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THE POLAK'S MACROECONOMIC MONETARY MODEL

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ABSTRACT

The Polak's macroeconomic monetary model reflecting the monetary approach to the balance of payments was developed in the International Monetary Fund (IMF). Its purpose is to integrate monetary, income and balance of payments analysis, and it became the basis of the conditionality applied to IMF credits.

The dynamic nature of the Polak's monetary model, in contrast to most academic monetary models of the balance of payments, yields not only the final equilibrium value of the endogenous variables but also the time path toward these values. This makes the model particularly suitable for presentation and manipulation in system-dynamic notation.

Based on the original mathematical form of the Polak's monetary model we constitute the causal loop diagram, first of the basic model and then the extended, goal oriented model variant. Based on the causal structure we also form the corresponding flow diagram of the model in POWERSIM notation.

Polak's model is especially suitable for operative application in IMF financial programming missions in developing countries. Since Croatia is one of these countries, it is chosen as a case to test applicability and validity of the system-dynamic version of Polak's extended monetary model. The model parameters are calibrated and validity of the model is tested on the basis of data for the period of 1994-1996 (based on the quarterly data).

Keywords: macroeconomic, Polak's monetary model, financial programming, system-dynamic simulation, POWERSIM

1. THE POLAK'S MONETARY MODEL

The Polak's macroeconomic monetary model (*Polak, J.J. 1977*) reflecting the monetary approach to the balance of payments was developed in the International Monetary Fund (IMF) in the 1950s. Its purpose was to integrate monetary, income and balance of payments analysis, and it became the basis of the conditionality applied to IMF credits. From the day in 1947 that the Fund opened its doors for business, member countries came to it to seek credit when they encountered deficits in their balances of payments that they found difficult to finance from their own reserves. To ensure that these countries would correct their payments positions within a reasonable period, the Fund had to have an understanding of the causes of the payments deficits and, both qualitatively and quantitatively, of the policy measures necessary to overcome them. Only then could it come to a judgement whether the actual or proposed policies of the member would be sufficient to restore balance and, if not, to insist on a strengthened policy package as a condition for its credit. The Polak monetary model that the Found introduced in the 1950s to meet this need appeared to be still very much alive 30 or 40 years leter.

One key characteristic of the model is its *simplicity*. For this were two good reasons. At the analytical level, this simplicity was inevitable in view of the paucity of data for many of the Fund's member countries, the total absence of econometric models to describe their economies and indeed of any hope to remedy this situation for decades ahead. In this circumstances a ready-made model that needed as inputs only two sets of statistics that were generally available, *banking and trade data*, went a considerable distance toward meeting the needs of the organization for analytical tools for its financial operations. Equally important, however, and relevant to countries both large and small, was the focus of the model on the key variable that the authorities could control, *domestic credit creation*, and that was seen as crucial to the correction of the balance of payments problems for which the Fund assistance had been invoked.

The Polak's monetary model was designed to study the effects on both income formation and the balance of payments of the two most important exogenous variables operating on the economics of the great majority of countries in the early postwar period: *autonomous changes in exports* and *the creation of domestic bank credit*, or in monetary terms: *foreign and domestic autonomous additions to a country's money supply*. The linkage of domestic autonomous expenditure to credit creation, and of exports to additions to the money supply from abroad, required a model that explicitly recognized a *demand-for-money function*. The evidence from many countries suggested that the simplest form of such a function, *namely demand proportional to GNP*, would constitute a reasonable approximation (see equation 1).

$$\Delta MO = k * \Delta Y \qquad (1)$$

The change in a country's money supply (ΔMO) is proportional to the change in its income (ΔY) by a factor *k*, which is *the inverse of the velocity of circulation of money* ($k=MO/Y$).

As a second behavioral equation the model contained a *function for the demand for imports* (see equation 2).

$$M = m * Y \qquad (2)$$

The demand for imports (M) is a function of a country's income (Y), where *m* is *the country's marginal propensity to import*.

The change in the money supply (ΔMO) is by definition equal to *the change in a country's foreign reserves* (ΔR) plus *the change in domestic credit of the banking* *system* (ΔD). The change in foreign reserves (ΔR) is by definition equal to *exports* (X) minus *imports* (M) and plus *net capital inflows of the nonbank sector* (K).

$$\Delta MO = \Delta R + \Delta D \qquad (3)$$
$$\Delta R = X - M + K \qquad (4)$$

The dynamic character of this model derives from the fact that it contains both *income* and the *change in income*. Solving the model gives us values for the variables that are determined by the model, such as *income* and the *change in foreign reserves*, as weighted averages of the values for the current and past years of *export*, *capital inflows of the nonbank sector*, and *the change in the domestic credit of the banking sector*. The dynamic nature of *the Polak's monetary model*, in contrast to most of the academic monetary models of the balance of payments, yields not only the final equilibrium value of the endogenous variables but also the time path toward these values.

2. SYSTEM DYNAMIC VERSION OF THE POLAK'S MONETARY MODEL

Based on the mathematical form of the Polak's monetary model from the previous section we have constructed the *Causal Loop Diagram* in accordance with the system-dynamic methodology for real system modeling. *Figure 1* shows how the causal model structure is *dominated by a negative cycle of recurrent action* ("-" *Causal Loop*) with the expected *stabilising effect*.

The theoretical basis for the established causal chain is as follows: The Quantitative monetary theory states that there is a proportional positive link between the income (Y-rate variable) and money supply (MO - level variable) where proportionality coefficient is 1/k (velocity of circulation of money), which is supposed to be constant in time. Furthermore, import (M - rate variable) is the function of income, and the positive link between the observed variables is expressed by the coefficient m (marginal or average propensity to import), which is also assumed to be constant in time. The accounting identity of the balance of payments reveals the size of change in foreign reserves where every increase of the endogenously determined import reduces foreign reserves (negative link), and every increase of exogenously determined import variables and net capital inflows of the non-bank sector increases foreign reserves (positive links). Then, the change in money supply (MO) is determined by the change in a country's foreign reserves (with a positive link) and the change in the domestic credit of the banking system (also with a positive link).

The logic of the last chain link is the following: money appears by the process of domestic credit expansion (increase of D) or comes from the outside (increase of R), and money disappears by the process of domestic credit contraction (decrease of D) or goes out (decrease of R).

Figure 1.

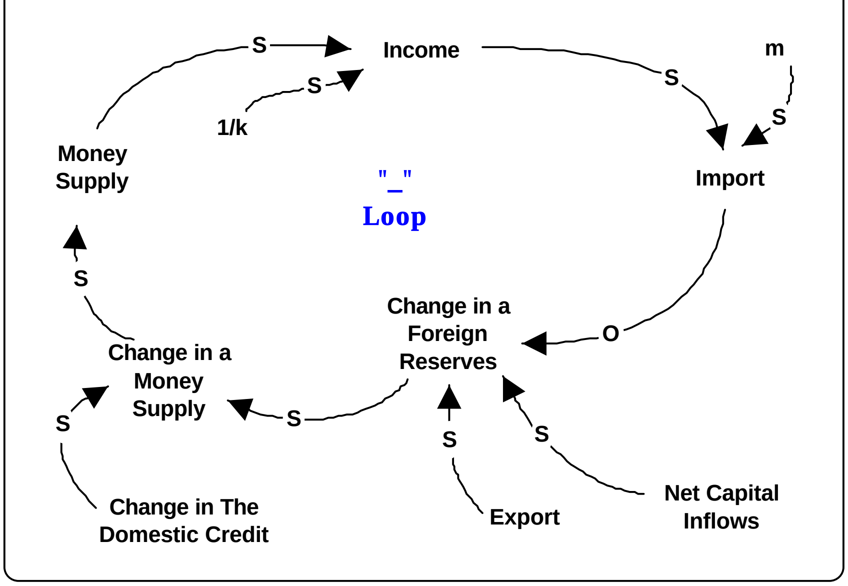


Figure 1. Causal Loop Diagram

Note: The symbol “S” presents change in **S**ame direction, and the symbol “O” presents change in **O**pposite direction.

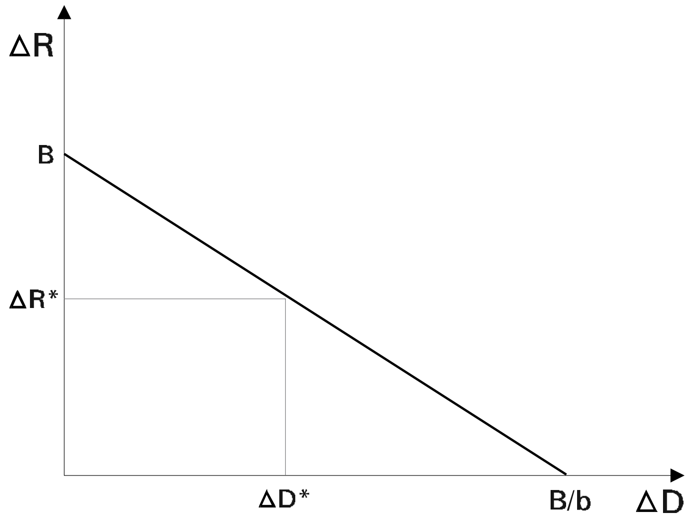
Based on the previous causal loop we can state that an increase/fall of any of the autonomous, exogenous components (assuming constant values of parameters m and k) will affect the increase/fall of imports. However, in the second part of the causal loop such change of import will cause changes opposite to the variable within the observed causal loop. Net-effects can be seen only when all change-cycles are considered (theoretically they are infinite, but still most of them are effected in a countable number of cycles).

One of the basic applications of the Polak’s model is in the *field of managing monetary policy focused on the balance of payments.* Due to that this model is the basis of financial programming in the IMF, especially in the calculation of restrictions on the net domestic assets of the banking systems of country members – clients. Regarding this, an issue of special interest is the relation between the mentioned net domestic assets and size, or the target increase of the net foreign assets. Algebraic solution of the Polak’s model offers an expression connecting the two components (*Prais, S.J. 1977*):

$$\Delta R = B - b*\Delta D,$$

where: B=(k/k+m)*(E+K-U) and b=(m/m+k). This relation is in the heart of every IMF programme where ΔR, or R is given as the target, and achieving the target is effected by regulating net domestic assets (ΔD, or D). It is obvious that every credit expansion causes reduction of the net foreign assets R and vice versa, which is shown in the following diagram:

Figure 2.



As in the IMF programmes the target size of the currency reserves (ΔR^*or R^*) is determined on the basis of sufficiency criteria, and most often it is the level corresponding to the three months' imports value, it is possible to precisely determine the upper limit of *net domestic credit increase* (D) in the banking system:

$$\Delta D^* = B/b - 1/b^*\Delta R^*.$$

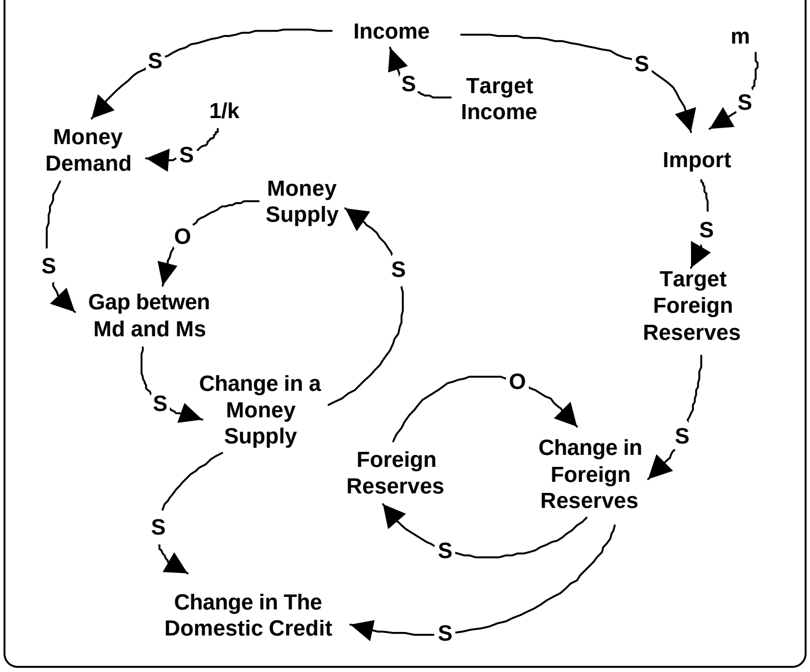
However, the previously given algebraic approach to the problem (arising from the monetary approach to the balance of payments) offers with the help of Polak's model the *final effects* of the proposed policies on the endogenous model variables, but *does not provide an insight into the dynamic structure of the changing mutual effects of variables in the model.*

The basic question here is duration of time in which the mentioned effects will be fully effected. This refers especially to the adjustment of f*oreign reserves* level. Besides, the target-oriented approach changes the structure of the initial Polak's model. Furthermore, there is the issue of target values of other important variables in the model (for instance, the aimed income increase dynamics), as well as the effect of the target approach on some, earlier exogenous and now endogenous, or more precisely, residual variables (e.g. net capital inflows of the non-bank sector).

The c*ausal loop diagram* of the modified target oriented Polak's model now looks like this:

Figure 3.

Figure 3. Causal Loop Diagram of The Modified Polak's Monetary Model

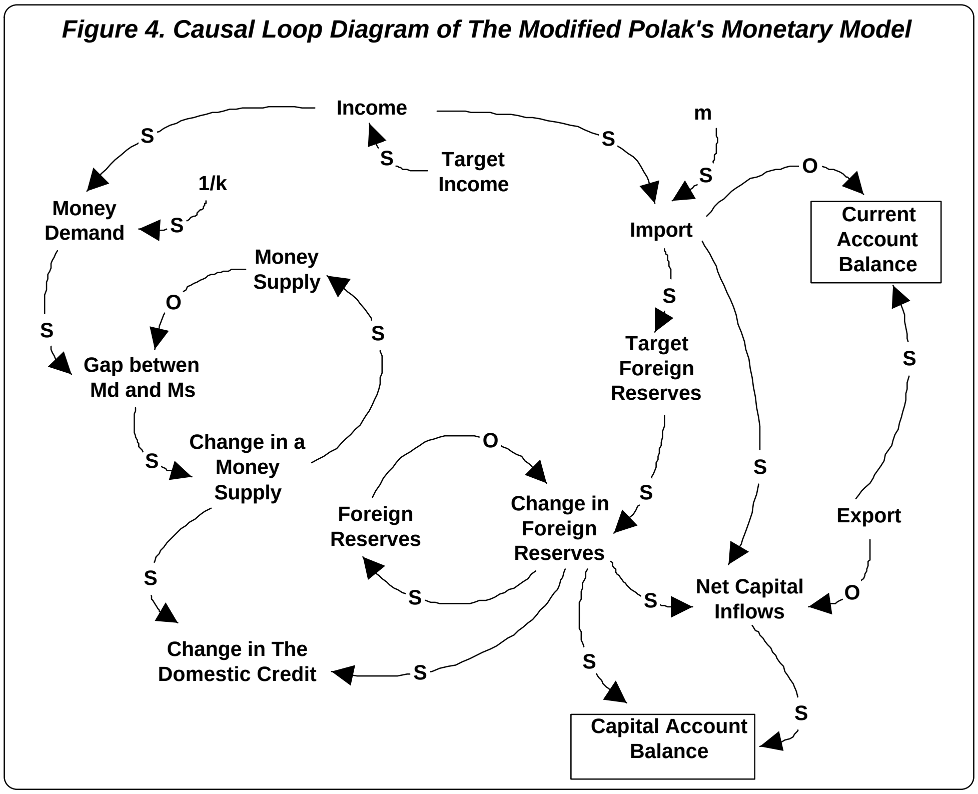


The structure presented above is characterised by the target dynamics of the GDP (or National Income), the target level of international reserves, and the endogenous treatment of change in domestic credits. This provides the simulation of *the necessary dynamics of domestic money creation adjusted to the given macroeconomic targets*.

The effect of the new, target-oriented model structure on the changes in the balance of payments can be defined by an extended causal-loop diagram presented in the *Figure 4.*

Now the model functions in the following way: The target-oriented income level on one side determines the level of money demand (Md), and with the given level of money supply (Ms) a gap appears in the money market. This gap requires the corresponding change in the money supply. Assuming a constant monetary multiplicator, the money market balance can be restored by a change in the monetary basis, i.e. by a change in foreign reserves and/or a change in the domestic credits. As the level of foreign reserves in the new model structure is aimed (most frequently determined at the level of three months imports), and as for their adjustment a longer period of time is required, the main instrument to restore the balance is *net domestic credit*.

Figure 4.



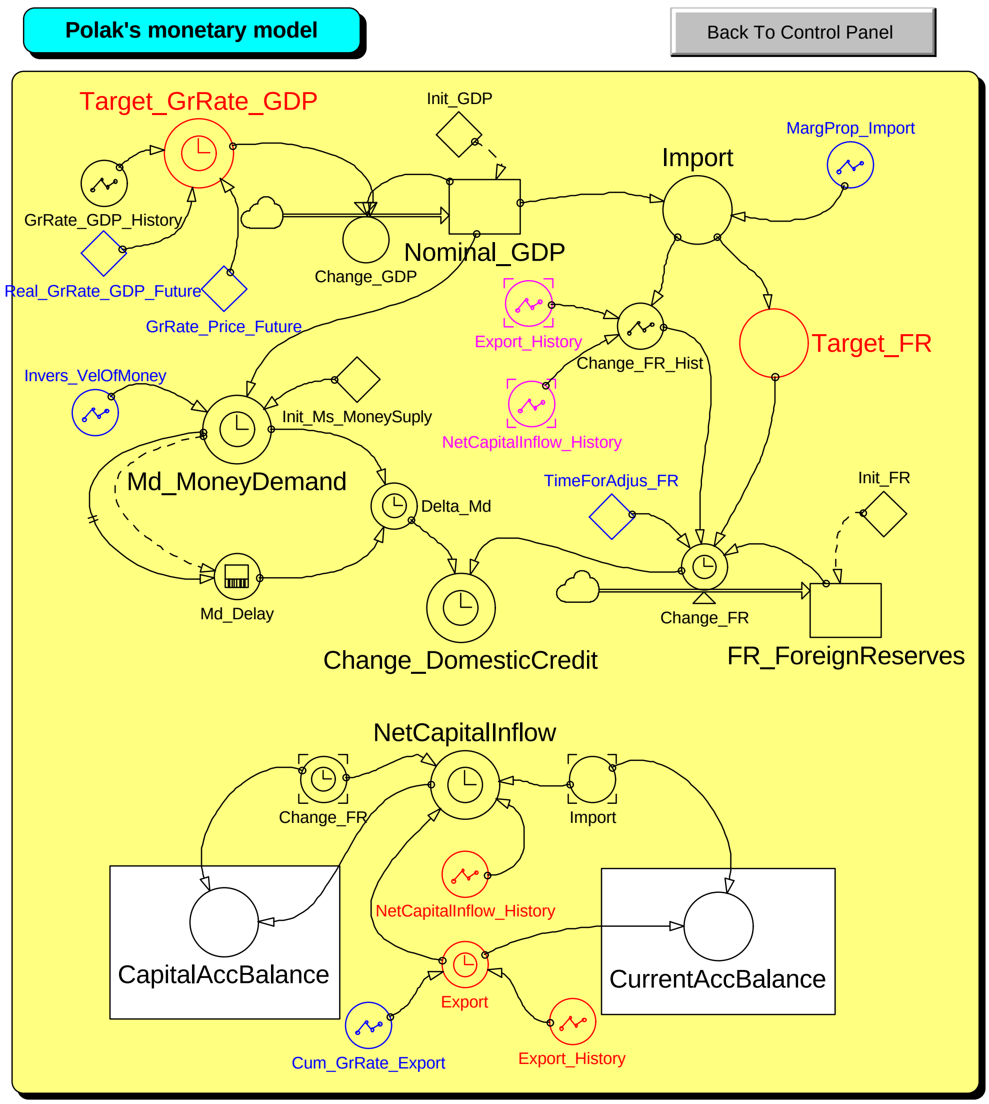
Changes in the balance of payments *current account* are determined by the endogenous change of imports (affected by the aimed income level and dynamics), and by exogenous export dynamics. Changes in the balance of payments *capital account* are determined by the endogenous change of foreign reserves and by net capital inflows.

3. APPLICATION OF THE MODIFIED POLAK'S MONETARY MODEL ON THE CROATIAN CASE

Croatia is suitable to illustrate the application of the Polak's monetary model for several reasons. She is one of the developing countries that are remarkably open to the world (the size of goods and services exchange exceeds the value of the GDP). Because of that she is susceptible to lots of positive and negative influences from her environment that can endanger not only her external, but also internal stability. Consequently, her monetary policy is particularly important, especially in the context of the so-called monetary approach to the balance of payments. Furthermore, the lack of the national accounting system hampers the application of the more complex models supporting the economic policy. With the Polak's model there are no problems in data collecting for a limited number of variables included in the model structure. Moreover, we are witnessing the situation in which the Croatian economic policy is to a large extent carried out in co-operation with the IMF. Because of that, the so-called financial programming based on the application of the Polak's model is of special importance for Croatia.

The modified Polak's model in the system-dynamic form is built by use of POWERSIM notation. Model parameters calibration is carried out based on original quarterly data on basic variables trends for the period of 1994-1997. The Polak's model system-dynamic form flow diagram is presented in Figure 5.

Figure 5. Flow-diagram of the modified Polak's monetary model

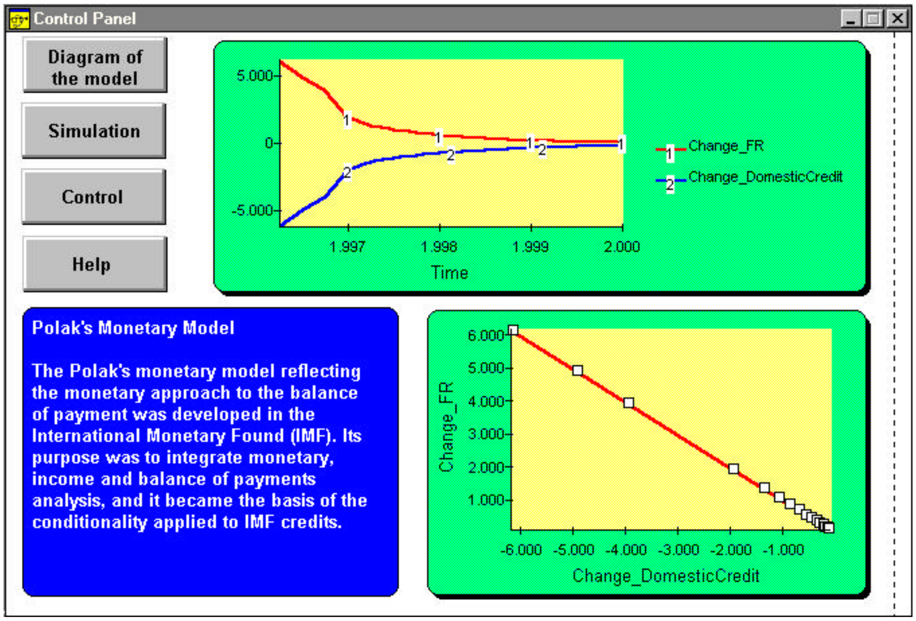


The key parameters in the given structure determining the model dynamics are:

Target Growth Rate of GDP defined by Real Growth Rate of GDP_Future and Growth Rate of Price_Future, *Target Foreign Reserve* and *average Time to Adjust Foreign Reserve*. The basic endogenous variable to test the target dynamics of the model is Change_Domestic Credit, and also of interest is the dynamics of the variable NetCapitalInflow, and the related trend of CapitalAccBalance and CurrentAccBalance..

Figure 6 presents the *Control Panel* of the Polak's monetary model showing the two basic diagrams with simulation results for the period from 1996 to 2000. With the earlier in-built assumption on the target level of Foreign Reserves related to the value of three months imports, and with the added assumption on the zero-rate of GDP growth, the model completely simulates the expected behaviour of variables Change_FR and Change_DomesticCredit.

Figure 6. Control Panel of The Polak's Monetary model



In the first diagram we can recognise the stabilisation effects of the substitutive relationship of the mentioned changes during the simulation period, and the second diagram confirms the linear negative connection between the same changes presented in the earlier provided *Figure 2*. The change or adjustment of the controlled model parameters (*RealGrowthRate_GDP_Future* and *TimeForAdjus_FR*) during the simulation process, and control of the key variables output is provided by the *Controller and Display Window*.

It is particularly important to point out once more that the model dynamics is affected by the time required to adjust the current level of Foreign Reserves to the target level. The sequence presents the trend of Change_FR and Change_DomesticCredit depending on the estimation of the average TimeForAdjust_FR. In the first simulation passage (curves denoted with '1' and '3') TimeForAdjust_FR=1.25, and in the repeated simulation passage (curves denoted '2' and '4') TimeForAdjust_FR=2.25.

Figure 7. Controler and Display - Window of The Polak's Monetary model

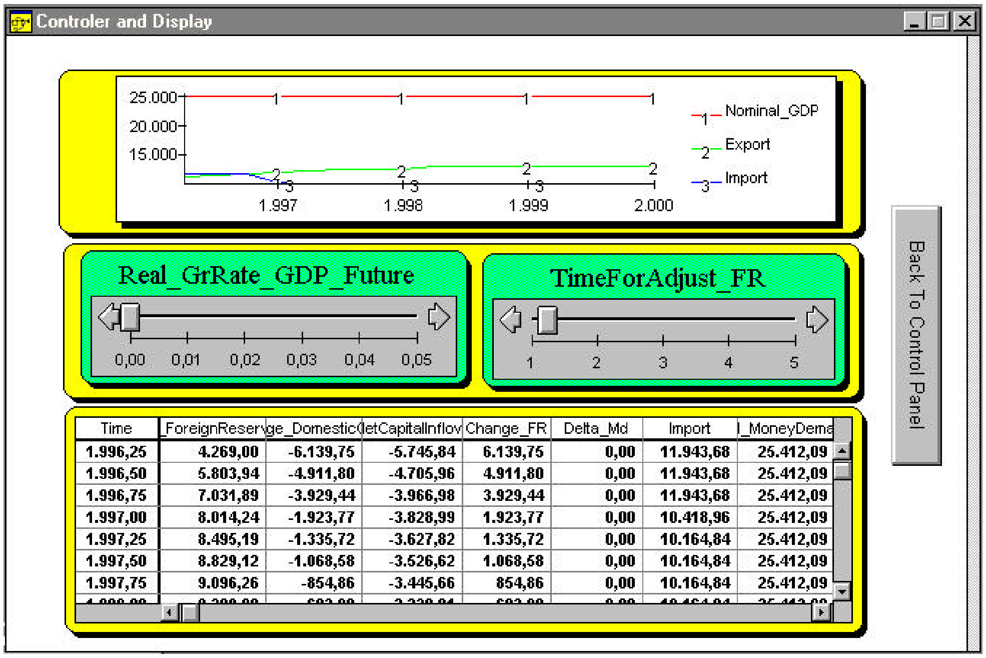
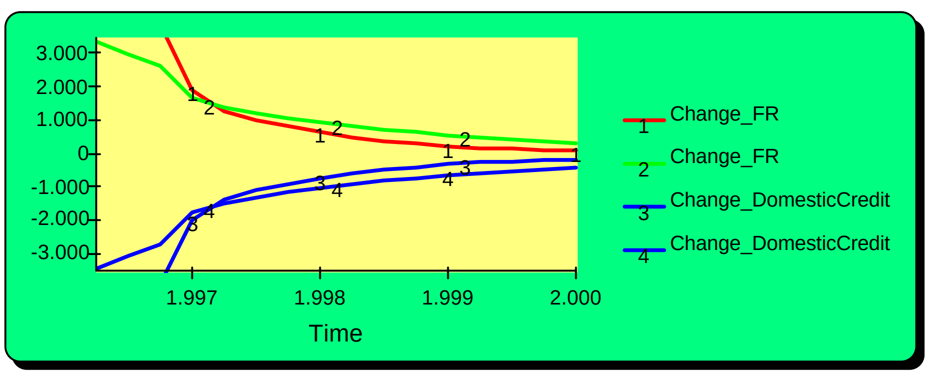
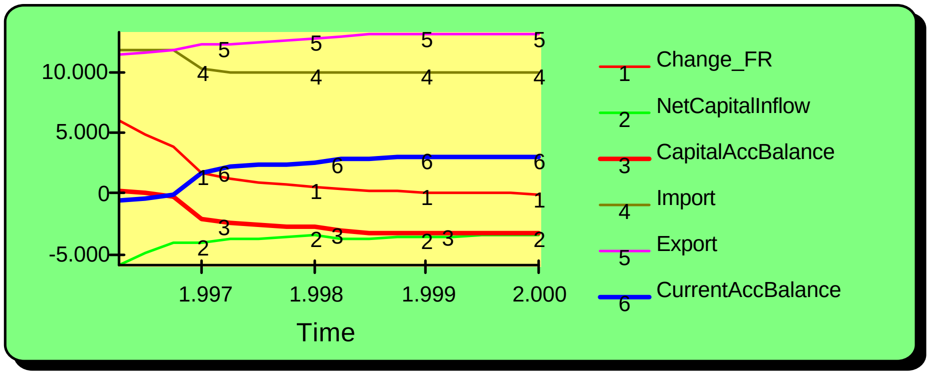


Figure 8.



In the end, let us check out the dynamics validity of the variables determining the balance in the current and capital balance of payments accounts. Remember that the current account balance directly depends on the exogenous export dynamics (Export), and that the same variable indirectly (via endogenous NetCapitalInflow) affects the balance in the capital account of the balance of payment. The simulation results presented in the Figure 9 show the regular relations of variable trends in this model block:

Figure 9.



CONCLUSION

The Polak's macroeconomic monetary model id developed within the IMF aiming to integrate monetary, income and balance of payments analysis in a single, relatively simple model. One of its basic purposes is in the sphere of monetary policy design with the emphasis on the balance of payments. Due to this, the model is the main support of the IMF's financial programming, especially in calculation of restrictions on the net domestic credit of the country members banking system.

The Polak's model has a pronounced dynamic character as its structure contains simultaneously level variables and rate variables. Due to this, it is suitable for simulation based on the principles of system-dynamic methodology. Such approach is superior to the classic algebraic model solution, as it provides an insight into the dynamic structure of the mutual effects of variables included in the model.

This paper has shown how the model structure can be efficiently adjusted to the specific requirements of monetary policy designers. This primarily refers to the target-oriented structure providing the simulation of the necessary dynamics of the domestic money creation adjusted to the given macroeconomic targets.
We have tested the system-dynamic form of the Polak's model on the case of Croatia proving its validity in terms of simulation of the expected behaviour patterns of the basic model variables. The completely arranged model interface in POWERSIM notation provides a simple and efficient manipulation of the model in its experimental stage.

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