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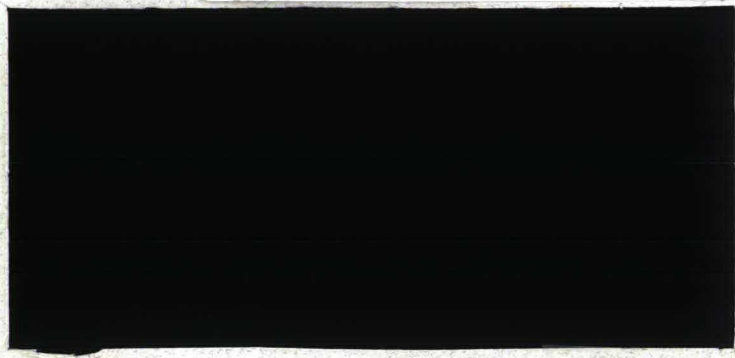
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**CURRENCY SUBSTITUTION AND
CURRENCY CONTROLS: THE POLISH
EXPERIENCE OF 1990**

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Currency substitution and currency controls : the Polish experience of 1990.

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Abstract

This paper considers the social welfare consequences of currency substitution and determines under which circumstances it is efficient from a social welfare perspective to prohibit currency substitution in a small open economy by means of imposing currency controls and under which circumstances it is inefficient to impose such controls. An empirical application of the analytical results is considered with respect to currency substitution in Poland. In January 1990, Polish authorities decided to remove the strict foreign exchange controls. A strong increase in currency substitution took place. Empirical evidence is found for a structural break in Polish money demand around the removal of the controls, giving partial empirical support for the analytical results. The removal of foreign exchange controls was a crucial element in the reform program that aimed at transforming Poland from a communist into a democratic market-oriented society. Because of the rashness and pervasiveness of the reform implementation, this reform is often referred to as the 'Polish Big Bang'. The removal of foreign exchange controls was also part of an extensive disinflation program that was launched in January 1990 that aimed at stopping the rampant hyperinflation that developed in the second half of 1989, as a consequence of the removal of former price ceilings in a shortage economy with monetary overhang and a system of general wage- and income indexation. The Polish experience is likely to be instructive for other developing countries that have to decide whether or not to remove currency controls.

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§ *1. Introduction.*

In January 1990 Polish monetary authorities decided to restore convertibility with the US
$ and the European currencies as part of the entire reform program towards a democratic
market-oriented economy. This decision was motivated by both structural considerations -
the removal of currency controls is likely to encourage foreign trade and the reform
process towards a market-oriented economy- and short-term inflation stabilization conside-
rations. The stabilization program was carried out under supervision of the IMF. Figure 1
displays the Polish annualized rate of inflation and the (natural logarithm) of real money
balances:

Figure 1.   Inflation and velocity Poland.

The graph reveals the sharp increase in inflation and velocity at the end of 1989. After
implementation of the stabilization program inflation started to decrease throughout 1990
and 1991. The setup and ultimate results of the Polish stabilization program of 1990 are
well documented, e.g. in Kolodko [1991] and therefore we concentrate on one monetary
aspect : the removal of currency controls and the consequences of an increase in currency
substitution that is likely to have accompanied the program.

Currency substitution entails a partial replacement of the amount of domestic money in

circulation in the domestic economy by foreign money, both for transaction purposes and as a store of value. Currency substitution arises from currency - or money demand that is sensitive to both domestic and foreign influences, in particularly it is likely to depend strongly on home and foreign interest rates. If real interest rates are assumed to be small and constant, the opportunity costs of holding domestic and foreign money depend almost entirely on the domestic and foreign rate of inflation. Currency substitution in the domestic country is likely to increase with a higher domestic interest rate (viz. inflation rate) and a lower foreign interest rate (viz. inflation rate). This "inflation driven" currency substitution stands central in our analysis of the Polish experience. The part of currency substitution that was driven by increases in foreign trade and other possible factors encounters less attention : it comes in as a constant.

The presence of currency substitution of a significant degree is likely to influence monetary dynamics and public finance in a small open economy. Currency substitution influences public finance since it enables the domestic agents to circumvent the inflation tax imposed by the domestic government on holders of domestic money. When domestic money is held by foreign agents, an additional foreign source of seignorage revenues is available. Via their influence on seignorage revenues, currency substitution and currency controls affect the whole public finance. Moreover, currency substitution will foster inflationary discipline, which could provide an incentive for macroeconomic policymakers to avoid excessively inflationary policies, in this manner contributing to a higher level of social welfare. These effects of currency substitution on public finance, and by that on social welfare, have to be considered by monetary policymakers if they set the interest rate such as to maximize domestic social welfare.

In this paper the public finance -, and consequently the social welfare consequences of currency substitution and of currency controls that seek to discourage currency substitution, stand central. In the model that is developed it is possible to determine when it is optimal and when it is not optimal from a social welfare perspective to impose a currency control in a small open economy with currency substitution.

In our analysis we assume that the government sets the domestic interest rate such as to

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maximize domestic social welfare. The consequences of currency substitution -inflationary discipline and the impact on domestic seignorage revenues- are balanced at the margin if interest rates / inflation rates are set optimally. Then we proceed by introducing the possibility that authorities can choose to implement a currency control that effectively prevents domestic residents to hold foreign money. It is shown when a decision to implement or remove a currency control is efficient from a welfare economic perspective. Currency controls entail social welfare costs since they prevent domestic agents to maintain an optimal portfolio of domestic and foreign money and do not provide the inflationary discipline of currency substitution. Currency controls, on the other hand prevent a leakage of seignorage revenues to the foreign authorities when domestic agents substitute away from domestic to foreign money. A decision to impose or remove a currency control, if to be efficient, takes account of these effects in a balanced manner.

While currency substitution in its most strict definition refers to the circulation of foreign currency or base money in the home country, often a more broad perspective is associated with currency substitution by including foreign currency denoted sight- and time deposits. The use of such an extended money definition is more useful in countries with well developed monetary and financial systems. Applying broader money definitions, implies that currency substitution becomes closely related to capital mobility and capital flight.

Canzoneri & Diba [1992] compare the optimal rates of inflation when monetary authorities ina 2-country game play seignorage maximization games with the optimal rate of inflation when countries play welfare maximization games. Optimal inflation rates in both monetary policy games critically depend on the degree of currency substitution and in welfare maximization games optimal inflation rates also depend on the marginal distortion of ordinary taxation. A higher degree of currency substitution lowers the optimal rate of inflation in both games as expected, while a higher marginal distortion from ordinary taxation increases the optimal rate of inflation in the welfare maximization game. This paper extends the work of Canzoneri & Diba by considering the welfare consequences of introducing currency controls by the monetary authorities in an attempt to discourage currency substitution. Because of complexity the analysis is not cast into a 2-country

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game as in the Canzoneri & Diba article but in a small country framework.

The structure of this paper is as follows : section 2 introduces a macroeconomic model in which currency substitution is present. Social welfare is determined in the presence of currency substitution when monetary authorities set the interest rate such as to maximize domestic social welfare. In section 3 the welfare consequences of introducing currency controls are derived. Section 4 applies the results from theory to the case of Poland. Section 5 concludes.

§ *2. Modelling currency substitution.*

As mentioned in the introduction, currency substitution extends traditional money demand modelling by allowing for the possibility that domestic agents hold both domestic and foreign money. Real macroeconomic money demand for domestic and foreign money balances can either be postulated or derived from an underlying micro-economic maximization problem. While the former approach has the advantage of simplicity, the latter approach is more attractive from a theoretical point of view.

An often encountered manner to derive such a micro-founded macroeconomic money demand function is the money-in-the-utility function (MIUF) approach : it assumes that money in itself is valued because of the direct utility it produces. The cash-in-advance approach (CIA) is another approach : it takes transaction technology as a starting point and derives from it real money demand. The money-in-the-utility function approach stresses the importance of money as a store of value and as a speculative asset while the cash-in-advance approach concentrates on the transaction part of real money demand. The cash-in-advance approach can be shown to be a specific case of the money-in-the-utility function approach, namely in which real money and real consumption complementary goods in the utility function, and money demand has unitary income elasticity[2].

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[2] Vègh [1989] analyses the effects of currency substitution when money demand is based on cash-in-advance constraints.

Consider the following small open economy in which we analyse currency substitution and currency controls. Since the store of value function of money stands central in our analysis of currency substitution we chose to derive money demand according to the money-in-the-utility function approach. The representative domestic agent is assumed to maximize a utility function that has as its arguments real consumption and the amount of real money balances:

$$\max_{c_t, m_t, n_t} U_t = \int_{t_0}^{\infty} \{u(c_t) + v(m_t, n_t; \sigma)\}.e^{-\delta t} \, dt \quad u_c, v_m, v_n > 0 \quad u_{cc}, v_{mm}, v_{nn} \leq 0 \quad (1)$$

$$s.t. \quad \dot{w} = r_t.w_t + y_t - \tau_t - c_t - i_t.m_t - i_t^*.n_t \quad (2)$$

$$w_t = m_t + n_t + f_t$$

$$\lim_{t \to \infty} f_t.e^{-\delta t} = 0 \quad m_t, n_t \geq 0$$

All variables are in logarithms. c_t denotes real consumption of the domestic agent, y_t is real income, which is assumed to be given and constant in the short run, τ_t are lump-sum taxes that are imposed by the fiscal authorities. m_t are domestic agents' real balances of domestic money, defined as nominal money balances deflated by the domestic price level. n_t are the real balances of foreign money. The real value of foreign money is equal to their nominal value (in foreign currency) deflated by the foreign price level. f_t represent real net foreign asset holdings of domestic residents : like real foreign money balances they are defined as the nominal value (in foreign currency) deflated by the foreign price level. It follows that the 'foreign' part of real wealth, $n_t + f_t$, is not eroded by domestic inlfation while the 'domestic' part , m_t, is.

Both monies are non-interest bearing. Risk free bonds denominated in domestic and foreign currency are the only available financial assets and their nominal returns are denoted as i_t and i_t^*, respectively. The rate of time preference is given by δ. Real wealth, w_t, consists of domestic money, foreign money and net foreign assets and is subject to a no-Ponzi condition that prevents individuals -and the aggregate of domestic agents when

we aggregate- from a scheme of continuously rolling over an ever increasing amount of net foreign assets - or foreign debt. r_t is the real rate of interest. σ is a parameter associated with currency substitution : in the model we choose σ to be equal to minus the reciprocal of the currency substitution elasticity. This elasticity measures the sensitivity of the ratio of both monies M_t / N_t that agents hold with respect to changes in the interest rate differential $(i_t - i_t^*)$.[3]

The parameter σ summarizes the structural and institutional characteristics of the monetary system of the small open country, under study. Guidotti (1993) analyses the consequences of financial innovations that facilitate currency substitution in the domestic country, inducing a decrease of σ. When considering the welfare consequences of currency substitution and currency controls later on, it is shown how social welfare critically depends on the level of σ. In this respect changes over time of σ, are clearly very interesting to consider. Financial innovations enable the representative agent to economise on real money balances, which make him better off, as is clear when considering eq.(1). However a 'secondary' effect is present, as indicated by de Grégorio [1991] : a decrease in σ induces a decrease in holdings of real domestic money and therefore a decrease in real seignorage revenues that has to be compensated by a rise in ordinary taxes, τ_t, which makes the agent worse off. The exact magnitudes of both effects determine whether the economy is better off from a financial innovation or not.

The holdings of foreign money by domestic residents monies, n_t , and the holdings of domestic money by foreign residents -which will be denoted by m_t^* - reflect the presence of currency substitution between domestic and foreign money, and are a source of externalities between the small country and the rest-of-the-world.

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[3] The currency substitution elasticity is defined as :

$$\frac{\partial(m_t - n_t)}{\partial(i_t - i_t^*)} = -\frac{1}{\sigma}$$

Empirical estimates of the currency substitution elasticity usually yield quiet high values for the currency substitution elasticities in developing high inflation countries, in the range of 1.5 to 6. The elasticity is much less for low inflation countries, in the range 0 to 1. Iso-elasticity of monetary utility $v(m_t, n_t ; \sigma)$ in eq.(1) seems dubious in this light.

Solving the maximization problems of the representative agent yields implicit demand functions for consumption goods, domestic money and foreign money:

$$u_c = \lambda \tag{5}$$

$$v_m(m_t, n_t; \sigma) = i_t \tag{6}$$

$$v_n(m_t, n_t; \sigma) = i_t^* \tag{7}$$

$$\dot{\lambda} = \lambda.(r_t - \delta) \tag{8}$$

in which λ is the co state variable associated with real consumption. The real economy is assumed to be in equilibrium over time[4]: the real rate of interest is assumed to be equal to the rate of time preference and real consumption and real money balances enter the utility function in a separable fashion:

$$r_t = \delta \qquad \forall t \qquad u_{cm} = u_{cn} = 0 \tag{9}$$

Given the assumptions in eq. (9) and the Fisher-hypothesis, inflation rates change proportional to nominal interest rates:

$$i_t = \delta + \pi_t \tag{10}$$

Domestic and foreign inflation rates, π_t and π_t^*, are assumed to be linked by the assumption of relative purchasing power parity:

$$\pi_t = \pi_t^* + \dot{e} \tag{11}$$

in which $\dot{e}$ is the expected rate of depreciation of the home currency, which is equal to the actual rate of depreciation if we perfect foresight for granted. When the real interest

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[4] With regard to Poland this assumption seems to be exceptionally far from reality. Nevertheless we pursue this line as our analysis solely concerns itself with possible welfare effects of currency controls and currency substitution. The simple model that can derived in this manner seems well-suited to deal with these welfare considerations.

rate and the foreign rate of inflation are constant, equivalence between setting the interest rate, the rate of inflation and the rate of depreciation by the monetary authorities will hold[5]. The design of optimal interest rate targeting is then equivalent to the choice of optimal inflation and optimal exchange rate policies.

Public finance is subject to the usual dynamic government budget constraint:

$$g_t - \tau_t = s_t = i_t.m_t^s = i_t.(m_t + m_t^*) \tag{12}$$

in which g_t are real government expenditures τ_t are lump-sum taxes, s_t are real seignorage revenues accruing to the monetary authorities because of their monopoly in creating domestic (base) money and the ability to set the domestic interest rate[6]. m_t^s is the supply by the monetary authorities of real domestic money.

The fiscal deficit that a government runs -the LHS of eqs.(12)- is financed by seignorage revenues. The public finance view of inflation treats real seignorage revenues as being part of a wider tax system : by setting the nominal domestic interest rate holders of

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[5] Constant real interest and real exchange rates, admittedly, are not an accurate description of macro-economic reality in the short-run, especially not in a country like Poland. Varying real interest and exchange rates are considered as important adjustment devices in the real economy in the short-run. Since our analysis comes down to a steady-state comparison of social welfare in different monetary policy regimes, our simplifications may not be that inappropriate.

[6] Real seignorage revenues in eq.(12) are defined according to the 'opportunity cost' approach. The 'cash-flow' approach distinguishes two sources of seignorage : a) passive seignorage, which results from trend growth of real money balances, and b) active seignorage, $\pi_t.m_t^s$, which results from the inflation tax on money:

$$s_t = \dot{m}^s + \pi_t.m_t^s = \mu.m_t^s$$

in which μ is the growth rate of nominal money balances. The two approaches are similar but not equal in general. In case the second approach would have been taken, μ instead of i_t would have been our monetary instrument.

domestic money are implicitly taxed[7]. The government budget constraint determines that in a situation of constant real government expenditures, real seignorage revenues in excess of these expenditures are proportionally rebated to the domestic agents.

The inflation tax is distortionary in that a higher rate of domestic inflation induces agents to hold fewer domestic balances and to substitute away into foreign balances : according to eq.(6), only when the domestic nominal interest rate is equal to zero -or equivalently when the domestic rate of inflation is equal to minus the real rate of interest rate/rate of time preference- households' demand for domestic money will be satiated. This situation is known as the Friedman rule of optimal monetary policy. If ordinary taxes are distortionary, the Friedman rule is not optimal : efficient taxation requires setting positive nominal interest rates.

Currency substitution, via its influence on the inflation tax, introduces a source of externalities : seignorage revenues that domestic agents transfer to the foreign monetary authorities through currency substitution are proportionally rebated to foreign agents by the foreign monetary authorities, whereas the inflation tax on foreign holders of domestic money is proportionally rebated to domestic agents, together with the inflation tax levied on domestic holders of domestic money. Because of the fact that part of the inflation tax on domestic money can be shifted upon the shoulders of foreign agents, a rate of inflation higher than the Friedman rule will appear to be optimal, even when ordinary taxes are non-distortionary. Money market market equilibrium is defined as:

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[7] Efficient taxation entails the minimization of the discounted social costs of financing a given amount of public expenditures. Efficient taxation requires (a) the equalization of the marginal excess burden of all forms of taxation in one period (a static optimality condition) , (b) the equalization of marginal costs of ordinary taxation over different periods, a principle that is known as Barro's tax smoothing hypothesis, and (c) the equalization over time of marginal social costs of inflation taxation. (b) and (c) are dynamic optimality conditions. Empirical testing of the implications of optimal taxation principles would amount to testing whether inflation and ordinary tax rates are cointegrated (static optimality condition) and whether inflation and ordinary tax rates are random walks (dynamic optimality conditions). The presence of cointegration indicates that inflation - and ordinary tax rates are set efficiently *intra*temporally, while evidence of random walks in inflation - and ordinary tax rates, presents evidence for tax-smoothing, i.e. *inter*temporally optimal taxation.

$$m_t + m_t^* = m_t^s \tag{13}$$

The balance of payments definition, according to which the current account is equal to minus the capital account, is defined as[8]:

$$\dot{f} + \dot{n} - \dot{m}^* = r_t.f_t + y_t - c_t - g_t \tag{14}$$

Consider the following utility function in eq.(1):

$$U_t = \int_{t_0}^{\infty} \{c_t - 0.5(\gamma - m_t + \omega - n_t)^2 - 0.5\,\sigma\,[(\gamma - m_t)^2 + (\omega - n_t)^2]\}.e^{-\delta t}dt \quad \gamma,\omega,\sigma \geq 0 \tag{15}$$

in which γ and ω are constants that reflect optimal holdings of domestic and foreign money respectively. σ is a parameter that weights both parts of the RHS of eq.(15) and is equal to minus the reciprocal of the interest rate differential elasticity of the relative amount of real domestic money balances of domestic agents, (m_t-n_t), the currency substitution elasticity, for short. When positive, both monies are substitutes of eachother, when negative both monies are complements. $-1/\sigma = 0$ and $\omega = 0$ represents the case when no currency substitution occurs ($n_t = 0$) : in the large traditional literature on all sorts of aspects concerning monetary policy this is implicitly assumed. Allowing for currency substitution however certainly would change or modify most results from this literature. Optimal real balances of domestic and foreign money result when the marginal utility of m_t and n_t are equal to the domestic and foreign nominal interest rate. These 2 first-order-conditions can be solved to give m_t and n_t as a function of domestic and foreign interest rates :

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[8] Implicitly, it is assumed that the authorities do not hold any foreign money in the form of foreign exchange reserves : they are assumed not to practice any active form of exchange rate management. Any from of active exchange rate management -be it a fixed exchange rate system, a target zone or a crawling peg could be readily inserted in our model. The present analysis concentrates on a different form of monetary intervention in the economy.

$$m_t = \gamma - \frac{(\sigma+1)}{\sigma(\sigma+2)} \cdot i_t + \frac{1}{\sigma(\sigma+2)} \cdot i_t^* \tag{16}$$

$$n_t = \omega + \frac{1}{\sigma(\sigma+2)} \cdot i_t - \frac{(\sigma+1)}{\sigma(\sigma+2)} \cdot i_t^* \tag{17}$$

A rise of the domestic nominal interest rate induces a decrease in the demand for domestic money and an increase in the demand for foreign money, while a rise in the foreign interest rate has the opposite effects. $-(\sigma+1)/(\sigma(\sigma+2))$ is equal to the convential interest elasticity of real money demand. Holdings of both monies are nonnegative as long as we restrict the domestic nominal interest rate to be set within a certain range :

$$(a) \ m_t \geq 0 \quad \Leftrightarrow \quad i_t \leq \frac{\sigma(\sigma+2)}{\sigma+1} \cdot \gamma + \frac{1}{\sigma+1} \cdot i_t^* \tag{18}$$
$$(b) \ n_t \geq 0 \quad \Leftrightarrow \quad i_t \geq -\sigma(\sigma+2) \cdot \omega + (\sigma+1) \cdot i_t^*$$

If the domestic interest rate exceeds the upper limit of (a) a hyperinflation results : domestic agents seek to reduce their holdings of domestic real money to zero[9]. If the domestic interest rate is lower than the lower limit of (b) domestic agents actually would prefer to have a negative amount of foreign currency which is not possible. In the remainder of the analysis, it is assumed that the inequalities are not violated, to ensure nonnegativity of m_t and n_t. Foreign demand for domestic money is assumed to be constant:

$$m_t^* = \alpha \qquad \alpha \geq 0 \tag{19}$$

This assumption makes it possible to restrict computational complexity in the remainder of the analysis. This simplifying assumption can also be interpreted to represent a situation in which foreign demand for domestic money is constant and not sensitive to interest rates : such a situation is present when the σ^* in the foreign equivalent

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[9] Unstable hyperinflationary processes, in general, can only be ruled out when money is essential to agents, i.e. when $v(m=0) = -\infty$. When money is essential $\lim_{m \to 0} \{m.v_m'\} > 0$, as first shown by Obstfeld & Rogoff [1983]. Essentiality of money is however not an attractive property. Money in the present model is inessential, as can be seen by inspecting $v_m'(0,n_t;\sigma)$ and $v_n'(m_t,0;\sigma)$.

of eq.(15) goes to infinity.

The parameters $\{\sigma,\gamma,\omega,\alpha\}$ of the money demand system represent all factors that are not modelled but do affect demand for money : these parameters possibly change over time. An increase in ω could represent an increase in currency substitution arising from an increase in foreign trade and all other factors : an increase in Poland's ω is likely to have taken place in the period 1988-1991.

The money demand functions eqs.(16) and (17) illustrate the well-known property that an increase in currency substitution possibilities, i.e. a decrease in σ, raises the interest rate sensitivity of demand for domestic money demand. If data on m_t and n_t are available, estimation of σ, γ and ω from eqs.(16)-(17) is possible using nonlinear regression techniques. In the empirical section the lack of data on m_t and n_t is partly resolved by using the fact that eqs.(16) and (19) sum up to real money demand M1/P on which data are available. The virtual absence of a private banking systems makes our analysis quite applicable to the case of Poland.

Social welfare maximizing monetary policy.

Optimal monetary policy requires monetary authorities setting the interest rate such as to maximize national welfare. Interest rate targeting is achieved by setting of a prime lending rate, reserve requirements and open market policies. Currency substitution affects social welfare in two conflicting ways : currency substitution allows domestic agents to have a higher lifetime utility by the possibility to hold both monies and substitute between both monies when relative opportunity costs of holding both monies change. By holding foreign money, domestic agents are able to circumvent to a certain degree the distortionary effects of the domestic inflation tax. Currency substitution in this manner affects the division of seignorage revenues between countries : a higher interest rate differential induces a substitution towards the foreign money and a consequent loss of domestic seignorage proceeds (and an increase in foreign seignorage revenues). This is the important externality that was touched upon before. The maximization of social welfare requires the balancing both effects in setting the optimal rate of interest. This balancing of

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conflicting effects is also seen in the next section where we consider a situation where governments posses an additional instrument in imposing currency controls that effectively prevent currency substitution to be feasible.

The present value of domestic social welfare is equal to:

$$U_t = \int_{t_0}^{\infty} \{y_t - \tau_t - i_t.m_t - i_t^*.n_t + v(m_t,n_t;\sigma)\} \, . \, e^{-\delta.t} \, dt \qquad (20)$$

Public finance is subject to the intertemporal budget constraint on public finance, which is found by integrating eq.(12):

$$\int_{t_0}^{\infty} \{g_t - \tau_t\} \, .e^{-\delta.t} \, dt = \int_{t_0}^{\infty} \{i_t.(m_t + m_t^*)\} \, .e^{-\delta.t} \, dt \qquad (21)$$

according to which the present value of all future primary fiscal deficits is equal to the present value of future seignorage revenues, which originate from a domestic, m_t, and foreign tax base, m_t^*. The welfare maximization problem is solved by maximizing eq.(20) with respect to the domestic nominal interest rate, subject to eq.(21) -the intertemporal government budget constraint-, the money demand functions eqs.(16), (17) and (19) and monetary utility $v(.,.;\sigma)$ as defined in eq.(15):

$$\max_{i_t} \int_{t_0}^{\infty} \{y_t - g_t + i_t.m_t^* - i_t^*.n_t - 0.5(\gamma - m_t + \omega - n_t)^2 - 0.5\sigma((\gamma - m_t)^2 + (\omega - n_t)^2)\}.e^{-\delta.t}dt \qquad (22)$$

The term $i_t.m_t' - i_t'.n_t$ represents the seignorage flows in the presence of currency substitution between the small country and the rest-of-the-world. Outcomes of the social welfare problem in eq.(22), the command optimum, and the outcome without an optimizing social planner, the 'private solution' from the problem as stated in eq.(1), in generally will differ, as the individual agent is not able to internalize the public finance consequences of currency substitution, while a rational monetary policymaker can. The

optimal rate of interest that results is equal to[10]:

$$i_t = \frac{\sigma(\sigma+2)}{(\sigma+1)} . \alpha \tag{23}$$

Currency substitution as parametrized by σ and α influences the optimal nominal interest rate : a lower σ, or a higher currency substitution elasticity in the small country drives down the optimal nominal interest rate, while a higher α increases it. Social welfare in the small home country can then be calculated by using eq.(23) in eq.(22):

$$U_t = \int_{t_0}^{\infty} \{y_t - g_t - i_t^*.\omega + \frac{(\sigma+1)}{2(\sigma+2)}.i_t^{*2} + \frac{\sigma(\sigma+2)}{2(\sigma+1)}.\alpha^2 \}.e^{-\delta t} \, dt \tag{24}$$

Social welfare at time t, if monetary authorities set the interest rate according to eq.(23), depends on the parameters $\{i_t^*, \omega, \sigma, \alpha\}$ for a given dynamic path of y_t and g_t which are independent of monetary conditions in this framework.

§ 3. Social welfare implications of currency controls.

Until now it has been assumed that the monetary authorities did not impose any restriction on currency substitution. In this section we consider the welfare implications of the additional possibility of imposing currency controls by the monetary authorities in an attempt to avoid currency substitution to occur. Since the use of foreign exchange restrictions is widespread in reality[11], it seems interesting to incorporate this possibility

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[10] This result depends strongly on our assumption of non-distortionarity of ordinary taxes. If, as in Canzoneri and Diba [1992] collection costs $\kappa(\tau)$ are introduced which are a convex function of the tax rates, $\kappa'(.) > 0$ and $\kappa''(.) > 0$, ordinary taxes would no longer be non-distortionary and tax and inflation rates would have to be set jointly by monetary and fiscal authorities such as to minimize overall distortions from ordinary and inflation taxation. In the presence of distortionary ordinary taxation, optimal interest rates are set higher as compared to a situation where no-distorsions are present, proportional to the marginal cost of ordinary taxation.

[11] More institutional details on the use of foreign exchange restrictions can be found in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions [1990].

into the framework of optimal monetary policy in the presence of currency substitution :
by comparing of social welfare in the presence of currency controls with social welfare
without currency controls we can determine in which circumstances an optimizing govern-
ment is likely to impose such controls.

Consider the following definition of a perfect currency control in the home country[12]:

$$n_t = 0 \quad \forall \, t \tag{25}$$

Assume that the use of domestic money by foreign agents is not restricted by either
domestic or foreign monetary authorities. When a currency control is imposed by the
monetary authorities of the small country, the social welfare function as defined in
eq.(22) changes of course:

$$\max_{i_t} U_t = \int_{t_0} \{ y_t - g_t + i_t.m_t^* - 0.5(\gamma - m_t + \omega)^2 - 0.5\sigma((\gamma - m_t)^2 + \omega^2) \}.e^{-\delta.t} dt \tag{26}$$

Also demand for domestic money by domestic agents changes since their money demand
is the result of a different, more restricted, optimization program from which results:

$$m_t = \gamma + \frac{1}{\sigma+1}.\omega - \frac{1}{\sigma+1}.i_t \tag{27}$$

If we compare eq.(27), the 'restricted' demand for domestic money by domestic agents,
with the 'unrestricted' demand for domestic agents by domestic agents, eq.(16), it appears
that restricted money demand is higher by an amount of :

$$m_t^{UR} - m_t^R = -\frac{1}{(\sigma+1)}.\omega - \frac{1}{\sigma(\sigma+2)(\sigma+1)}.i_t + \frac{1}{\sigma(\sigma+2)}.i_t^* \tag{28}$$

An unanticipated abolition of a currency control at time t induces a structural break in
demand for domestic money by domestic agents -according to the model at least- : the
constant falls, while the sensitivity w.r.t the domestic and foreign interest rate increases.
These are three predictions that are more or less conform recurring themes in the

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[12] In reality, one would not expect monetary policymakers to be able to that effective
in imposing currency controls. A 'leaky' currency control $n_t = \nu$ with $\nu > 0$, could be
introduced instead of eq.(25).

currency substitution literature. In our empirical analysis of the Polish removal of exchange restrictions in January 1990, such a predicted structural break is also investigated.

Maximization of social welfare in eq.(21) in the presence of currency controls is achieved when the interest rate is set equal to:

$$i_t \quad (\sigma + 1).\alpha \tag{29}$$

Also in this situation a domestic interest rate beyond the threshold as defined in eq.(18) induces zero domestic real money and hyperinflation. When a currency control is imposed, optimal interest rates are set higher than when it is decided to refrain from a control, as is clear when subtracting eq.(29) from eq.(23):

$$i_t^{nc} - i_t^{cc} = -\frac{1}{(\sigma + 1)}.\alpha \leq 0 \tag{30}$$

in which i_t^{nc} refers to the optimal interest rate of eq.(23) when no currency control is imposed and i_t^{cc} to the optimal interest rate of eq.(29) when a currency control was imposed. The explanation for this difference is the working of currency substitution as a disinflationary device, which is activated when removing a currency control, when at least α is not equal to 0 or σ approaches infinity. Substituting eq.(29) back into eq.(26) allows us to determine social welfare when a currency control is imposed and interest rates are set optimal:

$$U_t^{cc} = \int_{t_0}^{\infty} \{y_t - g_t + \frac{1}{2}(2\sigma + 1).\alpha^2 - \frac{(2\sigma + 1)}{2(\sigma + 1)}.\omega^2 \}.e^{-\delta t} dt \tag{31}$$

Now that we have determined social welfare with currency controls when interest rates are set efficiently from a social welfare perspective, we can determine when it is optimal to impose a currency control and when not, by comparing eqs.(24), which gives U_t^{nc}, social welfare without currency controls, and (31), which gives U_t^{cc}, social welfare with currency controls:

$$U_t^{nc} - U_t^{cc} = \int_{t_0}^{\infty} \{-i_t^* \omega + \frac{\sigma+1}{\sigma(\sigma+2)} i_t^{*2} + \frac{(\sigma^2+\sigma-1)}{2(\sigma+1)} \alpha^2 + \frac{\sigma(\sigma+2)}{2(\sigma+1)} \omega^2\}.e^{-\delta.t} dt \quad (32)$$

If the expression in eq.(32) is positive, it is optimal not to impose a currency control in an attempt to prevent domestic agents to hold foreign money balances. In the opposite case when it is negative it is optimal from a social welfare perspective that the monetary authorities do not allow domestic agents to hold foreign money. By its decision to impose or not to impose a currency control and by efficient interest rate targeting, the monetary authorities in a way correct for the unintended externalities because of inefficient net seignorage flows between the home country and the rest-of-the-world, when domestic agents are not corrected. In the next empirical section, the expression in eq.(32) is evaluated empirically in the case of Poland which removed currency controls in January 1990. In appendix A the general form of social welfare -without interest rates necessarily being set optimally- is shown in the case where no currency controls are present and in the case where currency controls are present. Also the social welfare change from a removal of currency controls is calculated. These additional excercises were motivated by our doubts of the capability and willingness of Polish monetary authorities to set efficient interest rates.

§ *4. Empirical investigation of currency substitution and currency controls : the Polish experience of 1990.*

The removal of price ceilings together with the monetary overhang induced a hyperinflation in Poland in the second half of 1989, as illustrated in figure 1 before. Consequently, the democratically elected government Mazowiecki embarked upon a comprehensive disinflation program which entailed a fixing of the Zloty against the dollar, a reduction in the fiscal deficit, a restrictive income policy *and* the removal of currency controls. The removal of currency controls in Poland was achieved in 2 discrete steps : in March 1989 foreign exchange restrictions were weakened considerably for Polish households and in January 1990 the remainder of the system of currency controls was removed.

It is difficult to assess which step had the largest impact on currency substitution since data on foreign exchange holdings, to our knowledge, were not recorded. Since both dates do not lie far from each other assuming that January 1990 was the date of removal of Polish currency controls, does not seem to imply a large inexactitude. The workings and the removal of Polish currency controls of course will not correspond exactly to the way proposed in the theoretical section where it was assumed that currency controls are effective in avoiding currency substitution to happen. It is likely that Polish agents already possessed a certain amount of foreign exchange, even while not officially allowed to do so : this would amount to 'leaky' currency controls, upon which we touched before.

Apart from the lack of data on US dollar[13] holdings of Polish agents and on Zlotys' circulating abroad -n_t and m_t^* in the model- other difficulties with translating of the theoretical model to the Polish experience result from the lack of a market interest rate and consequently large swings in ex-post real interest rates, the doubtfullness of the constant real output and government expenditures assumption and the assumption of relative purchasing power parity -Poland maintained a relative uncompetitive exchange rate in the attempt to fight inflation-.

Given these drawbacks, we consider it nevertheless to be interesting to investigate the Polish case as an empirical application of our theoretical analysis. Our dataset encompasses data on the Polish money supply, M1, the Polish consumer price index, P, the official Polish 3-month deposit rate, i_t^p, and a US $ 3-month deposit rate, i_t^{us}. Data were available from the International Financial Statistics, an unbroken time series for all variables from July 1985 till December 1991 could be derived. In order to estimate the structural parameters in the money demand functions -eqs.(16)(17) and (19)- of the theoretical model, we make use of the fact that M1/P is the sum of real holdings of domestic money by domestic agents, m_t, and foreign agents, m_t^*. This allows us to estimate most structural parameters, despite the fact that me do not have any data on m_t,

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[13] DM / zloty currency substitution was investigated in the same manner as US dollar / zloty currency substitution. Empirical results were, however, considerably less convincing in the DM case and therefore not added to this section. If anything, DMs' appear to be rather a complement of the Zloty than a substitute.

n_t and m_t^* themselves.

One important empirical implication from the theoretical part was the structural change in demand for real Polish money : a decline in the intercept and an increase in the domestic - and foreign interest rate elasticity. A simple plot of real money balances in figure 2 indeed suggests a structural break money demand at the end of 1989:
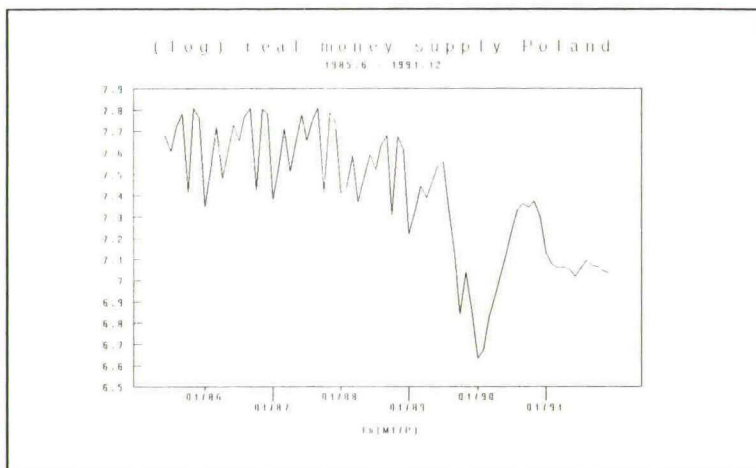
Fig.2   Real money balances in circulation.

We can test this theoretical implication by splitting the entire sample into two parts : one covers the period July 1985 till December 1989 when currency controls were in force and the second covers the period January 1990 till December 1991 when currency controls were not active, and test whether intercept and slopes of the money demand function changes.

In order to test for a structural break in the demand for money, we estimate a piecewise linear regression that combines in one functional form eqs.(16), (19) and (27) :

$$\ln(\frac{M1}{P})_t = \beta_0 + D_t . \delta_1 + \beta_1 . i_t^p + D_t . \delta_2 . i_t^p + D_t . \delta_3 . i_t^{us} + \epsilon_t \tag{33}$$

The dummy coefficients δ_1, δ_2 and δ_3 measure the 'regime switching' effects of a removal of currency controls on money demand. The dummy D_t takes a value 0 for the first

subsample and a value 1 for the second subsample. If δ_1 is negative, support for the prediction of a drop in the constant of the money demand function is found, while a positive value for δ_2 and a negative δ_3 support the prediction about the changes in the domestic - and foreign interest rate sensitivity of money demand.

The results from estimating eq.(33) are given in the second row of table 1. The estimates for the dummy coefficient more or less support the hypotheses : the estimates of δ_1 and δ_3 have the correct sign, δ_2 has a wrong sign but is not significant at a confidence level of 90%. A substantial and statistically significant drop in the constant results, according to the estimate of δ_1. The hypothesis that no structural break was present in Polish money demand, i.e. that all $\delta_1=\delta_2=\delta_3=0$, can be rejected at a 95% level of confidence.

An alternative way to test the predicted changes consists of estimating for both subsamples the following generalised money demand function :

$$m_t = \beta_0 + \beta_1 . i_t^{p} + \beta_2 . i_t^{us} + \epsilon_t \qquad (34)$$

A Chow-test can be carried out to test for the occurence of a structural change in eq.(34) with the removal of the currency control. The estimated money demand function for the first subsample is given in the third row of table 1, the results for the second subsample are found in the fourth row, while the results for the entire sample are collected in the fifth row. The F-value for the Chow-test on constancy of the regression coefficients across both subsamples equals 3.51 which is higher than the critical value of 2.76 at a 95% confidence level and 3 and 72 degrees of freedom. Therefore, the hypothesis of no structural change in the intercept and the slopes of the money demand function must be rejected.

M1/P	$(\alpha+\gamma)$	δ_1	β_1	δ_2	δ_3	β_2	ω	σ	λ	R^2	S.E.	DW
(33)	7.60 (60.16)	-.99 (-2.24)	-1.01 (-1.52)	.10 (1.46)	9.25 (1.46)	-	-	-	-	0.86	0.11	2.01
(34a)	7.48 (16.33)	-	-.48 (-.76)	-	-	-.49 (-.09)	-	-	-	0.79	0.09	1.92
(34b)	6.80 (32.11)	-	-.13 (-3.66)	-	-	6.86 (1.96)	-	-	-	0.46	0.14	1.97
(34c)	7.18 (20.29)	-	-.13 (-.85)	-	-	3.04 (.62)	-	-	-	0.85	0.11	2.04
(35)	7.21 [.04]	-	-	-	-	-	.72 [.14]	.78 [.21]	-	0.72	0.03	-
(37)	.58 (1.07)	-.31 (-2.75)	-.32 (-1.93)	-.11 (.66)	4.38 (2.77)	-	-	-	.93 (13.11)	0.88	0.10	1.81

Table 1. Estimation results of Polish money demand.

t-statistics in parantheses ( ), standard error of estimate in brackets[ ].

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The parameters $\{\alpha+\gamma,\omega,\sigma\}$ can be estimated by using nonlinear regression techniques : eqs.(16) and (27), namely, can be combined to the following piecewise nonlinear money demand function:

$$\ln(\frac{M1}{P})_t = (\alpha+\gamma) + \frac{1}{\sigma+1}.\omega.(1-D_t) - \frac{1}{\sigma+1}.i_i^p.(1-D_t) - \frac{(\sigma+1)}{\sigma(\sigma+2)}.i_t^p.D_t + \frac{1}{\sigma(\sigma+2)}.i_t^{us}.D_t$$

(35)

The estimation results from eq.(35) are found in the sixth row of table 1.

These estimates of the structural parameters $\{\sigma,\omega,\alpha+\gamma\}$ of the model make it possible to evaluate the welfare changes from the removal of a currency control, according to the model at least. The Polish interest rate in December 1989 was equal to 21% , while the US interest rate was equal to 8,39%. Filling in values of $\{0.0839, 0.7212, 0.7784\}$ for $\{i_t^*, \omega, \sigma\}$ in eq.(32) gives a relation between α and $U_t^{nc} - U_t^{cc}$. The relation that is found for this set of parameters is the following parabola in α:

$$U_t^{nc} - U_t^{cc} = \int_{t_0}^{\infty} \{0.221+0.327.\alpha^2\}.e^{-\delta.t}dt \approx \frac{0.221+0.327.\alpha^2}{\delta}$$

(36)

The shape of the α-parabola depends -for given values of ω and i_t^*- on the value of σ. If we take a value of 0.5 for σ instead of 0.78, the parabola becomes strictly decreasing in α. Figure 3 graphs eq.(36) for these different values of σ:

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Social welfare change from removing currency controls
for different σ ($\delta = 0.05$)
Poland 1990

$U_t^{nc} - U_t^{cc}$

30

25

20

15

10

5

0

-5

$\sigma = 0.78$

$\sigma = 0.62$

$\sigma = 0.5$

0   0.4   0.8   1.2   1.8   2.0

α
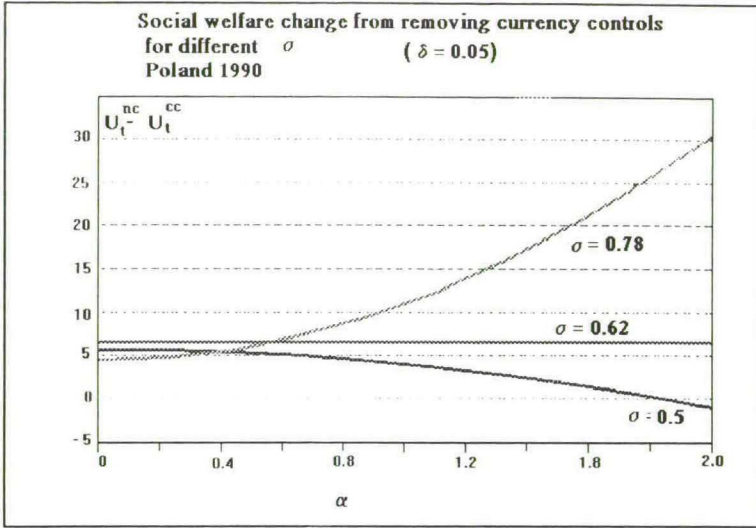
Fig. 3   Social welfare change as a function of σ and ω.

α is the modelparameter that we cannot estimate from eq.(35) : we can estimate the sum of $(\alpha+\gamma)$ but not how this sum is divided, due to the lack of data on m_t^*. There is, however, a possibility to infer an estimate of α from eq.(29) of our model indirectly : if we fill in values of i_t of 21% and σ of 0.7784, α amounts to 0.12, a fairly small number which is not counterintuitive since Polish Zloty are probably, even after restoration of convertibility, of limited use to residents of other countries. A value of 0.12 for α, implies a value of 7.09 of γ, given our estimate of $(\alpha+\gamma)$ of 7.21.

If we set α to 0.12 an instant increase in social welfare, according to eq.(36), of 0.226 results from the removal of the former currency controls. The present value of this instant social welfare change, i.e. the integral, can be approximated by dividing the instant social welfare change by the pure rate of time preference, if $\{i_t^*,\sigma,\omega,\alpha\}$ remain approximately constant over time. According to the model, therefore, the removal of the currency controls in Poland in January 1990 has been efficient from a social welfare perspective.

In Appendix A the model solution in the case when interest rates are not necessarily efficiently targeted, is derived as eq.(32)'. This exercise was undertaken because of our doubts whether Polish monetary authorities actually were concerned or able to set interest rates efficiently, according to eqs.(23) and (29). If we fill in the parameter estimates and

the actual interest rates, the estimated social welfare change from the removal of currency controls rises to 0.756. This result at the same time confirms our doubts about the efficiency of interest rate targeting and our finding that the removal of currency controls has been efficient from a social welfare perspective.

It is possible of course that α,γ,σ and ω did not remain constant over the whole sample, an assumption that underlies the estimation of eq.(35). A possibility that was not considered explicitly in the theoretical analysis but which has strong intuitive appeal : the removal of currency controls and the reform process in the Polish economy are likely to have stimulated the substituability of Polish Zloty's and foreign currency. It is also likely that the hyperinflation itself induces changes in σ and perhaps also in $\{\alpha,\gamma,\omega\}$. In particular a form of hysteresis in velocity could be induced that was not uncommon in Latin America after hyperinflations : even after a hyperinflation, domestic agents held a permanently higher level of US \$ and a permanently lower level of domestic money. The high degree of dollarization of the economy became a structural element. Agents are likely to react in this manner in our model if σ decreases and/or ω increases structurally. Clements & Schwartz [1993] find evidence for such a form of inertia in the demand for domestic money in the case of Bolivia, where after the hyperinflation of 1985, dollarization remained at a structurally higher level.

We replicate the analysis of Clements & Schwartz in the case of Poland by estimating a variant of eq.(33) that incorporates this hysteresis in currency substitution by means of inserting the lagged dependent variable as an explanatory variable:

$$\ln(\frac{M1}{P})_t \; = \; \beta_0 + D_t.\delta_1 + \beta_1.i_t^p + D_t.\delta_2.i_t^p + D_t.\delta_3.i_t^{us} + \lambda.\ln(\frac{M1}{P})_{t-1} + \epsilon_t \qquad (37)$$

The estimation results, as summarized in the last row of table 1, support the hypothesis of hysteresis in Polish currency substitution : a sigificant adjustment coefficient λ of the stock variable, real domestic money in circulation, is found. A coefficient of .93 implies that only 7% of the adjustment between desired and current real money balances occured instantaneously, that is in the current month. This form of hysteresis is likely to appear in situations where individuals doubt the duration of monetary stability after a hyperinflation

and therefore continue to demand foreign money balances from a precautionary motive.

§5. Conclusions

In the context of a small open economy model, a closer look at the social welfare consequences of currency substitution and currency controls was undertaken. Currency substitution of a significant degree was seen to have potentially strong influence on public finance and, consequently, social welfare. Currency substitution imposes inflationary discipline to monetary policymakers, because a higher degree of currency substitution makes demand for domestic money, and by that real seignorage revenues, more sensitive to inflation differentials between the small economy and the rest-of-the-world. Net seignorage flows because of currency substitution are likely to be negative for a small country since it is likely not to have the vehicle currency function that the foreign money possesses.

Much emphasis was put on the social welfare effects of imposing and removing of currency controls. Currency controls are a widespread phenomenon in developing countries and in the model they enter as device with which monetary authorities are able to avoid currency substitution and by that prevent the seignorage outflow due to currency substitution in the domestic economy. The removal of a currency control was seen to induce a structural break in money demand. An expression was derived in order to determine when removing a currency control is optimal according to the model.

An empirical illustration of the analysis was carried with respect to US dollar currency substitution in Poland, where the removal of a currency control on 1th January 1990 was part of a larger reform package and an active disinflation policy. The empirical results where not unfavourable to some theoretical hypotheses : evidence for a significant structural break in money demand was found. Empirical evaluation of the model allowed us to conclude cautiously that the removal of the system of currency controls in Poland was efficient from a social welfare perspective. Polish currency substitution displayed a

form of hysteresis : after the hyperinflation a structurally higher degree of dollarization was seen, which only gradually declined after the hyperinflation.

Appendix A

In general, if interest rates are not set necessarily equal to the optimal level of eq.(23), by filling in eq.(22) with the correct functions, a general social welfare function results :

$$U_t = \int_{t_0} \{ y_t - g_t + i_t.\alpha - i_t^*.\omega - \frac{(\sigma+1)}{2\sigma(\sigma+2)}.i_t^2 + \frac{(\sigma+1)}{2\sigma(\sigma+2)}.i_t^{*\,2} \}.e^{-\delta t} \, dt \quad (24)'$$

Eq.(24)' could be compared with eq.(24) such as to assess how inefficient current monetary policies are as compared to the optimum of eq.(24). The general form of the social welfare function in the presence of a currency control, so if interest rates are not necessarily set according to eq.(29), can be written as :

$$U_t^{cc} = \int_{t_0}^{\infty} \{ y_t - g_t + i_t.\alpha - \frac{(2\sigma+1)}{2(\sigma+1)}.\omega^2 - \frac{1}{2(\sigma+1)}.i_t^2 \}.e^{-\delta t} dt \quad (31)'$$

If the general expression for social welfare with currency controls, eq.(31)', is subtracted from social welfare without currency controls, eq.(24)', we get the general net gain or loss when removing a currency control:

$$U_t^{nc} - U_t^{cc} = \int_{t_0}^{\infty} \{ -i_t^*.\omega - \frac{1}{\sigma(\sigma+2)(\sigma+1)}.i_t^2 + \frac{\sigma+1}{2\sigma(\sigma+2)}.i_t^{*\,2} + \frac{2\sigma+1}{2\sigma(\sigma+1)}.\omega^2 \}.e^{-\delta t} dt \quad (32)'$$

where it has been assumed that the domestic interest is not changed by the myopic social planner, when a currency control is removed or imposed at time t. The negative first term in eq.(32)' is a net seignorage transfer abroad when removing currency controls, the second and third terms are 'interest rate' effects on social welfare from removal of currrency controls at time t and the last term is the increase in social welfare from the higher monetary utility when being allowed to hold foreign currency. Myopic monetary policies typically only would take into account the seignorage effect when motivating the use of currency controls. More efficient monetary policymaking would also take account

of the other three effects of removing a currency control. When the expression in eq.(32)' is positive a removal of currency controls is efficient, even if the domestic interest rate is not necessarily being set optimal.

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