rate series are presented for Kyiv.

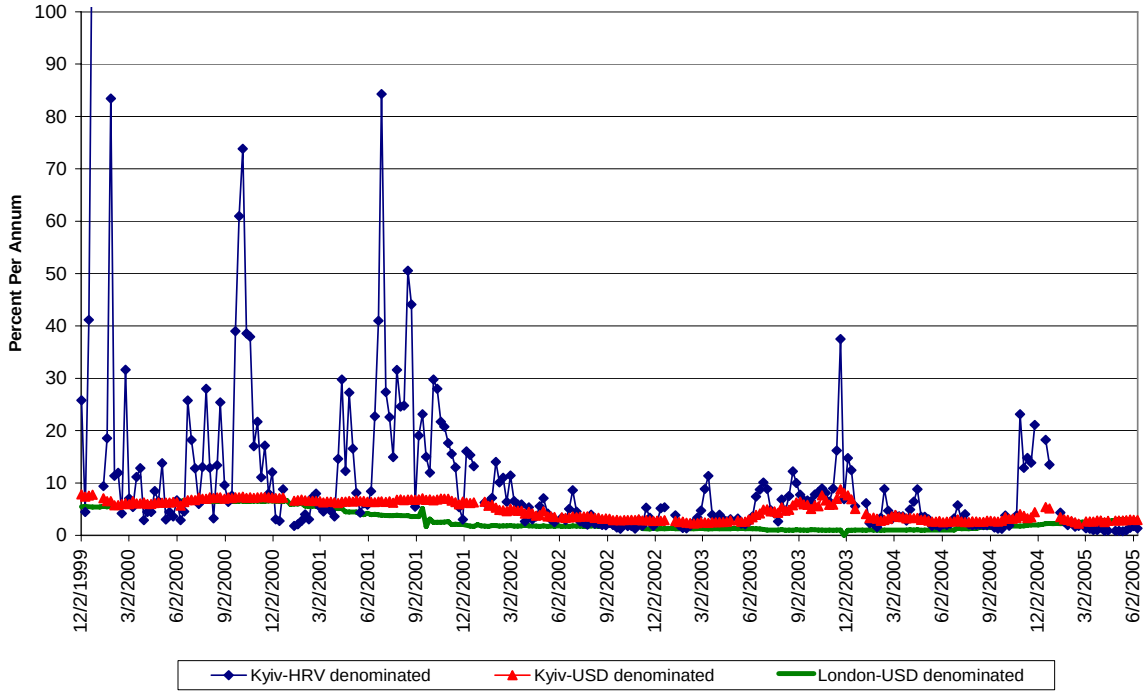
The theory of international finance suggests two potential sources of arbitrage or speculative profit in linking the Kyiv and London markets. I denote interest rates using the following notation.

$\rho^{\$}_{mt}$: the interest rate on a US dollar-denominated instrument with maturity m at time t in the London Interbank Market

$r^{\$}_{mt}$: the interest rate on a Ukrainian instrument denominated in US dollars with maturity m at time t in the Kyiv Interbank market.

r^{H}_{mt}: the interest rate on a Ukrainian instrument denominated in hryvnia with maturity m at time t in the Kyiv Interbank market.

Figure 4: Interest Rates on Overnight Interbank Credit



Sources: news reports, Datastream

There is first of all the arbitrage opportunity of trading in US dollar-denominated assets. In the absence of transactions costs, and for comparable credits, potential arbitrage profits imply that parity will exist in instruments of the same maturity and denomination.

$$(1+ \rho^{\$}_{mt}) = (1 + r^{\$}_{mt}) \qquad \text{for all m,t} \qquad (1)$$

There is secondly the opportunity to trade across currencies. In this case, uncovered interest parity implies

$$(1 + r^{\$}_{mt}) (e_{t+1}/e_t) = (1 + r^{H}_{mt}) \qquad \text{for all m,t} \qquad (2)$$

This is not an arbitrage opportunity, since the future exchange rate is unknown and there are no liquid forward markets. However, given the policy for stability of the exchange rate over time, the risks attached to such transactions would appear to be small.

The inter-bank credit market in Kyiv facilitates trades in credits of six maturities (overnight, 7-day, 14-day, 30-day, 60-day and 90-day) in two currency denominations (hryvnia, or HRV, and US dollar, or USD). The data are available weekly, and are measured on the same day (Thursday) of each week. The "bid" and "offer" rate are both collected. The midpoint between bid and offer rates is defined as the relevant interest rate, while the difference of bid and offer divided by one plus the bid rate is defined as the "spread" in inter-bank credits. For comparison, bid and offer interest rates at the same maturities were collected for the London Inter-bank market and the Moscow Inter-

bank market. For this study I examine overnight, 7-day, 30-day and 90-day inter-bank credits denominated in hryvnia and in US dollars on the Kyiv and London markets.

Interest rates on the London and Kyiv markets are each integrated of order one – in other words, their evolution is governed by a unit root. Table A1 in the Annex demonstrates this through a set of Augmented Dickey-Fuller tests for the eight interest-rate time series. Note that in each case, the null hypothesis of a unit root cannot be rejected for the variable in levels, while it is strongly rejected for the differenced version of the variable.

Integration of order one is not inconsistent with the parities of (1) and (2) if the two interest rates are cointegrated. The most direct test of this will be to specify the cointegrating relation between the two interest rates. I consider two forms of cointegration:

Term structure cointegration:

$$\rho^{\$}_{m90t} - \lambda^{1}_{k}\,\rho^{\$}_{mkt} = 0 \qquad \text{for given m, maturity } k \neq 90 \qquad (3)$$
$$r^{\$}_{m90t} - \lambda^{2}_{k}\,r^{\$}_{mkt} = 0$$
$$r^{H}_{m90t} - \lambda^{3}_{k}\,r^{H}_{mkt} = 0$$

Arbitrage cointegration:

$$\rho^{\$}_{mkt} - r^{\$}_{kt} = 0 \qquad \text{for given j, market } m \neq n \qquad (4)$$

For contracts traded in the two markets denominated in the same currency, I anticipate that the interest rates in the two markets for the same maturity will tend to converge (arbitrage cointegration). I also anticipate that the relationship between interest rates in the same market for different maturities will converge to a constant fraction λ^{i}_{k} for credit denomination i at maturity k.

The results from Table 2 indicate that in the London inter-bank market, term-structure cointegration is in fact observed. For each combination of maturities, the difference in yields across maturities illustrates a stationary process. In the Kyiv Inter-bank Market, by contrast, the condition of term-structure cointegration is violated: there is no evidence that the difference in yields across maturities is a stationary process. Finally, the difference between interest rates of the same maturity in different markets exhibits non-stationary behavior: they are not statistically cointegrated. While there is trade in the same contract in both London and Kyiv, the evidence here suggests that arbitrage does not serve to link the two markets together.[7]

Table 2: Tests for Cointegration				
Variable	Rho	Prob<rho	τ	Prob< τ
London market				
$\rho^{\$}_{90t} - \rho^{\$}_{30t}$	-23.77	0.00	-3.20	0.02
$\Delta(\rho^{\$}_{90t} - \rho^{\$}_{30t})$	-22.94	0.00	-3.15	0.02
$\rho^{\$}_{90t} - \rho^{\$}_{7t}$	-21.44	0.01	-3.05	0.03
$\Delta(\rho^{\$}_{90t} - \rho^{\$}_{7t})$	-23.77	0.00	-3.20	0.02
$\rho^{\$}_{90t} - \rho^{\$}_{1t}$	-22.94	0.00	-3.15	0.02
$\Delta(\rho^{\$}_{90t} - \rho^{\$}_{1t})$			-11.79	0.00
KIBOR market				
$r^{\$}_{90t} - r^{\$}_{30t}$	-7.32	0.25	-1.18	0.68
$\Delta(r^{\$}_{90t} - r^{\$}_{30t})$			-5.69	0.00
$r^{\$}_{90t} - r^{\$}_{7t}$	-5.36	0.40	-1.27	0.64
$\Delta(r^{\$}_{90t} - r^{\$}_{7t})$			-7.47	0.00
$r^{\$}_{90t} - r^{\$}_{1t}$	-4.84	0.45	-1.36	0.60
$\Delta(r^{\$}_{90t} - r^{\$}_{1t})$			-8.34	0.00
Cointegration: LIBOR with KIBOR				
$\rho^{\$}_{90t} - r^{\$}_{90t}$	-3.32	0.61	-1.17	0.68
$\rho^{\$}_{30t} - r^{\$}_{30t}$	-2.28	0.74	-1.19	0.68
$\rho^{\$}_{7t} - r^{\$}_{7t}$	-2.22	0.75	-1.02	0.74
$\rho^{\$}_{1t} - r^{\$}_{1t}$	-1.12	0.87	-0.44	0.90

Source: author's calculations

[7] Conway (2006) decomposes the rejection of uncovered interest parity into three premia: depreciation risk, convertibility risk, and liquidity risk. The fixed exchange rate served to eliminate the first, but either left untouched or exacerbated the others.

While the conditions of cointegration are violated, dynamic interdependence could still be observed through the transmission of shocks from one market to the other. Under this hypothesis, shocks in the London market will be passed through to the Kyiv market with a lag. To test this hypothesis I estimate a vector-autoregression model in error-correction form.[8] If interdependence were an important feature of these markets, then changes observed in the London market should be transmitted to Kyiv in subsequent periods. The coefficient γ_k is of special interest: it is the error-correction coefficient, and in models of cointegrated variables will measure the partial adjustment of the dependent variable to deviations from the cointegrating relation.

$$\Delta r^{\$}_{kt} = a_o + \Sigma_j a_j \Delta r^{\$}_{kt-i} + \Sigma_j b_j \Delta\rho^{\$}_{kt-j} + \gamma_k(r^{\$}_{kt-1} - \rho^{\$}_{kt-1}) + e_{ukt} \qquad (5)$$

Table 3 reports the results of these error-correction regressions for the four maturities in the dataset. The left-hand panel includes the regressions in KIBOR interest rates, and the right-hand panel reports the regressions in LIBOR interest rates. The right-hand results reinforce the common-sense conclusion: shocks to the Ukrainian inter-bank market do not transmit to the London market. Nor is there any partial adjustment of the London interest rates to existing differences in rates between the two markets. In fact, there is little evidence of a dynamic with weekly frequency.

The left-hand panel illustrates the differences in the Kyiv market. There is strong evidence of shock transmission in Kyiv at the weekly frequency – in fact, positive shock

[8] The coefficients in (5) are derived directly from the coefficients of a (j+1)-lag vector autoregression. If the underlying coefficients are all positive, then the a_j and b_j will be negative. γ_k will be equal to $(\Sigma_k^{j+1} c_k - 1)$, where c_k are the j+1 coefficients on lagged own variables in the equation for ρ_{ukt}.

transmission is evident in some cases with a four-week lag.[9] By contrast, while the coefficients for the most part take the correct signs, there is almost no significant evidence of transmission from the London to Kyiv markets.[10] The error-correction coefficient is significant in all cases, but takes the wrong sign, indicating that deviations from the long-run relation trigger even larger deviations in the future.

The preceding analysis has considered only inter-bank credits denominated in the same currency. Given the professed stable exchange rate policy, it is reasonable to ask if a similar dynamic interdependence will be found between USD-denominated and HRV-denominated credits in the Kyiv market. Table 4 reports the results of such an investigation for overnight credits.[11] The structure is that of equation (5). The null hypothesis is then that uncovered interest parity holds, with the alternative hypothesis being that interest rates denominated in the two currencies are independent. Three variables are included to test this independence. First, the lagged change in excess demand for inter-bank credits (Δxc^{H}_{t-1} for HRV-denominated credits and $\Delta xc^{\$}_{t-1}$ for USD-denominated credits) is included as an explanatory variable. If there were complete integration with international markets, the excess demand would have no effect on the change in interest rate, while if the market is independent there will be a positive coefficient. Two variables are introduced to proxy for monetary stance: the discount rate and the Lombard-discount channel. The discount (r_{dt}) and Lombard (r_{Lt}) rates in Ukraine play similar roles to those in other European banks. The discount rate is the lowest rate at

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[9] Longer lags were insignificant in all regressions.

[10] The significant coefficients appear in the 30-day equation. Two are unrealistically large for such a model and have offsetting sign – indication perhaps of the impact of outliers or mismeasurement in estimation.

[11] Similar tables are available for all four maturities, and will be provided on request. While there are slight differences in emphasis from table to table, the conclusions drawn from Table 4 are valid for the others as well.

which banks can borrow from the NBU, and is often below the market rate. Bank-level quotas for borrowing at that rate are set by the NBU. The Lombard rate is charged on emergency loans from the NBU to banks. No quota is placed on its use, and it thus should serve as an upper bound on market overnight interest rates. These two rates are set by NBU officials at periodic meetings. The Lombard/discount channel is $L_t = (r_L - r_d)/(1+r_d/100)$ and is an indicator of interest-rate volatility acceptable to the NBU. The changes in the NBU discount rate and the Lombard/discount channel are included in Table 4 as indicators of monetary policy stance.

The first two columns provide the error-correction specification for the USD-denominated overnight interest rate. There is no evidence of dynamic interdependence with the HRV-denominated credit market, and in fact little evidence of auto-regressive structure at all. Excess demand for credit takes a coefficient of the correct sign, but is insignificantly different from zero. Monetary policy settings have no significant impact. There is also no spillover effect, as noted before, from the London markets.[12] Exchange-rate depreciation also plays no role in interest-rate determination. The error-correction effects reflecting potential convergence to a long-run parity are also insignificant. The F value for this regression indicates that this specification is statistically indistinguishable from a random walk. I return to the policy implications of these results in a later section.

The third and fourth columns report the error-correction specification for the HRV-denominated overnight interest rate. There is little significant autoregressive

[12] Four overnight interest rate series were originally treated as jointly cointegrated: the three overnight rates discussed in this paper ($r^{\$}_{1t}$, r^{H}_{1t}, $\rho^{\$}_{1t}$) and the overnight rate on ruble-denominated credits in Moscow (r^{r}_{1t}). Preliminary analysis indicated that the Moscow and London rates were determined independently of the Kyiv rates. The impact of the London rate on $r^{\$}_{1t}$ is considered in the estimation of Table 3, while the Moscow rate was excluded because of its insignificant effect on the Kyiv overnight markets both in the short and long runs. The results of regressions including the Russian variables are available on demand.

structure evident in the data, and no significant spillover effects from the USD-denominated market. The exchange-rate depreciation makes an insignificant contribution. There are three significant results of this estimation, however. First, the error-correction terms are significant, suggesting that the HRV-denominated rate did over time converge toward parity with the USD-denominated rate. Second, there is evidence that increased excess inter-bank demand for HRV-denominated credit translates into a significantly larger rise in this overnight rate. Finally, monetary policy has the expected effect, with a larger rise in the discount rate leading to a reduction in the change in the interest rate on HRV-denominated overnight credits.[13] The discount-Lombard channel, by contrast, has a coefficient with expected sign but insignificantly different from zero.

The evidence paints a rather stark picture of financial-market non-integration. The Kyiv inter-bank markets are not well integrated into the European financial system as represented by London's inter-bank market. The HRV-denominated and USD-denominated credits traded at interest rates that were linked only by the gradual adjustment of HRV interest rates toward the USD rates of the same maturity.[14]

[13] This effect is not quite significant for overnight credits, but is significant at the 95 percent level of confidence for all other HRV-denominated maturities.

[14] This conclusion is in part due to the fact that the variables are only sampled at a weekly interval. It is possible, and likely, that shocks to one market propagate nearly instantaneously. After one week, their impact may be impossible to distinguish. If the USD-denominated rate is contemporaneously causal and $\Delta\ln(1+r^{\$}_{mt})$ is included in the regression for $\Delta\ln(1+r^{H}_{mt})$, the coefficient is significant and positive at all maturities m. Other coefficients of the $\Delta\ln(1+r^{H}_{mt})$ regressions retain their signs and significance, and thus the interpretations drawn above carry through in this case as well.

Table 3: Error-Correction Regressions in Interest Factors

	$\Delta r^{\$}_{1t}$	$\Delta r^{\$}_{7t}$	$\Delta r^{\$}_{30t}$	$\Delta r^{\$}_{90t}$		$\Delta\rho^{\$}_{1t}$	$\Delta\rho^{\$}_{7t}$	$\Delta\rho^{\$}_{30t}$	$\Delta\rho^{\$}_{90t}$
Intercept	**-0.002**	**-0.003**	**-0.003**	**-0.012**		-0.000	-0.000	-0.000	-0.000
$\Delta r^{\$}_{jt-1}$	**-0.276**	**-0.233**	**-0.240**	**-0.291**		-0.021	0.010	-0.037	0.000
$\Delta r^{\$}_{jt-2}$	**-0.261**	**-0.318**	**-0.220**	**-0.190**		0.004	0.015	0.005	-0.000
$\Delta r^{\$}_{jt-3}$	**-0.254**	**-0.144**	**-0.283**	-0.134		-0.005	-0.001	-0.014	0.001
$\Delta r^{\$}_{jt-4}$	**-0.212**	**-0.258**	0.082	-0.058		0.007	-0.005	-0.020	**-0.008**
$\Delta\rho^{\$}_{jt-1}$	-0.250	-0.140	**-0.730**	-0.652		**-0.173**	0.018	**-0.496**	**0.178**
$\Delta\rho^{\$}_{jt-2}$	0.072	-0.019	**1.936**	-0.560		0.056	0.099	**-0.126**	0.034
$\Delta\rho^{\$}_{jt-3}$	-0.228	-0.658	**-1.344**	-0.420		-0.016	-0.025	0.204	-0.046
$\Delta\rho^{\$}_{jt-4}$	-0.104	-0.156	-0.609	-1.484		**0.286**	0.071	0.035	0.137
$r^{\$}_{jt-1}$	**0.072**	**0.061**	**0.040**	**0.108**		-0.001	0.002	0.004	0.003
$\rho^{\$}_{jt-1}$	**-0.072**	**-0.061**	**-0.040**	**-0.108**		0.001	0.003	-0.004	-0.003
N	191	191	177	179		191	191	177	179
R^2	0.14	0.17	0.49	0.15		0.17	0.05	0.22	0.13
F	**3.29**	**4.17**	**18.19**	**3.28**		**4.17**	1.02	**5.13**	**2.75**

The coefficients on the lagged level variables are constrained to be equal in absolute value unless the restriction is rejected in the data. Coefficients in bold are significantly different from zero at the 95 percent level of confidence. Standard errors and other statistics from estimation are available on request.

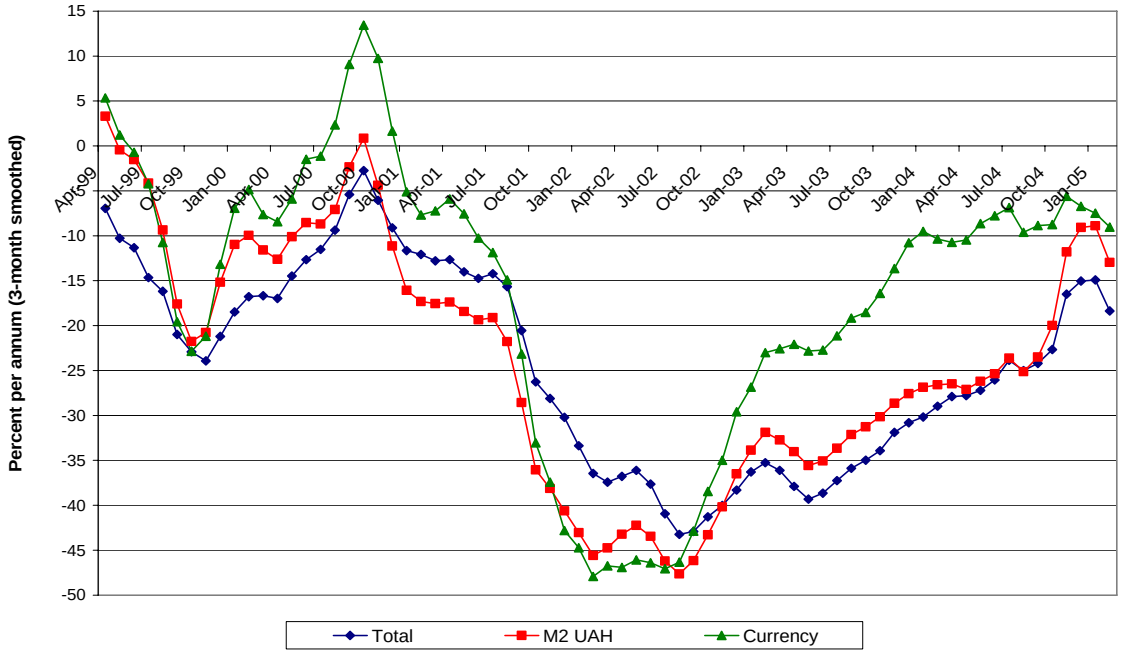
Table 4: Evolution of Overnight Rates in Kyiv				
	$\Delta\ln(1+r^{\$}_{1t})$		$\Delta\ln(1+r^{H}_{1t})$	
	Coefficient	Standard Error	Coefficient	Standard Error
Intercept	0.001	(0.001)	-0.04	(0.02)
$\Delta\ln(1+r^{H}_{1t-1})$	-0.0002	(0.007)	0.05	(0.10)
$\Delta\ln(1+r^{H}_{1t-2})$	0.004	(0.006)	-0.01	(0.09)
$\Delta\ln(1+r^{H}_{1t-3})$	0.005	(0.005)	-0.06	(0.08)
$\Delta\ln(1+r^{H}_{1t-4})$	0.004	(0.005)	**0.21**	(0.07)
$\Delta\ln(1+r^{\$}_{1t-1})$	-0.12	(0.09)	-1.59	(1.33)
$\Delta\ln(1+r^{\$}_{1t-2})$	-0.15	(0.09)	-1.44	(1.30)
$\Delta\ln(1+r^{\$}_{1t-3})$	**-0.28**	(0.09)	-1.51	(1.30)
$\Delta\ln(1+r^{\$}_{1t-4})$	-0.09	(0.09)	-1.58	(1.35)
$\Delta\ln(1+\rho^{\$}_{1t-1})$	-0.08	(0.16)		
$\Delta\ln(1+\rho^{\$}_{1t-2})$	-0.01	(0.19)		
$\Delta\ln(1+\rho^{\$}_{1t-3})$	-0.10	(0.19)		
$\Delta\ln(1+\rho^{\$}_{1t-4})$	-0.11	(0.15)		
$\ln(1+r^{H}_{1t-1})$	0.001	(0.006)	**-0.49**	(0.10)
$\ln(1+r^{\$}_{1t-1})$	-0.03	(0.04)	**1.34**	(0.44)
$\ln(1+\rho^{\$}_{1t-1})$	-0.005	(0.03)		
$\ln(e_t/e_{t-1})$				
$\ln(e_{t-1}/e_{t-2})$	-0.001	(0.001)	-0.02	(0.02)
$\ln(e_{t-2}/e_{t-3})$	0.001	(0.001)	-0.02	(0.02)
$\ln(e_{t-3}/e_{t-4})$	0.001	(0.001)	-0.02	(0.01)
$\Delta\ln(xc^{H}_{t-1})$			**1.47**	(0.60)
$\Delta\ln(xc^{\$}_{t-1})$	0.03	(0.03)		
$\Delta\ln(1+r^{d}_{t})$	-2.90	(6.23)	-169.03	(90.79)
L_t	0.02	(0.03)	0.54	(0.36)
N	202		188	
R^2	0.12		0.34	
F	1.10		**5.68**	

Coefficients significantly different from zero at the 95 percent level of confidence are printed in bold.

II. Exchange-Rate Stability, Monetary Growth and the Deposit Boom.

The econometric results from the previous section used high-frequency data to confirm the heuristic evidence of Figures 2 and 4: the hypothesis that the fixed exchange rate served as a nominal anchor to assure international parity in either the goods or financial markets is rejected. That leaves a broader question unanswered: while the fixed exchange rate did not ensure stability of commodity prices or interest rates, did it induce rapid growth and financial-market volatility in Ukraine over this five-year period through some other channel?

Figure 5: Various Measures of Velocity Growth in Ukraine



Source: National Bank of Ukraine

I will argue that it did so through bringing about a "deposit boom": by increasing the population's willingness to hold Ukrainian financial assets. The historical record of

velocity presented in Figure 5 illustrates this linkage.[15] The non-significance of money growth and economic growth in the inflation equation of Table 1 is manifest here as well in the instability of measures of velocity growth.[16] While the indicators of velocity differ in important respects, they share a strongly non-linear, and typically quite negative, growth over time. The negative velocity growth is a manifestation of the private sector's willingness to hold money, both currency and deposits, over and above the amount necessary for transactions purposes. This has two implications for economic behavior – the government has greater access to seigneurage as a financing source, and the banking system potentially plays a greater intermediating role in encouraging economic growth.

In this section I present a simple model of production and portfolio holding. It is not designed to describe all facets of the economy, but rather to show the links between productive and financial sectors that are important to this episode of fixed exchange rates. It will also serve as the template for econometric hypothesis tests.

Goods-market equilibrium. I summarize the real side of the economy quite simply.[17] There is productive capacity, and use of this capacity is dependent upon the availability of working capital as an input to the enterprise. The appendix provides a detailed exposition of such a model based upon the endogenous-degree-of-specialization

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[15] "Total" velocity growth uses M_2 inclusive of foreign time deposits as the money measure. The "M_2 UAH" velocity growth uses only the components of M_2 denominated in hryvnia. The "currency" velocity growth uses hryvnia currency in circulation as the money measure. All are created using the equation $(dv/v) = (dp/p) + (dy/y) - (dm/m)$, with m the money measure.

[16] The variable growth of velocity over this period implies an unstable money demand function. Oomes and Ohnsorge (2005) approach this in the case of Russia by creating an estimate of the stock of foreign exchange in circulation. By adding together the stock of local-currency-(in their case, ruble-) denominated monetary assets and the foreign-exchange monetary assets they find an aggregate with more stable behavior. From the point of view of the monetary authority, however, this leaves an important question unanswered: convincing the residents to hold resources in hryvnia-denominated instruments will have a seigneurage-windfall effect that is evident in the Ukrainian case.

[17] A version of this model is presented and analyzed in greater detail in Conway (2001).

model of Becker and Murphy (1992).[18] The enterprise has a demand for loanable funds L_t in period t derived from (6) that is increasing more than proportionally with output. $\kappa(\rho_t, y_t)$ can be interpreted as the demand for working capital as a ratio to final product and K_t represents the non-credit determinants of output.[19] Demand is summarized by absorption expenditure Z_t, government spending g_t and net exports x_t.

$$y_t = y(K_t, L_t) \tag{6}$$

$$L_t = \kappa(\rho_t, y_t, K_t)\, y_t \qquad \kappa_1 < 0, \kappa_2 > 0, \kappa_3 > 0 \tag{7}$$

$$Z_t + x_t + g_t = y_t \tag{8}$$

For the short horizon of the fixed exchange-rate episode in Ukraine, and given its history in transition, I assume that there is sufficient unused capacity to sustain the rapid growth observed over the period in question without investing in new machines or technology.

This equilibrium can be restated in terms of supply and demand for saving. Enterprise demand for saving is L_t. The government has its own demand for saving related to the social safety net assumed to equal a fraction γ_t of output.[20] The private supply of saving decision depends in theory not only upon current income, but also upon the real interest rate on saving and the value of accumulated wealth. I define real private

[18] Other specifications are possible to yield the same result: Roubini and Sala-i-Martin (1992) include the cost of credit in the (concentrated) production function, while Christiano and Eichenbaum (1992, 1995) follow Buffie (1984) and van Wijnbergen (1983) in including a cash-in-advance constraint in the production process.

[19] The enterprise will in general also have a demand for loanable funds to finance investment expenditure as well. This use of funds could be introduced without altering the results, but is excluded to retain the focus upon output contraction and the financial markets.

[20] This corresponds to a fiscal current deficit: expenditure not matched by tax revenues. Government expenditure to support state enterprises will enter identically to the present formulation of the enterprises themselves approaching the loanable-funds market.

saving in period t as a share σ_t of real income. The private saving share is increasing, ceteris paribus, in the real interest rate and is decreasing in the ratio of real accumulated wealth (A_{t-1}/P_t) to income.[21]

$$\sigma_t = \sigma(\rho_t, (A_{t-1}/P_t)/y_t) \qquad \sigma_1 > 0, \sigma_2 < 0 \qquad (9)$$

It will be useful to denote the wealth/income ratio as $r_t = (A_{t-1}/P_t)/y_t$ and the real value of accumulated wealth as $a_t = (A_t/P_t)$. The evolution of this wealth can be written

$$a_t = A_{t-1}/P_t + \sigma(\rho_t, r_t)y_t$$

or

$$a_t = a_{t-1}/(1+\pi_t) + \sigma(\rho_t, r_t)y_t \qquad (10)$$

with π_t denoting the rate of inflation in commodity price in period t relative to period t-1. This ratio is rising with past accumulated wealth, declining with a rise in current inflation, and rising with current real saving.

Equilibrium in the supply and demand for saving is ensured by

$$\gamma_t + \kappa(\rho_t, y_t) + x_t/y_t = \sigma(\rho_t, r_t) \qquad (11)$$

Increased wealth, increased net exports and increased government deficit have the expected effects on the real interest rate for given levels of y_t.[22]

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[21] There is a solid theoretical basis for the interest-rate elasticity of saving, but controversy over whether that effect is observed in practice. Giovannini (1985) rejected the conclusion of significant positive elasticity in an empirical sample of developing countries. Ostry and Reinhart (1992), in a dynamic analysis for a broader sample of developing countries, find significant positive interest-rate effects on saving.

Financial equilibrium. To simplify the problem for the moment, suppose that savers allocate private nominal wealth (A_t) to the holdings of currency (H_t), deposits (D_t) and foreign exchange (F_t).[23] The behavioral equations that characterize this allocation can be written

$$D_t = \alpha(\rho_t, y_t)\, A_t \qquad \alpha_1>0,\ \alpha_2<0 \qquad (12)$$

$$e_t F_t = \beta(\rho_t, y_t, \delta_t)\, A_t \qquad \beta_1<0,\ \beta_2>0,\ \beta_3>0 \qquad (13)$$

$$H_t = (1-\alpha(\rho_t, y_t)-\beta(\rho_t, y_t, \delta_t))\, A_t \qquad (14)$$

$$A_t = D_t + H_t + e_t F_t \qquad (15)$$

The shares α and β define the percent of private wealth allocated to deposits and foreign exchange, respectively. The real interest rate on domestic deposits ρ_t is equal to the nominal interest rate on those deposits (i_t) minus the domestic inflation rate (π_t). The real interest rate on foreign currency is equal to zero.[24] The depreciation rate for the hryvnia in terms of the US dollar is δ_t. The partial derivatives of α and β functions are indicated by subscripts corresponding to the position of the arguments and are governed by the adding-up constraints outlined in Tobin (1969). For given y_t and e_t, and for F_t and H_t determined at any point in time, equations (12) through (15) can be solved for endogenous variables D_t, δ_t, ρ_t, and A_t.

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[22] This relation can also be derived from (8), noting that $\gamma_t = (g_t-\tau_t)$, $\sigma_t y_t = y_t - c_t - \tau_t$ and $Z_t = c_t + \kappa(\rho_t, y_t) y_t$.

[23] The difference between hryvnia-denominated and USD-denominated deposits is introduced later.

[24] This instrument could equally well be thought of as land or some other asset in limited supply. The e_t will in that case be the market price of that asset.

The private saving ratio σ_t plays an important role in this portfolio allocation. Private saving is the source of the flow demand for financial assets as a whole, while stock-shifts from one asset to another occur in response to relative-price changes. These effects can be derived by differencing equations (12) through (14). They are deflated by the current price level to indicate comparable real values.

$$(H_t - H_{t-1})/P_t = - [\alpha(\rho_t,y_t)-\alpha(\rho_{t-1},y_{t-1}) + \beta(\rho_t,y_t,\delta_t)-\beta(\rho_{t-1},y_{t-1},\delta_{t-1})]\ r_t\ y_t + (1-\alpha(\rho_t,y_t)-\beta(\rho_t,y_t,\delta_t))\ \sigma(\rho_t, r_t)\ y_t \quad (16)$$

$$(D_t - D_{t-1})/P_t = [\alpha(\rho_t,y_t)-\alpha(\rho_{t-1},y_{t-1})]\ r_t y_t + \alpha(\rho_t,y_t)\ \sigma(\rho_t, r_t)\ y_t \quad (17)$$

$$(e_tF_t-e_{t-1}F_{t-1})/P_t = [\beta(\rho_t,y_t,\delta_t)-\beta(\rho_{t-1},y_{t-1},\delta_{t-1})]r_t y_t + \beta(\rho_t,y_t,\delta_t)\ \sigma(\rho_t,r_t)\ y_t \quad (18)$$

The first term on the right-hand side of these equations is the portfolio reallocation effect; it sums to zero across the three equations. The second term represents the allocation out of current saving, and sums to private saving across the three equations. In equilibrium, $(e_{t+1}-e_t)/e_t = \delta_t$.

There are separate equilibrium conditions in this financial market. The government finances its deficit through issuing bonds (B_t) but cannot borrow from commercial banks. Enterprises, by contrast, are able to borrow from the commercial banking system. Net exports augment the holdings of foreign currency domestically.[25] Finally, equation (22) represents the change in the balance sheet of the NBU. Its assets are its holdings of foreign exchange (FN_t), its credits to commercial banks (BC_t) and its

[25] This is a strong simplification. It neglects direct foreign investment, for example, or Ukrainian portfolio investments abroad.

holdings of government bonds (B_t). Its liabilities are currency in circulation (H_t) and deposits by commercial banks (BD_t). It also has reserve funds (R_t).

$$\gamma_t y_t = (g_t - \tau_t) y_t = (B_t - B_{t-1})/P_t \quad (19)$$

$$\kappa(\rho_t, y_t) y_t = (D_t - D_{t-1})/P_t \quad (20)$$

$$x_t = (e_t F_t - e_{t-1} F_{t-1})/P_t \quad (21)$$

$$(e_t FN_t - e_{t-1} FN_{t-1}) + (BC_t - BC_{t-1}) + (B_t - B_{t-1}) = (H_t - H_{t-1}) + (BD_t - BD_{t-1}) + (R_t - R_{t-1}) \quad (22)$$

FN_t represents the share of foreign exchange held at the NBU as reserves, and as such will be less than or at most equal to F_t. If we simplify (22) by setting $(e_t FN_t - e_{t-1} FN_{t-1}) = (BC_t - BC_{t-1}) = (BD_t - BD_{t-1}) = (R_t - R_{t-1}) = 0$, the simplified (22) can be combined with (19) to describe the usual seigneurage episode: the government budget deficit is financed ultimately by the issuance of currency. In Ukraine, though, this simple story does not apply due to the NBU stable exchange rate policy.

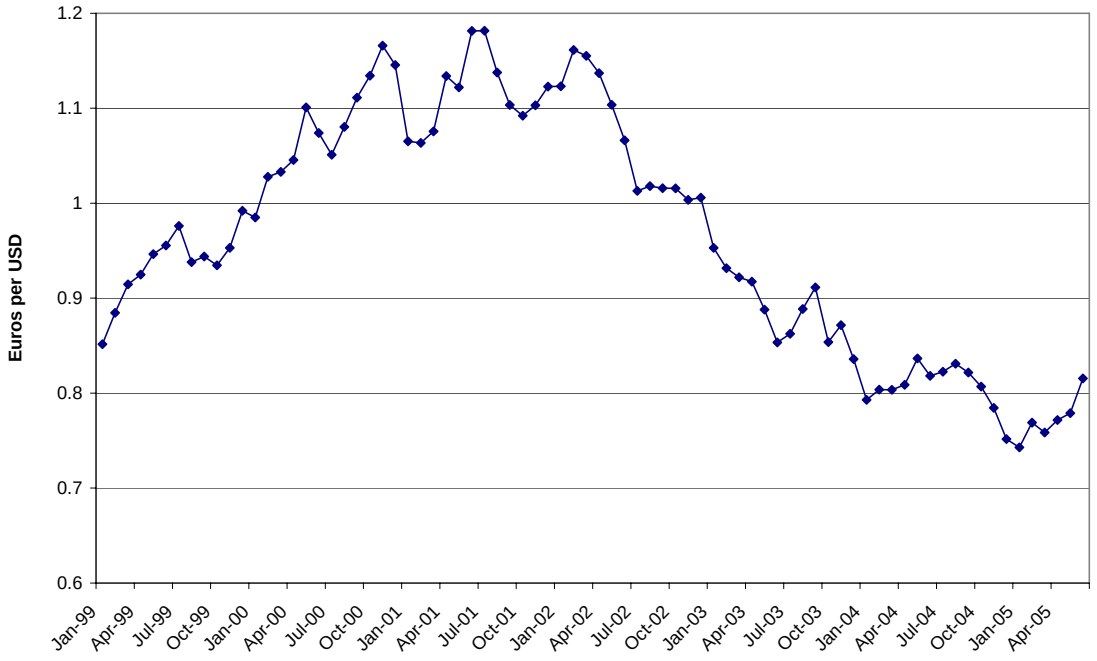
Impact of establishing a fixed exchange rate. In the Ukrainian case, the NBU's policy shift changed a steadily depreciating exchange rate to a fixed exchange rate (with the US dollar). As is evident in (13), the impact effect of this shift is an attempted reallocation of the private portfolio from holding F_t to holding D_t and H_t (from equation (14)). The NBU will stand ready to trade H_t for F_t to ensure the fixed rate. The private portfolio holders will then deposit a portion of the H_t in the bank to increase D_t as well. If commercial banks are willing to absorb the new deposits at the current real interest

rate, there will be no effect on ρ_t, while if the banking system is unwilling there will be a drop in ρ_t and consequent additional adjustment in portfolio shares.

The dynamic effects of the policy shift over time stem from three sources. Suppose that the fixed exchange rate is set at a historically undervalued level. First, there will be increased export growth and consequent output growth. This will ceteris paribus raise ρ_t to entice greater saving. Second, the current-account surplus leads to an inflow of foreign currency F_t. Portfolio holders exchange parts of this flow with the NBU for greater holdings of H_t and D_t, either expanding FN_t (the official reserves at the NBU) or through direct deposit into USD-denominated deposits at commercial banks. Third, the policy shift will have an effect on private saving, either directly through creating increased confidence in financial stores of value or indirectly through the impact on the real interest rate.

The NBU choice of parity of hryvnia with the US dollar in late 1999 did not seem calculated to be undervalued. However, the fixed exchange rate may have been expansionary during the later years of this period for reasons outside NBU control. The increase in current account surpluses in 2003-2005 coincided with the depreciation of the US dollar against the Euro. Figure 6 illustrates this movement: since Ukraine's largest Western markets transact in Euros, the USD movement against the Euro during this period created a price advantage for Ukrainian goods. Ukraine's timing was fortuitous. Its initial decision to fix to the USD corresponded with a period of strength of the US dollar relative to the Euro, and this provided a derived strength to the hryvnia as a store of value. The depreciation of the US dollar against the Euro then provided a strong export-led growth boost to Ukrainian output.

Figure 6: the USD/EURO Exchange Rate



Source: Datastream

The NBU served as a critical component of financial-market adjustment. For this period the balance-sheet adjustment can be represented approximately as

$$(e_t FN_t - e_{t-1} FN_{t-1}) + (B_t - B_{t-1}) \approx (H_t - H_{t-1}) \qquad (22a)$$

The government's budget was largely in balance or surplus during this period, so that (B_t-B_{t-1}) was negative on average.[26] The government's commitment to a fixed exchange rate, however, meant that the money in circulation rose proportionally to the value of foreign-

[26] There is an important qualification to this. In the last half of 2004 the government introduced a much more expansionary fiscal policy, and as end result the consolidated budget in 2004 moved strongly into deficit. This expansionary policy had the earmarks of a political business cycle, since the government of Prime Minister Yanukovych was enmeshed in a tight struggle with former Prime Minister Yuschenko for the Presidency. This election, and the claims of improprieties during the election, led to the events of the Orange Revolution.

exchange reserves. The population's desire to rebalance portfolios toward HRV-denominated assets led to growth in FN_t and then to growth in currency in circulation.

III. Testing the deposit-boom hypothesis.

There are three components to the deposit-boom hypothesis, and I consider them in turn.

The credit-growth nexus. One building block to the deposit-boom hypothesis is the contribution of working capital to the production process as outlined in equations (6) through (8). In Table 5 I test the strength of the credit-growth linkages against both exports and fiscal expansion as determinants of real economic growth. The three equations reported in the table are estimated as a system.

The first two columns of the table report the coefficients and standard errors for the growth equation. There is a strong autoregressive component to real economic growth, as indicated by the significant coefficients on $g(y_{t-1})$ of 0.61 and $g(y_{t-3})$ of 0.26. There is also a significant impact of increased real credit growth on economic growth, with the coefficients of both $g(CR_{t-1})$ and $g(CR_{t-2})$ equal to 0.03. Concurrent increases in the current account (ΔCA_t) and the budget surplus to GDP ratio (b_t/y_t) both have coefficients that are insignificantly different from zero, and the current-account effect also has the wrong sign.

The third and fourth columns of the table present a parallel description of the determinants of real credit growth. There is a significant autoregressive component, as indicated by the coefficient 0.57 on $g(CR_{t-1})$, but credit growth is not itself "caused" by economic growth. (We return to determinants of credit growth in the next section.)

Table 5: **Estimation of the credit-growth nexus**						
	$g(y_t)$		$g(CR_t)$		ΔCA_t	
Explanatory Variables	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Intercept	**-1.65**	0.51	**11.40**	5.75	-0.13	6.50
$g(y_{t-1})$	**0.61**	0.07	0.35	0.84		
$g(y_{t-2})$	-0.11	0.07	0.44	0.64		
$g(y_{t-3})$	**0.26**	0.05	-0.48	0.35		
$g(CR_{t-1})$	**0.03**	0.01	**0.57**	0.09		
$g(CR_{t-2})$	**0.03**	0.02	-0.02	0.07		
$g(CR_{t-3})$	0.01	0.01	0.17	0.10		
ΔCA_t	-0.57	0.33				
ΔCA_{t-1}					**1.42**	0.03
ΔCA_{t-2}					**-0.78**	0.03
$\Delta b_t/y_t$	-0.05	0.05				
ε_t					**-0.41**	0.20
ε_{t-1}					-0.002	0.17
ε_{t-2}					-0.33	0.21
R^2	0.89		0.46		0.94	
N	69		69		69	
Objective	0.43					

GMM Estimation. Coefficients significantly different from zero at 95 percent level of confidence are indicated in bold.

Correlation of contemporaneous errors:

	$g(y_t)$	$g(CR_t)$	ΔCA_t
$g(y_t)$	1.0	0.22	-0.06
$g(CR_t)$	0.22	1.0	0.19
ΔCA_t	-0.06	0.19	1.0

Correlation of errors from systems estimation in Table 5. None of these correlation coefficients is significantly different from zero at the 95 percent confidence level.

The final two columns of Table 5 illustrate the determinants of changes in the current account. There is, once again, a strong autoregressive component with significant coefficients 1.42 and -0.78 on ΔCA_{t-1} and ΔCA_{t-2}. The final determinant is the Euro-USD exchange rate (ε_t). Appreciation of ε_t has a significant expansionary effect on the

Ukrainian current account, as indicated by the coefficient -0.41, because the hryvnia is fixed in value to the US dollar during this period. There are similar expansionary effects with a lag, but these are not significantly different from zero.

The credit-growth nexus can be summarized as follows. When alternative theoretical explanations for economic growth are considered, only the positive impact of credit expansion on economic growth is found to be statistically significant. The impact of expansionary fiscal policy has the correct sign, but is insignificantly different from zero. The impact of expanding exports enters insignificantly, but takes the wrong sign. (I will investigate as well the expansionary effect of a current account surplus through the portfolio channel, as discussed below.)

The regressions reported in Table 5 take a vector autoregressive form, and as such do not address the question of contemporaneous correlations. In the final panel of Table 5, I report the correlation of the errors from the three equations. These illustrate the contemporaneous covariation of the errors with one another. There are no significant correlations among the residuals. As expected, real credit growth and real economic growth are positively covarying; so also are real credit growth and the current account surplus. None of these results suggests a contradiction to the conclusions drawn from the top panel of Table 5.

The credit-deposit nexus. The second component of the deposit-boom hypothesis is found in the credit-deposit nexus. A positive innovation in deposit growth will translate into a positive innovation in credit growth.

Commercial banks act as intermediaries on the financial markets: they accept deposits and extend credits. In Ukraine, both depositors and creditors have a choice of

denomination in their transactions. Table 6 illustrates the magnitude and denomination of both "credits to the economy" and "deposits of enterprises, institutions and households" in the commercial banking system.[27] The first set of columns describes credits granted by commercial banks. The share of commercial-bank credits in GDP has risen throughout the period in question, from 9 percent in 1999 to 36 percent in 2005. The share of HRV credits declined over time, from 75 percent in 1996 down to 48 percent at the end of 1999 and rising slightly to 57 percent at the end of 2005.[28] The second set of columns presents the liabilities of the commercial banks. Deposits as a percent of GDP rose from 9.3 percent in 1999 to 33.2 in 2005. The share of HRV liabilities remained fairly steady throughout, ending in 2005 at 66 percent.

Table 6: Total Credits and Deposits of the Commercial Banks

	Credits			**Deposits**		
	Value	HRV share	Percent of GDP	Value	HRV share	Percent of GDP
1996	5452	0.75	6.7	5145	0.69	6.3
1997	7295	0.71	7.8	6357	0.74	6.8
1998	8873	0.58	8.6	8278	0.60	8.0
1999	11787	0.48	9.0	12156	0.56	9.3
2000	19574	0.54	11.5	18739	0.62	11.0
2001	28373	0.56	13.9	25674	0.68	12.6
2002	42035	0.58	18.6	37715	0.62	16.7
2003	67835	0.58	25.4	61617	0.68	23.0
2004	91769	0.59	25.7	82959	0.64	24.0
2005	143418	0.57	35.8	132745	0.66	33.2

Source: National Bank of Ukraine

Two features stand out in this table. First, there has been remarkable growth in the financial intermediation of the economy. Both assets and liabilities of commercial

[27] These credits exclude "net credit to the government" from commercial banks. This was a relatively small amount throughout the period studied.

[28] Decomposition of credits into short-term (less than or equal to one year maturity) and long-term (greater than one-year maturity) illustrates that short-term credits remain predominantly HRV while long-term credits are nearly 50 percent USD.

banks grew rapidly in absolute terms and relative to nominal GDP. Second, the deposits denominated in foreign currency did not keep up with the credits extended in foreign currency.

Credit/deposit equilibrium as presented in (20) indicates a simultaneous determination of credit, deposit and real interest rate. Table 7 reports the results of estimating a system including endogenous variables real credit growth ($g(CR_t)$), real deposit growth ($g(DEP_t)$) and changes in the 30-day real interest rate on interbank credits. Real deposits and credits are specified in an error-correction framework, with the addition of the contemporaneous interest rate jointly estimated in the system.

The first two columns indicate the evolution of deposit growth. There is a significant autoregressive effect. Two-period past growth in real credit does have a significant negative effect on current real growth in deposits, but the joint impact of the three lags is positive (though insignificantly different from zero). There is a significant error-correction effect, indicating that any deviation from the long-run ratio of credits to deposits is 20 percent erased through movements in real deposits.

The third and fourth columns consider credit growth. Our hypothesis suggests that credit growth will be spurred by deposit growth, and that is clearly evident in the estimates. A positive 10-percent shock to real deposit growth will over the next three months lead to a 4.4-percent increase in real credit growth. Further, any deviation of the credit/deposit ratio from its long-run value will be 80 percent made up through adjustments in real credit growth. (The two error-correction effects suggest that all of the deviation from the long-run ratio will be made up in the next year, with the real credit growth adjusting four times as much as real deposit growth.)

The real interest rate is also modeled in error-correction form. There are significant autoregressive effects, and there is also a significant error-correction term. The notion of uncovered interest parity is rejected, once again, as the 30-day interest rate on USD-denominated credits in London enters with negative and significant coefficient. The contributions of the real interest rate to the credit and deposit growth equations also are contrary to theory: the sign in the deposit equation should be positive, while the sign in the credit equation should be negative.

Table 7: **Estimation of the credit-deposit nexus**

	$g(DEP_t)$		$g(CR_t)$		$\Delta\rho_{30t}$	
Explanatory Variables	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Intercept	**8.14**	2.31	**17.55**	3.01	**1.88**	0.36
$g(DEP_{t-1})$	**0.74**	0.08	**0.47**	0.05		
$g(DEP_{t-2})$	0.02	0.06	**-0.13**	0.05		
$g(DEP_{t-3})$	-0.004	0.06	-0.10	0.06		
$g(CR_{t-1})$	0.06	0.05	**0.27**	0.05		
$g(CR_{t-2})$	**-0.09**	0.04	0.06	0.04		
$g(CR_{t-3})$	0.06	0.03	**0.18**	0.04		
$\Delta\rho_{30t}$	-0.02	0.03	**0.33**	0.03		
$\Delta\rho_{30t-1}$					**0.29**	0.03
$\Delta\rho_{30t-2}$					**0.14**	0.02
ρ_{30t-1}					**-0.27**	0.02
$\ln(CR_{t-12})$-$\ln(DEP_{t-12})$	**0.200**	0.08	**-0.86**	0.12		
$\Delta\rho^*_{30t}$					**-2.48**	1.07
R^2	0.52		0.63		0.36	
N	69		69		69	
Objective	0.44					

GMM Estimation. Coefficients significantly different from zero at 95 percent level of confidence are indicated in bold.

Correlation of contemporaneous errors:

	$g(DEP_t)$	$g(CR_t)$	$\Delta\rho_{30t}$
$g(DEP_t)$	1.0	**0.74**	-0.05
$g(CR_t)$	**0.74**	1.0	0.08
$\Delta\rho_{30t}$	-0.05	0.08	1.0

Correlation of errors from systems estimation in Table 7. Correlation coefficients significantly different from zero at the 95 percent confidence level are indicated with bold.

The contemporaneous correlations reported in the final panel indicate a positive contemporaneous covariation of deposit and credit growth residuals. While there is no presumption of causality, the evidence from lagged effects suggests that this too may be consistent with the hypothesis that real deposit growth causes real credit growth through bank intermediation.

The seigneurage boom. Figure 7 illustrates the evolution of seigneurage over time.[29] There was a substantial shift in 1999 toward greater seigneurage as a share of consolidated budget expenditures. However, the consolidated government budget in Ukraine was in surplus for much of the period in question, and so the deposit boom represents an atypical example of seigneurage.

As Agenor and Montiel (1996, p. 111) define it, seigneurage is "the amount of real resources appropriated by the government by means of base money creation". In the typical case (Agenor and Montiel, 1996, chapter 4) the government uses the proceeds from seigneurage to finance a government budget deficit. The Ukrainian government did not have this need, in part due to substantial non-tax revenues during this period.[30] Rather, as (22a) illustrates, the appropriated real resources were added to central bank assets in the form of increased holdings of foreign exchange-reserves. Seigneurage in this instance represents accumulated real resources for future use.

Sources of the deposit boom. The rapid growth in deposits has already been documented in Table 6. The previous section, including Table 7, documented the link between deposits and credits. The final piece of the puzzle must explain the growth of

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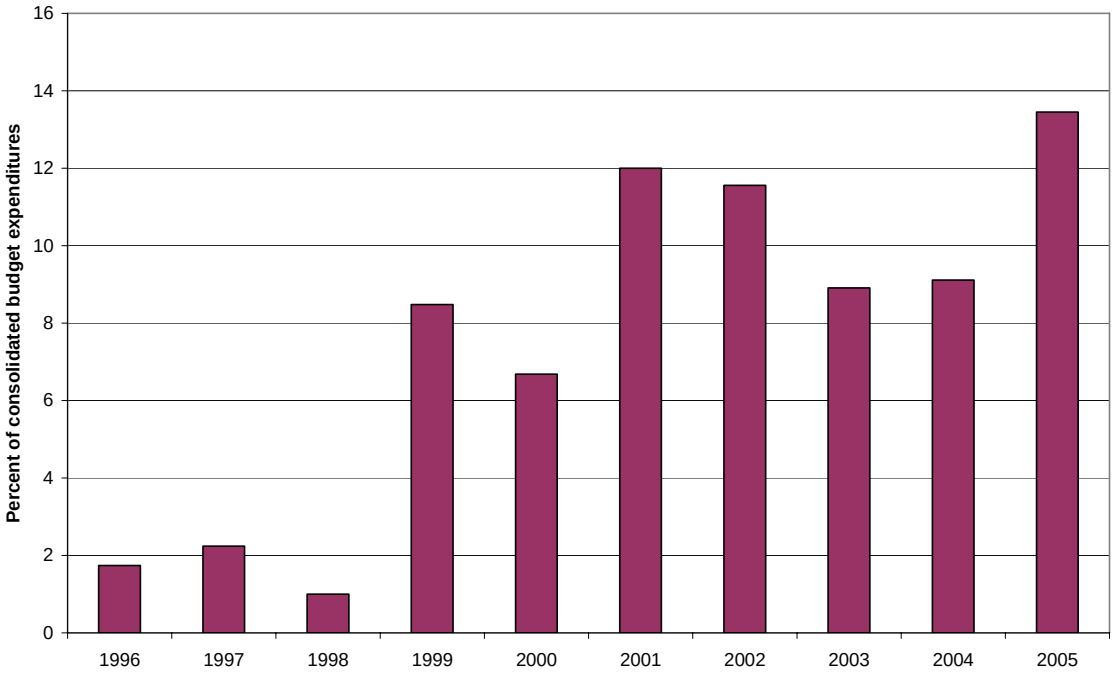
[29] Seigneurage is calculated as the change in nominal currency in circulation per annum divided by the nominal consolidated government expenditures of that year.

[30] In 2005, for example, 27 percent of consolidated government revenues were non-tax revenues. These were primarily privatization proceeds: privatization of Kryvorizhstal alone (to Mittal Steel) was 18 percent of consolidated government revenues.

deposits. Theory suggests (as in equations (16)-(18)) that the growth of deposits at a more rapid rate than output could be due to (a) a stock-shift of portfolio holding away from other assets to deposits or (b) an increase in the saving rate.

Figure 7: Seigneurage in Ukraine

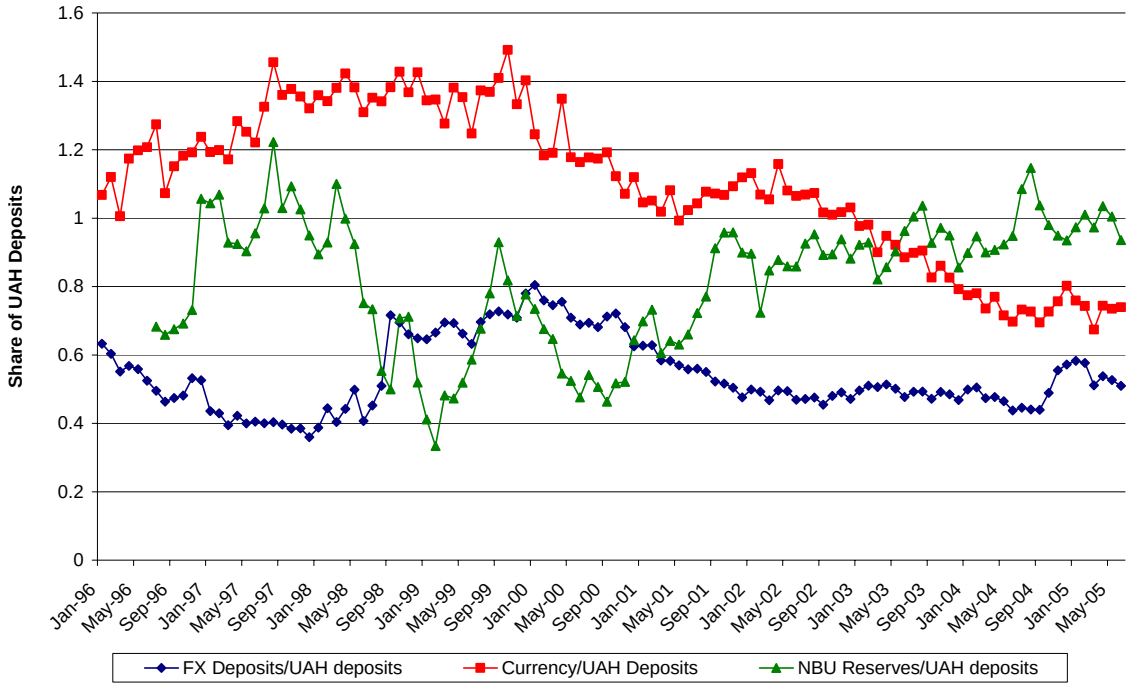


Source: National Bank of Ukraine

In Figure 8 I illustrate the evolution of portfolio holdings from beginning-1996 to mid-2005. The two downward-sloping lines represent the ratios of currency holdings (the upper) and USD-denominated deposit holdings (the lower) to hryvnia-denominated deposit holdings. There is a rising trend in each until late 1999 and then a downward trend thereafter. The period immediately prior to introduction of the fixed exchange rate was characterized by increased holdings of currency and foreign-currency deposits relative to hryvnia-denominated deposits. The fixed exchange rate had the initial effect of encouraging USD-denominated deposits, but shortly thereafter the hryvnia-

denominated deposits gained steadily relative to the other two portfolio assets. Despite the massive gain in currency in circulation over the fixed-rate period (as evidenced in the seigneurage boom), the growth in hryvnia-denominated deposits strongly exceeded it. There were more modest gains in hryvnia-denominated deposits relative to USD-denominated deposits, although those gains were largely completed by the beginning of 2002. The portfolio shares of local and foreign-currency deposits remained quite stable until the Orange Revolution, when there was a flight from hryvnia deposits both to USD-denominated deposits and currency.

Figure 8: Shifting Portfolio Shares in Ukraine



Source: National Bank of Ukraine

The fundamental difficulty in portfolio analysis for Ukraine is the lack of information on the volume of total holdings F_t of foreign currency. The sole proxy available is the NBU holdings of foreign-exchange reserves FN_t. The last line in Figure 9

illustrates the ratio of FN_t to hryvnia-denominated deposits.[31] NBU reserves were declining on average from 1996 through the introduction of the fixed exchange rate in mid-1999. The first decline corresponds to NBU intervention to stabilize the hryvnia in the aftermath of the Russian financial crisis. There is a temporary spike as the NBU announces its goal to stabilize the value of the currency, but only in 2000 does the NBU begin to accumulate reserves – and at that time it accumulates them even more rapidly than the private sector collects hryvnia deposits. This accumulation corresponds to the emission of currency into circulation, and thus provides a mirror image in this period to the currency share.

The theory of the previous sections suggests that currency holdings will evolve with the interventions of the monetary authorities. With the fixed exchange rate, this increase in currency in circulation will be triggered by two flows: the flows out of domestic holdings of foreign exchange and the capital inflows from current account surpluses. Private portfolio holders will convert a given fraction of receipts into currency and will then choose between currency and deposits based upon portfolio preferences. The spikes in NBU reserve holdings in Figure 8 are the stock-shift decisions of portfolio holders to reallocate their assets away from US dollars toward hryvnia-denominated assets. These are observed in mid-1997, as portfolio holders fled the Russian ruble; and in late 1999, as portfolio holders responded to the announcement of the fixed exchange rate. Table 8 reports the results of estimating a system of equations with real growth in deposits and currency in circulation. Two candidates are considered for the positive shock to assets: shocks to the current account, and shock to fiscal policy. Expanding the fiscal surplus will cause a reduction in growth in currency in circulation. Expanding the

[31] The reserves are converted to hryvnia for comparison at the NBU exchange rate.

current account surplus will in theory increase the holdings of deposits, and through the fixed exchange rate also lead to an increase in currency in circulation. There is a crucial difference between the two types of assets, because deposits facilitate intermediation while currency holdings do not.

The last two columns describe the growth in real currency in circulation. The story is quite simple: growth in real currency follows an autoregressive process, but other variables play no significant role in that growth rate. Current-account surpluses enter with ambiguous sign, but always insignificantly. While the contemporaneous effect is the expected positive sign, the sum of the three effects is negative. The impact of budget surpluses on real growth of currency in circulation has the expected negative sign, both contemporaneously and in aggregate, but the effects are insignificantly different from zero.

The growth in real deposits, reported in the first two columns, also takes a form consistent with theory. It has a significant first-order autoregressive form. Past growth in currency in circulation leads to current growth in deposits in a form of portfolio shifting. Increased current-account surpluses lead to a reduction in the real growth of deposits, although this effect is insignificantly different from zero. An increase in budget surpluses has a negative contemporary effect, but an aggregate positive effect over three years.

When the deposit/currency ratio deviates from its long-run value, deposit-holding adjusts to bring it back into line. The error-correction coefficient of -0.43 indicates that 43 percent of any deviation from the long-run ratio is made up in a single year. The analogous statistic for currency-holding indicates no significant adjustment of the stock of currency toward that long-run value.

Table 8: **The Diffusion of Liquidity**				
	$g(DEP_t)$		$g(H_t)$	
Variables	Coefficient	Standard Error	Coefficient	Standard Error
Intercept	**10.13**	3.01	7.40	3.99
$g(DEP_{t-1})$	**0.67**	0.16	-0.07	0.11
$g(DEP_{t-2})$	0.10	0.15	-0.09	0.18
$g(DEP_{t-3})$	0.21	0.14	0.08	0.18
$g(H_{t-1})$	**0.23**	0.08	**0.70**	0.14
$g(H_{t-2})$	**-0.22**	0.09	-0.12	0.10
$g(H_{t-3})$	**0.19**	0.08	0.24	0.13
$\ln(DEP_{t-12})-\ln(H_{t-12})$	**-0.43**	0.10	0.02	0.10
ΔCA_t	-2.25	17.09	4.13	25.52
ΔCA_{t-1}	-3.50	21.90	-16.11	36.66
ΔCA_{t-2}	-1.78	13.78	6.51	18.59
b_t/y_t	-0.23	0.39	-0.49	0.30
b_{t-1}/y_{t-1}	-0.50	0.55	-0.29	0.68
b_{t-2}/y_{t-2}	**1.00**	0.36	0.46	0.44
R^2	0.74		0.68	
N	69		69	
Objective	0.08			

GMM Estimation. Coefficients significantly different from zero at 95 percent level of confidence are indicated in bold.

Correlation of contemporaneous errors:

	$g(DEP_t)$	$g(H_t)$
$g(DEP_t)$	1.0	**0.29**
$g(H_t)$	**0.29**	1.0

Correlation of errors from systems estimation in Table 7. Correlation coefficients significantly different from zero at the 95 percent confidence level are indicated with bold.

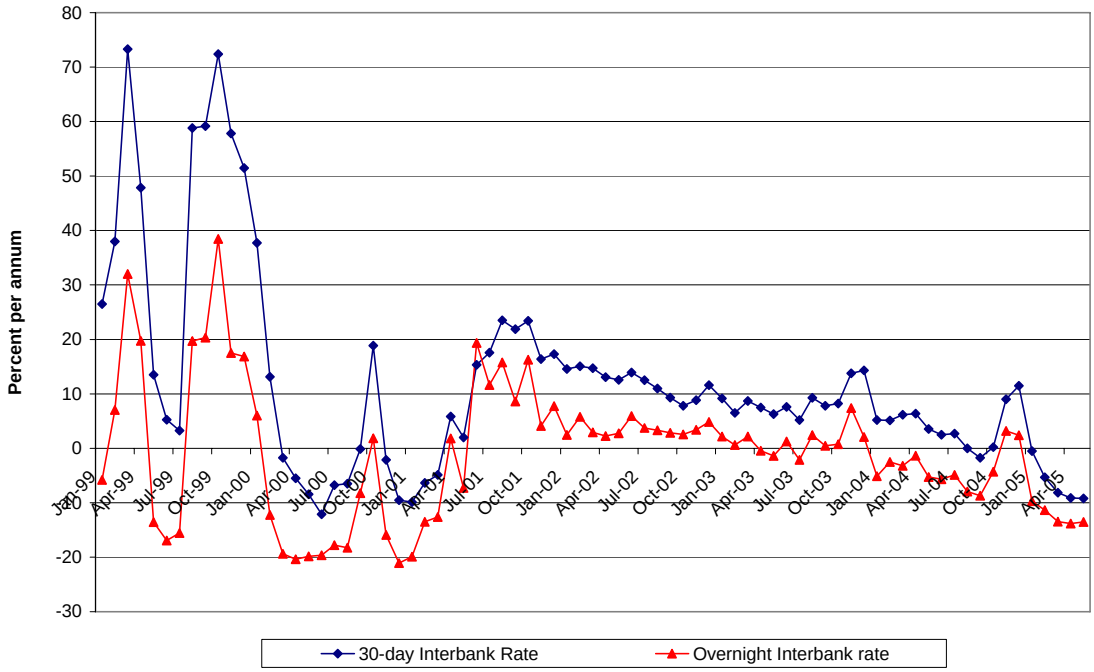
IV. Implications for monetary policy, credit policy and interest rates.

The fixed exchange-rate regime is the monetary policy of Ukraine during this period. However, the lack of financial-market integration demonstrated in section I implies that the NBU has the power to operate a credit policy independent of that of the European or US financial markets. The NBU has not evidently taken advantage of this power, with the end result of gradually increasing "excess liquidity" that depresses nominal interest rates and yields negative real interest rates.

The period of fixed exchange rate in Ukraine has been coincident with two cycles in real interest rates. In the first period (from May 1999 to April 2001), the announcement of the fixed exchange rate policy brought about sharply positive real interest rates. Figure 9 illustrates this using monthly averages of the 30-day and overnight interest rates from hryvnia-denominated credits on the Kyiv Interbank market and the consumer price inflation rate. From that high, the real interest rates followed a steady downward trend, broken only by a temporary spike in October 2000. In mid-2001 strongly positive real interest rates were re-established; these declined steadily thereafter. By the end of 2003 the real interest rate in the overnight market was negative, and by the end of 2004 the real interest rate was also negative on the 30-day rate. The negative tendency in this second period was less abrupt, but ended with the same result – negative real interest rates.

The NBU had in place instruments to control the expansionary credit policy of this period, but for the most part did not use them. Figure 10 illustrates three HRV interest-rate series: the Lombard rate, the discount rate, and the overnight inter-bank offer rate. All are daily observations.

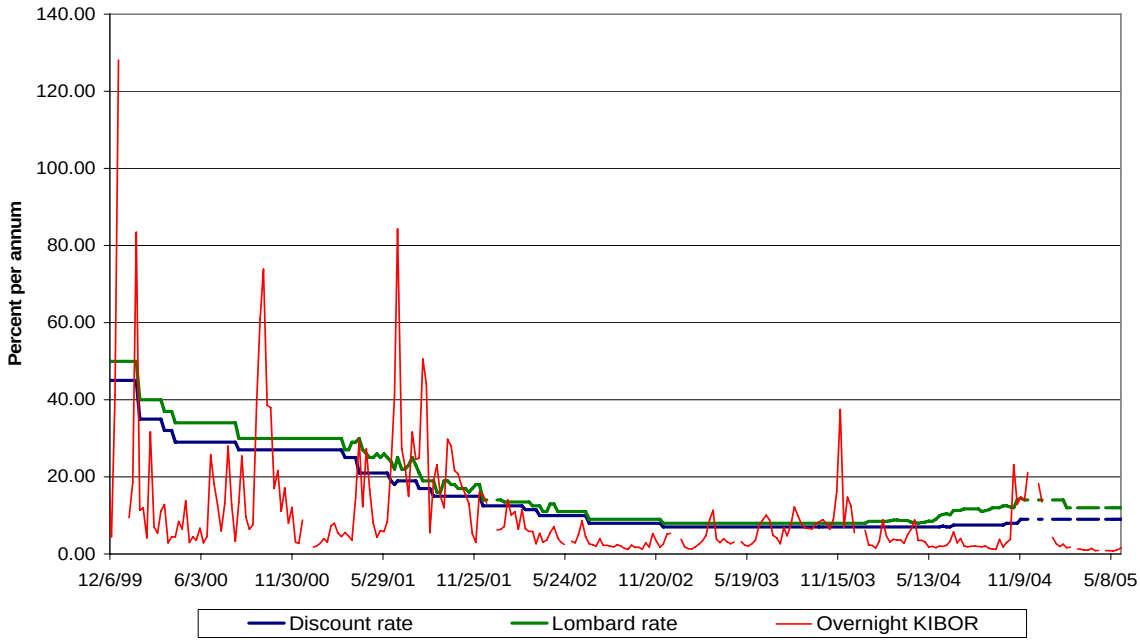
Figure 9: Evolution of the Real Interest Rate



A number of transition economies (e.g., Poland) has been successful in controlling interest rates on credits by introducing the "channeling" policy of Woodford (1991). With this policy, the discount and Lombard rates represent bounds on the overnight rate: the central bank stands ready to provide funds at the Lombard rate, or accept funds at the discount rate. In these countries, the "discount-Lombard channel" contains the overnight interest rate. As is evident from Figure 11, the "discount-Lombard channel" did not form firm bounds on the overnight inter-bank rate in Ukraine. Rather, it is evident that the NBU maintained a sporadically active Lombard facility (and from mid 2001 an overnight credit facility). Its issuance of credits to stanch excess demand was especially evident in 2001 and 2003, but even there the NBU issuance was insufficient to forestall a spike in

nominal interest rates.[32] The dominant tendency in the data, however, is an inter-bank rate substantially less than the discount rate.

Figure 10: Overnight Interbank Rates, with Lombard and Discount Bounds



Sources: National Bank of Ukraine, author's database

Excess liquidity. Does the fixed-rate regime necessarily lead to excess liquidity and negative real interest rates? The totals of credits and deposits in Table 6 indicate an excess demand for credits throughout the period. The percentage in hryvnia-denominated credits and deposits, however, suggests a more nuanced story. Figure 11 illustrates the excess supplies (deposits minus credits) to commercial banks for HRV and USD instruments at a monthly frequency. The variable xc_t is the excess demand for total credit in period t.[33] The variable $xc^{\$}_t$ is the excess demand for USD credits in period t, and xc^{H}_t

[32] IMF (2004) has a more detailed discussion of this intervention.

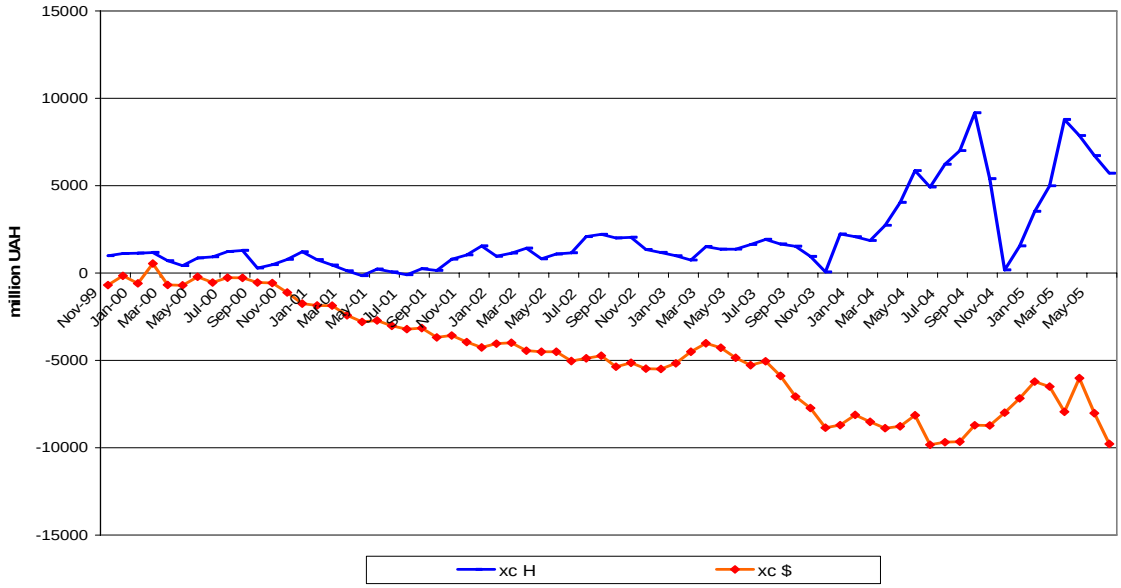
[33] This is measured as a percentage of deposits. If total credits of commercial banks are denoted cr_t and total deposits are dep_t, then $xc_t = (cr_t - dep_t)/dep_t$. The HRV and USD components are defined analogously.

is the excess demand for HRV credits in period t. There is a sustained excess demand for USD credits in the commercial banking system – more USD credits are issued than USD deposits are received. There is also a sustained excess supply of HRV credits, with deposits in general exceeding demands for HRV credits. The net effect of the two is that of excess demand for credits. While there was an excess supply of credits overall prior to September 2000; only in October 2004 and March-April 2005 was the excess supply of credit observed again. This mismatch of denominations is associated with its expected effect – interest rates on hryvnia-denominated interbank credits fall below the interest rates on equivalent-maturity USD-denominated interbank credits. This was also the message when xc^H_t was included in the regressions of Table 4.

The excess supply evident in the commercial bank balance sheets does not characterize the financial market as a whole. The commercial banks use NBU refinancing in hryvnia-denominated credits to bring overall supply and demand into balance. This implies a convertibility risk to the commercial banks, though, as their balance sheets are "long" in USD-denominated assets and "short" in hryvnia-denominated assets. Due to this, the banks build in a convertibility premium in their USD-denominated lending (see Conway (2006)). The currency mismatch in credits, however, perpetuates the "excess liquidity" in hryvnia-based instruments.

The NBU balance sheet illustrated in equation (22) suggests a solution for the "excess liquidity" outcome. While currency issuance is used to maintain the fixed exchange rate, the NBU discount window can be used to absorb excess hryvnia-denominated credit as BD_t. The NBU can then open a separate Lombard-like window in US dollar-denominated credits to meet the excess demand for these as BC_t.

Figure 11: Excess Supply of Funds to Commercial Banks



Source: National Bank of Ukraine

Why is there a preference for hryvnia-denominated deposits? To investigate this, I estimate explanatory equations for two ratios. The variable cr_t is the ratio of hryvnia-denominated credits to USD-denominated credits extended by the banking system. The ratio dr_t is the ratio of hryvnia-denominated deposits to USD-denominated deposits extended by the banking system. Theory suggests that, due to multi-month contracts, the ratios will exhibit inertia. An increase in the exchange-rate adjusted interest rate on USD-denominated deposits should increase the credit ratio and reduce the deposit ratio. Table 9 reports estimation results on monthly data from end-1999 to mid-2005.

Table 9: **Determinants of Credit and Deposit Ratios**			
	Δcr_t		Δdr_t
Intercept	0.002		-0.001
	(0.004)		(0.005)
Δcr_{t-1}	**-0.45**		
	(0.14)		
Δcr_{t-2}	-0.32		
	(0.17)		
Δcr_{t-3}	**0.32**		
	(0.15)		
Δdr_{t-1}			0.02
			(0.12)
Δdr_{t-2}			-0.19
			(0.12)
Δdr_{t-3}			**0.42**
			(0.13)
$\Delta(r^{H}_{t-1}-r^{\$}_{t-1})$	0.07		-0.03
	(0.05)		(0.06)
$\Delta(r^{H}_{t-2}-r^{\$}_{t-2})$	-0.03		0.03
	(0.05)		(0.06)
$\Delta(r^{H}_{t-3}-r^{\$}_{t-3})$	**-0.18**		0.07
	(0.05)		(0.06)
$\Delta \pi_{t-1}$	0.004		-0.004
	(0.003)		(0.003)
$\Delta \pi_{t-2}$	**-0.01**		-0.001
	(0.003)		(0.004)
$\Delta \pi_{t-3}$	0.004		-0.002
	(0.003)		(0.004)
$\Delta\varepsilon_{t-1}$	**-0.09**		-0.03
	(0.02)		(0.02)
$\Delta\varepsilon_{t-2}$	**-0.11**		**-0.07**
	(0.02)		(0.02)
$\Delta\varepsilon_{t-3}$	**-0.08**		-0.03
	(0.02)		(0.02)
N	68		69
R^2	0.51		0.34
F	**4.92**		**2.40**

Standard errors in parentheses. Coefficients in bold are significantly different from zero at the 95 percent level of confidence.

There is evidence of inertial evolution of the two ratios over time. In the credit ratio, positive shocks in previous periods lead to negative movements in the ratio in the current period – a type of reversion toward the mean. In the deposit ratio, by contrast, there is an explosive effect with past positive shocks to the deposit ratio causing further positive effects in the present. Changes in relative interest rates have the expected effect on the credit ratio; as the exchange-rate adjusted differential between hryvnia-denominated and USD-denominated interest rates rises, the credit ratio falls. This opposite is observed in the deposit ratio, also as theory predicted, but in the latter case the effect is not significantly different from zero.

In sum, the evidence leaves this question open. While the credit ratio evolves as suggested by theory, the deposit ratio demonstrates only insignificant effects of the expected causal variables.

V. Conclusions.

The Ukrainian decision in 1999 to fix its exchange rate with the US dollar was followed by five years of rapid growth and relatively low but variable inflation. I suggest in this paper that the exchange-rate policy did contribute to this success, but not in the way that is usually expected. The impetus for rapid growth was not the choice of an undervalued parity or the nominal anchor of goods or financial-market integration. Rather, the impetus for rapid growth came from the financial deepening that this induced within the Ukrainian economy. During this period there was a striking build-up of real holdings of hryvnia-denominated financial assets by the population, a phenomenon I call the deposit boom. These deposits were intermediated to fuel a credit-driven expansion of

output. The mirror image of the deposit boom is observed in the foreign-exchange reserves of the NBU; these rose as the population chose to rebalance portfolios away from foreign-currency holdings and toward financial-sector deposits.

This conclusion has a number of implications for Ukrainian macroeconomic policy. First, the gains due to financial intermediation are important, but will be transitory. Once the population reaches its target holdings of hryvnia-denominated financial assets, the potential for inflation-free seigneurage or rapid growth in deposits will disappear. At that point, export-led growth (or some other growing source of demand) must become the primary motive force. Second, the practical non-integration of Ukrainian financial markets with those of Europe leaves scope for independent credit policy. While independent money-supply interventions are not possible with fixed rates, the lack of arbitrage and speculation to ensure interest parity implies that the government can use credit-market interventions to manage the interest rate. The Woodford "channeling" approach is one example that has had success in other transition economies, and it can be implemented without inducing offsetting capital flows from abroad. Third, the excess liquidity characterizing the hryvnia-denominated inter-bank markets is in part a product of denomination mismatch between commercial-bank credits and deposits. The NBU could consider offsetting that mismatch through accepting deposits in hryvnia and providing loans to commercial banks in US dollars.

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Data sources

There are four sources for the data used in this paper.

- High-frequency data (daily and weekly) are drawn from a data base I maintain with the expert assistance of Ms. Anna Shevtsova in Kyiv. The interest-rate and exchange-rate variables are all drawn from this source. When used in lower-frequency analysis I create simple averages of the interest rates observed weekly. Exchange-rate depreciation, when used in concert with an interest rate, is created to coincide exactly with the maturity of the interest rate. Since all interest rates are quoted at an equivalent-annual rate, the depreciation rate is then scaled up to its equivalent-annual value.

- Macroeconomic data and data on financial instruments (currency, deposits, reserves) are as reported by the National Bank of Ukraine in its publications. Current-account data are available there only quarterly. When needed, I construct a spline series of current account to interpolate estimated monthly values.

- Interest rates on the Moscow Interbank market and the London Interbank market are drawn from Datastream for the appropriate time period. The euro-US dollar exchange rate is also taken from Datastream.

- Data on US deposits, inflation, and nominal GDP are taken from the data tables of the Economic Report of the President.

Seigneurage is calculated on an annual basis by taking the difference between end-of-year currency in circulation in two adjacent years and dividing by the nominal consolidated government expenditures as of the end of the later year.

Appendix A. Time Series Properties of Interest Rates.

Table A1: Stationarity Tests

Variable	Rho	Prob<rho	τ	Prob< τ
$r^{\$}_{1t}$	-2.33	0.74	-1.31	0.62
$\Delta r^{\$}_{1t}$			-7.55	0.00
$r^{\$}_{7t}$	-2.58	0.70	-1.64	0.46
$\Delta r^{\$}_{7t}$			-9.52	0.00
$r^{\$}_{30t}$	-2.55	-.71	-1.87	0.34
$\Delta r^{\$}_{30t}$	-201.34	0.00	-6.03	0.00
$r^{\$}_{90t}$	-4.06	0.52	-1.61	0.47
$\Delta r^{\$}_{90t}$			-7.45	0.00
$\rho^{\$}_{1t}$	0.32	0.97	0.27	0.98
$\Delta\rho^{\$}_{1t}$	-597.05	0.00	-8.02	0.00
$\rho^{\$}_{7t}$	0.28	0.97	0.25	0.98
$\Delta\rho^{\$}_{7t}$	-173.68	0.00	-6.46	0.00
$\rho^{\$}_{30t}$	0.19	0.96	0.16	0.97
$\Delta\rho^{\$}_{30t}$	-199.27	0.00	-6.67	0.00
$\rho^{\$}_{90t}$	-0.01	0.96	-0.01	0.96
$\Delta\rho^{\$}_{90t}$	-82.95	0.00	-5.21	0.00

These are Augmented Dickey Fuller Unit Root tests with 5 lags of the variable and controlling for a single mean. Results under alternative assumptions on lag length or mean yield the same conclusion.

Appendix B
Derivation of Dynamic Equations for Equilibrium

Money market equilibrium:

$$\gamma_t = (g_t-\tau_t) = -\,[\alpha(\rho_t,y_t)-\alpha(\rho_{t-1},y_{t-1}) + \beta(\rho_t,y_t)-\beta(\rho_{t-1},y_{t-1})]\; r_t \; + \\ (1-\alpha(\rho_t,y_t)-\beta(\rho_t,y_t))\; \sigma(\rho_t,\, r_t) \qquad \text{(B1)}$$

$$d\gamma_t = (1-\alpha-\beta)\sigma_A\, r_t\, (da_{t-1}/a_{t-1} - d\pi_t/(1+\pi_t)) \\ - \rho_t((\sigma_t+r_t)(\alpha_\rho+\beta_\rho)-(1-\alpha-\beta)\sigma_\rho)(d\rho_t/\rho_t)-(y_t(\alpha_y+\beta_y)(\sigma_t+r_t)+(1-\alpha-\beta)\sigma_A r_t)(dy_t/y_t)$$

$$\text{but } (dy_t/y_t) = -\,\theta\,(d\rho_t/\rho_t) \quad \text{and } (d\rho_t/\rho_t) = di/(1+i) - d\pi_t/(1+\pi_t)$$

then define:

$$\eta_o = \rho_t((\sigma+ r_t)(\alpha_\rho+\beta_\rho)) > 0$$
$$\eta_1 = y_t(\alpha_y +\beta_y)(\sigma+ r_t) < 0$$
$$\eta_2 = (1-\alpha-\beta)\sigma_A\, r_t < 0$$
$$\eta_3 = \rho_t(1-\alpha-\beta)\sigma_\rho > 0$$
$$\eta = \eta_o-\eta_3-\eta_2(1+\theta)-\theta\eta_1, \text{ assumed positive}$$

$$d\gamma_t = \eta_2(da_{t-1}/a_{t-1} - d\pi_t/(1+\pi_t)) \; - (\eta_o-\eta_3)\,(d\rho_t/\rho_t) - (\eta_1 + \eta_2)\,(dy_t/y_t)$$

$$= \eta_2\, da_{t-1}/a_{t-1} - \eta_2\, d\pi_t/(1+\pi_t) - (\eta_o - \eta_3 - \theta\,(\eta_1 + \eta_2))(di/(1+i) - d\pi_t/(1+\pi_t))$$

$$= \eta_2\, da_{t-1}/a_{t-1} - (\eta_2 - \eta_o + \eta_3 + \theta\,(\eta_1 + \eta_2))\, d\pi_t/(1+\pi_t) - \\ (\eta_o - \theta\,(\eta_1 + \eta_2))di/(1+i)$$

$$d\pi_t/(1+\pi_t) = (1/\eta)[d\gamma_t - \eta_2\,(da_{t-1}/a_{t-1}) + (\eta+\eta_2)(di/(1+i))]$$

Deposit-market equilibrium:

$$\kappa(y_t) = [\alpha(\rho_t,y_t)-\alpha(\rho_{t-1},y_{t-1})](r_t + \; \alpha(\rho_t,y_t)\sigma(\rho_t,\, r_t)) \qquad \text{(B2)}$$

$$[y_t\kappa_y + (\alpha/(1-\alpha-\beta))\eta_2 - y_t\alpha_y\,(\sigma_t+r_t)](dy_t/y_t) = [(\sigma_t+r_t)\alpha_\rho+ \alpha\sigma_\rho]d\rho_t \\ + (\alpha/(1-\alpha-\beta))\eta_2(da_{t-1}/a_{t-1} - d\pi_t/(1+\pi_t))$$

Updating equation, accumulated wealth:

$$a_t = a_{t-1}/(1+\pi_t) + \sigma(\rho_t,r_t))y_t \qquad \text{(B3)}$$

$$da_{t-1}/a_{t-1} = -\pi_t/(1+\pi_t) + \sigma(\rho_t,r_t)y_t/a_{t-1} = (-\pi_t + \sigma(\rho_t,r_t)/r_t)/(1+\pi_t)$$

Exchange rate depreciation:

$$(e_tF_t-e_{t-1}F_{t-1})/P_t = [\beta(\rho_t,y_t)-\beta(\rho_{t-1},y_{t-1})]r_t + \; \beta(\rho_t,y_t)\; \sigma(\rho_t,r_t)\; y_t \qquad \text{(B4)}$$

$$de_t/e_t = \pi_t - (dF_t/F_t) + (y_t/\beta a_t)\{[(1+\beta)\sigma_t + r_t\,(1-\sigma_A/y_t)](dy_t/y_t) + (\beta_\rho(\sigma_t+r_t)+\beta\sigma_\rho)(d\rho_t/\rho_t)$$