

Monetary Policy, the Labor Market and Pegged Exchange Rates: A Study of the German Economy*

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Abstract

The European Community operated from 1979 to 1999, before the Euro was introduced, under a pegged exchange rate regime, the European Monetary System (EMS). This was also the time period when the European unemployment rate was secularly rising. Germany was the dominant country in Europe and other countries had, to a great extent, to follow Germany's monetary policy. Kenen (2002) calls this the leader-follower model. On the other hand, German monetary policy, operating under the EMS, was restricted by an open economy dynamic. In the context of a Keynesian open economy macro dynamic model, in the spirit of James Tobin's work, we explore (1) the implication of pegged exchange rates on the macroeconomic dynamics of a large economy – the German economy, and (2) study how successfully monetary policy can be conducted under pegged exchange rates. A core of our dynamic macro model is an open economy price and wage Phillips-curve. Concerning monetary policy we study two alternative rules: the monetary authority targeting money growth or the inflation rate (Taylor rule). The model is estimated with time series data of the German economy and impulse-response mechanisms explored.

Keywords: European Monetary System, pegged exchange rates, open economy macrodynamics, monetary policy rules.

JEL classifications: E31, E32, E37, E52

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1 Introduction

In Europe for a long time period, from 1979 to 1999, a pegged exchange rate system was the dominant exchange rate arrangement. In January 1999 the European Monetary System (EMS), under which the currencies of the member states of European Union were pegged within a band, was replaced by a single currency, the Euro. For the time period from 1979 to 1999 the German monetary policy, when it was confronted with a secular rise of unemployment in the 1980s and 1990s, operated under the EMS.

It is worthwhile to take stock of the experience of EMS and to learn how the pegged exchange rate system for the EU has operated, and how successful monetary policy can be to simultaneously achieve price and output stability as well as pegging the exchange rate in an open economy. One of the major reasons for a pegged exchange rate system has been that countries with strongly integrated trade save considerable transaction costs when moving from highly volatile flexible to pegged exchange rates. Yet, frequently it is argued that the countries will lose monetary policy as stabilization instrument because monetary authorities are obliged to use monetary instruments to keep the exchange rate constant. As usually stated money becomes endogenous because it has to be devoted to this task and one cannot pursue a stabilization policy (McCallum 1996, ch.7).

Yet, the experience of the EMS from 1979-1999, with the exception of the serious disturbance 1992, seems to have shown that pegged exchange rates can work and demonstrate that monetary policy can, though with some difficulties, be conducted even by being devoted to three goals: exchange rate stabilization and stabilization of inflation and output. Surely, there are disadvantages with these three goals of monetary policy, yet one might want to demonstrate (1) how the macroeconomic dynamics work¹ and (2) how monetary policy can be inacted even under pegged exchange rates.

To study these questions is important since many regions that are nowadays highly integrated through trade naturally tend to adopt pegged exchange rate systems between the integrated economies. Yet, for a country under pegged exchange rates there are essential restrictions under which monetary policy operates.

We will develop a prototype Keynesian macroeconomic framework² for an open economy with pegged exchange rates and study those above mentioned questions. We allow for disequilibria in the product and labor market, sluggish wage, price and output adjustments and the trade account responding – given that the nominal exchange rates are fixed with in a band – to real exchange rates. A major core equation of our model will be an open economy Phillips-curve for the labor market.

More specifically we consider Germany as an example of an open economy with pegged exchange rates. We presume that 1) intermediate goods as well as private and public consumption demand respond to real exchange rates and 2) a wage and price Phillips-curve is impacted by real exchange rates. In this context then macroeconomic dynamics as well as effectiveness of monetary policy are studied. Concerning monetary policy we consider two rules – the monetary authority targeting the money growth rate or directly targeting the inflation rate (and output) through the Taylor rule. We want to note that in one of his last papers James Tobin gives an evaluation of these two rules where he shows that the Taylor rule in fact permits a discretionary monetary policy, see Tobin (1998). Yet, we want to remark that our study goes a bit further and also beyond the usual studies. Usually, the working of monetary policy rules are studied only for a closed economy. Ball’s study, see Ball (1999), is a notable exception.³

The remainder of this paper is organized as follows. Section 2 introduces the open economy model of a country under pegged exchange rates with product market disequilibrium, wage and price Phillips-curves for an open economy and balance of payment adjustment mechanism. Section 3 transforms the model into an intensive form so that the existence of the equilibria as well as the macroeconomic dynamics can be studied. In Section 4 the dynamics are more specifically studied for the above two monetary policy rules. Section 5 estimates the model for time series data of a prototype economy of the EMS, namely the German economy. Section 6 studies impulse response functions and section 7 concludes the paper. The appendix demonstrates the working of the current account under a pegged exchange rate system and lists the symbols and the sources of data.

2 The Model in Extensive Form

Our model is explained best by successively introducing modules for the different components of the model. Module 1 below provides some definitions of basic variables of the model: the real wage ω , the expected rate of return on capital ρ^e (δ the depreciation rate), real financial wealth W (consisting of money, domestic and foreign bonds and equities) and the real exchange rate η .⁴ The expected rate of return on physical capital is based on expected sales from which depreciation, real wages and real imports of firms have to be deducted. Firms therefore make use of a three factor technology where besides capital K and labor L^d imports J^d are used to produce real output Y . In addition to the measure of the currently expected returns on capital we use normal returns ρ^n in the investment function of the model, which are

based on the normal utilization of capacity $y_o = \bar{U}y^p$ and the normal sales to capital ratio y_o^d .⁵ Due to the historical background chosen, the exchange rate e is an exogenous magnitude of the model which implies that domestic and foreign fix price bonds (prices set equal to one in each currency for simplicity) can be considered as perfect substitutes if they earn the same nominal rate of interest.

1. Definitions (income distribution, real wealth, real exchange rate):

$$\omega = w/p, \rho^e = (Y^e - \delta K - \omega L^d - J^d/\eta)/K, \eta = p/(ep^*) \quad (1)$$

$$W = (M + B_1 + eB_2 + p_e E)/p, p_b = p_b^* = 1, e = \text{const.} \quad (2)$$

$$\rho^n = y_o^d - \delta - \omega y_o/x - j y_o/\eta, y_o^d = \bar{U}^c y^p/(1 + n\beta_{n^d}), y_o = \bar{U}^c y^p \quad (3)$$

Module 2 provides the equations for the household sector, consisting of workers and asset holders, with lump-sum taxes, T_w , concerning wage and interest income of workers and T_c , concerning the dividend and interest income received by asset holders, held constant net of interest per unit of capital, see the government module below, since fiscal policy is not a topic in the present paper.⁶ Asset demand is shown in general terms in equations (4) and (5), where only money demand is explicitly specified.⁷ The wealth constraint for asset reallocations is (4). Its implications are explicitly considered only in the case of money demand (5) which allows the usual LM-determination of the domestic nominal rate of interest.

Domestic bonds and foreign bonds exhibit the same rate of interest rule. In our case it is based on the dominance of the domestic, German, money supply rule or rate of interest rule.⁸ Domestic equities are also considered as perfect substitutes, see eq. (30), where equity prices are assumed to adjust such that returns are equalized with those on short-term domestic bonds. The reallocation of interest bearing assets may thus be ignored, since asset holders accept any composition of such assets if money demand has adjusted to money supply by movements of the short-term rate of interest r .

Eqs. (6), (7) define the real disposable income of pure asset holders and workers, respectively interest rate reaction function of the Taylor type is inacted. The consumption of the two groups of the domestic goods, C_1 , and the foreign goods, C_2 , depends both in the case of asset owners and of workers on the real exchange rate η in the usual way, which is here formalized by means of the consumption ratio $\gamma(\eta)$ namely as fraction of their total consumption expenditures, based on given saving ratios s_w, s_c of these two groups of agents. Note that consumption of foreign goods is based on real income in domestic terms and must thus be transformed by means of the real exchange rate η . Aggregate domestic consumption C is defined in Eq. (10).

Note finally that workers save in the form of money and domestic bonds,

while asset holders also save in the form of foreign bonds and domestic equities. We thus assume that only bonds are traded internationally. This is not a severe restriction in the present formulation of the model, since financial asset accumulation does not yet feed back here into the real part of the economy, due to neglecting wealth and interest rate effects in the consumption functions of both workers and asset holders. The model that we are investigating here thus still exhibits only a very traditional type of real-financial interaction, basically based on the assumed simple LM-theory of the money market or a Taylor interest rate policy rule. Note however that the model allows for saving of workers and the accumulation of money and short-term domestic bonds by them. Note furthermore that we assume with respect to asset holders that all expected profits are paid out as dividend to which interest income here and abroad must be added to obtain their before tax total income.

Private saving S_p of asset holders and workers together absorb the change in money supply caused by the open market operations of the central bank, the new equity issue of firms, part of the domestic new bond issue and in general also foreign bonds to some extent. We have to check later on that there is consistency in the absorption of flows and thus no obstacle for the supply of new money, new domestic bonds and the issue of new equities. Note that the flows shown in Eq. (11) need not all be positive since we also allow for flows out of the stocks of domestic and foreign bonds held domestically. Finally, labor supply L grows at a constant rate n_l , which – augmented by Harrod neutral technical change – is assumed to determine the trend growth rate in investment, sales expectations and inventories (in order to avoid the introduction of further laws of motion).

2. Households (workers and asset-holders):

$$W = (M^d + B_1^d + eB_2^d + p_e E^d)/p \quad (4)$$

$$M^d = h_1 p Y + h_2 p W (r_o - r), \quad W \text{ reduced to K later on} \quad (5)$$

$$Y_w^D = \omega L^d + r B_{1w}/p - T_w, \quad s_w Y_w^D = \dot{M}_w + \dot{B}_{1w} \quad (6)$$

$$Y_c^D = \rho^e K + r B_{1c}/p + e r^* B_2/p - T_c, \quad (7)$$

$$s_c Y_c^D = \dot{M}_c + \dot{B}_{1c} + e \dot{B}_2 + p_e \dot{E}$$

$$C_1 = \gamma(\eta)((1 - s_w)Y_w^D + (1 - s_c)Y_c^D), \quad (8)$$

$$\gamma(\eta) = \gamma_o + \gamma_1(\eta_o - \eta) \in (0, 1)$$

$$C_2 = \eta(1 - \gamma(\eta))((1 - s_w)Y_w^D + (1 - s_c)Y_c^D) \quad (9)$$

$$C = C_1 + (e p^*/p)C_2 = C_1 + C_2/\eta \quad (10)$$

$$S_p = Y_w^D + Y_c^D - C = s_w Y_w^D + s_c Y_c^D = (\dot{M} + \dot{B}_1 + e \dot{B}_2 + p_e \dot{E})/p \quad (11)$$

$$\hat{L} = n_l = \text{const.} \quad (12)$$

The third module concerns firms, modelled here with respect to their output and employment decision Y, L^d and their needs of imports for production. We thus have a three factor production technology and assume fixed proportions in production and thus strictly proportional relationships between capital K and potential output Y^p , output Y and employment L^d as well as the imported intermediate good factor J^d . On this basis we can also define unambiguously the capacity utilization rate of firms U^c and the rate of employment of the labor force V . Next, in Equ. (16) we describe the net investment decision of firms which is based on medium run values for the return differential between normal nominal profitability $\rho^n + \hat{p}$ and the nominal rate of interest r , with \hat{p} the rate of inflation.

Excess returns $\epsilon = \rho^n + \hat{p} - (r + \xi) = \rho^n - (r + \xi - \hat{p})$ of firms, with ξ a given risk premium, transformed to such medium run values ϵ^m , interpreted as the currently prevailing investment climate, are one driving force for the investment decision, while the deviation of capacity from its normal value provides the short-run influence of the state of the business cycle on the investment decisions of firms. We assume that the medium run values ϵ^m follow their short-run analogs in an adaptive fashion, representing the way how the medium run climate expression is updated in the light of the current experience on their short-run analogs. In later propositions on the model we will basically make use of the short-run excess variable in the investment function solely and leave the delayed influence of excess real profitability over the real rate of interest for the empirical investigation of the model.

The excess of expected sales Y^e over aggregate demand Y^d for the domestic commodity is shown next. Here, the index 1 is used in the usual way to denote the domestically produced commodity (also demanded by foreigners in the amount of Y_1^{d*}). Furthermore, we use $*$ to denote foreign demand and supply. In Equ. (18) we state that the saving of firms are equal to their voluntary production of inventories which in turn is equal to the excess of their production over their expected sales by definition. Finally we have the financing condition of firms, equ. (20), which states that all investment and all unintended inventory changes (windfall losses) are financed by the issue of new equities, which means that we do not yet allow for credit financing and the like. If $\dot{N} - \mathcal{I}$ is negative, firms do have windfall gains in the place of windfall losses and are using them for their investment financing and thus do not have to issue as many equities as their investment decision would in fact demand. Note again that expected profits are paid out as dividends and are thus not available for the financing of investment plans.

The last equation of module 3, finally, states that we consider only Keynesian regimes as temporary positions of the economy, where in particular all investment orders are always fulfilled, i.e., firms never run out of invento-

ries and indeed always serve aggregate demand, see module 6. of the model. Note that the present formulation of the sector of firms considers imported goods only as intermediate goods in production, not as part of the investment efforts of firms which are solely based on domestic commodities. This is an assumption that may be justified in particular with regard to the German economy.

3. Firms (production-units and investors):

$$Y^p = y^p K, \quad y^p = \text{const.}, \quad U^c = Y/Y^p = y/y^p \quad (y = Y/K) \quad (13)$$

$$L^d = Y/x, \quad n_x = \hat{x} = \dot{x}/x = \text{const.}, \quad V = L^d/L = Y/(xL) \quad (14)$$

$$J^d = jY, \quad j = \text{const.} \quad (15)$$

$$I/K = i_1 \epsilon^m + i_2 (U^c - \bar{U}^c) + n, \quad n = n_l + n_x \quad (16)$$

$$\dot{\epsilon}^m = \beta_{\epsilon^m} (\epsilon - \epsilon^m), \quad \epsilon = \rho^n + \hat{p} - (r + \xi) = \rho^n - (r + \xi - \hat{p}) \quad (17)$$

$$\Delta Y^e = Y^e - C_1 - Y_1^{d*} - I - \delta K - G_1 = Y^e - Y^d \quad (18)$$

$$Y_f = S_f = Y - Y^e = \mathcal{I} \quad (19)$$

$$p_e \dot{E}/p = I + \Delta Y^e = I + (\dot{N} - \mathcal{I}) \quad (20)$$

$$\hat{K} = I/K \quad (21)$$

Module 4 describes the government sector of the economy in a way that allows for government debt in the steady state and for a simple monetary policy rule (to be modified later on). Government taxation of workers and asset holders income is such that taxes net of interest receipts are held constant per unit of capital. This simplification allows to treat tax policies as parameters in the intensive form of the model, since our stress is on the role of monetary policy rules, and removes in addition the impact of interest payments on the consumption decisions of both types of households.

Government consumption per unit of capital is also assumed a parameter of the model, but is divided into domestic demand and demand for the foreign commodity at the same ratio as for the sector of households –which is thus uniform across consuming sectors.⁹ The definition of government saving is an obvious one, as is the growth rate for the money supply, assumed to equal the domestic steady state rate of real growth n augmented by the steady state rate of inflation of the foreign country.

Finally \dot{B} describes the law of motion for government debt, which results from the decision on taxation T , government consumption G and the money supply \dot{M} . Note that the central bank has not to be involved in foreign exchange market operations, since we can show later on that the balance of payments is balanced in this model without any intervention from the monetary authority.

4. Government (fiscal and monetary authority):

$$T = T_w + T_c \quad (22)$$

$$t_w = \frac{T_w - rB_{1w}/p}{K} = \text{const.}, \quad t_c = \frac{T_c - (rB_{1c} + er^*B_2)/p}{K} = \text{const.} \quad (23)$$

$$G = gK, \quad g = \text{const.} \quad (24)$$

$$G_1 = \gamma(\eta)G, \quad G_2 = \eta(1 - \gamma(\eta))G \quad (25)$$

$$S_g = T - rB/p - G \quad (26)$$

$$\hat{M} = n + \bar{\pi} = n + \hat{p}_o^* = \text{const.} \quad \text{at first} \quad (27)$$

$$\dot{B} = pG + rB - pT - \dot{M} \quad (28)$$

The fifth module lists the equilibrium conditions for the four financial assets of the model: money, domestic and foreign bonds and equities. Due to the perfect substitutability assumptions (30), (31) it suffices to specify money demand explicitly, as wealth owners are indifferent to the allocation of the remaining terms, their domestic and foreign bond holdings, which only have interest returns, and their equity holdings (whose return consists of dividend returns as well as capital gains).

Note that we have assumed in Equ. (31) that the domestic economy dominates the other economies included in the pegged exchange rate system with respect to interest rate formation (here based on its still simple money supply rule). We thus presume that the other economies will always adjust the nominal interest rate achieved by the domestic economy so as to keep the nominal exchange rates constant. Such a behavior of the other countries to adjust their interest rate within a pegged exchange rate region has been called the leader-follower model, see Kenen (2002). This may not always be convenient for the other economies but this was what in fact has happened under the EMS.

We stress that the model cannot be considered as being completely specified, since there may be more than one path for the accumulation of bonds as the model is formulated which however does not matter for the real dynamics in its present formulation. Macroeconometric studies frequently assume, for example, that there is a fixed proportion according to which domestic and foreign bonds are accumulated in order to allow for a unique path in the accumulation of assets. Here we simply avoid this problem by stating again that the accumulation of financial assets does not yet matter for domestic consumption demand.

5. Equilibrium conditions (asset-markets):

$$M = M^d = h_1 p Y + h_2 p K (r_o - r) \quad (29)$$

$$r = \frac{\rho^e p K}{p_e E} + \hat{p}_e \quad (30)$$

$$r^* = r \quad (31)$$

Our description of the asset markets¹⁰ of an open economy with four types of financial assets is already very complex but it is still restrictive and can be improved, see Köper (2000) for an attempt into this direction.

Module 6 describes the adjustment process of output and inventories toward aggregate demand and desired inventories and is formulated following Chiarella and Flaschel (2000, Ch.6), there however for a closed economy. The only difference here is that actual saving is no longer identical to actual investment in capital goods and inventories, but are now obtained by adding the surplus of the current account (including the balance of the interest payment account), equal to the negative value of the capital account as we shall show below.

Such accounting identities are added as consistency checks – in Equ. (37) – to the disequilibrium adjustment process that is considered in module 6 of our macrodynamic model. Note again that investment goods are only purchased from domestic production, while all other components of private domestic demand depend on the real exchange rate as described above. We thus only have index 1 commodities in this quantity adjustment process and the demand of foreigners for the domestic product Y_1^{d*} in addition.

The module 6 considers desired inventories N^d as proportion of adaptively adjusted expected sales Y^e and determines on this basis intended inventory changes as an adjustment of actual inventories N towards desired inventories, augmented by a term that accounts for trend growth. Production is then determined by the sum of expected sales and intended inventory changes, sales expectations Y^e being revised in a straightforward adaptive fashion, also augmented by a term that accounts for trend growth. Finally actual inventory changes \dot{N} are simply given by the excess of actual output over actual demand. which closes our description of the output and inventory adjustment mechanism of firms.¹¹

6. Disequilibrium situation (goods-market):

$$Y^d = C_1 + I + \delta K + G_1 + Y_1^{d*} \quad (Y^e \neq Y^d \text{ in general}) \quad (32)$$

$$\dot{Y}^e = \beta_{y^e}(Y^d - Y^e) + nY^e \quad (33)$$

$$\mathcal{I} = \beta_n(N^d - N) + nN^d, \quad N^d = \beta_{n^d}Y^e \quad (34)$$

$$Y = Y^e + \mathcal{I} \quad (35)$$

$$\dot{N} = Y - Y^d = Y - Y^e + (Y^e - Y^d) = \mathcal{I} + \Delta Y^e \quad (36)$$

$$\begin{aligned} S &= S_p + S_f + S_g \\ &= I^a + (e\dot{B}_2 - \dot{B}_1^*)/p = I^a + NCX/p \\ &= I^a + \{Y_1^{d*} - (ep^*/p)(C_2 + G_2 + J^d)\} + \{er^*B_2/p - rB_1^*/p\} \\ &= I^a + NX + NFX/p, \quad I^a = I + \dot{N} \end{aligned} \quad (37)$$

Module 7 models the dynamics of the wage-price module with two separate Phillips-curves for nominal wage and price inflation, \hat{w} and \hat{p} , in the place of only one of reduced-form type (for price inflation solely). This module represents a considerable generalization of many other formulations of wage-price inflation, e.g. of models which basically only employ cost-pressure forces on the market for goods or a single across markets Phillips curve.

Since workers consume both the domestic and foreign goods, we have to use a weighted average \hat{p}_c of domestic and foreign price inflation as cost-pressure term in the money wage Phillips curve. This weighted average is shown in Equ. (40). Here and everywhere, the weight is assumed to be given by the steady state value of $\gamma(\eta)$, which is γ_o , and thus not allowed to vary with the real exchange rate η (or the variable cost structure within firms). Note here also that the foreign inflation rate is assumed to be steady. Forming a concept of medium-run cost of living inflation as shown in Equ. (40) therefore requires no change as far as foreign price inflation is concerned. Altogether we have formulated here two Phillips-curves which take into account the real exchange rate dynamics in a specific way, see below.

With respect to medium-run inflation at home we use – as in the case of the investment climate – a measure π^m that is updated in an adaptive fashion, measuring the inflationary climate in which current price inflation (which is perfectly foreseen) is operating. The average in the money wage Equ. (38), with weight κ_w , indeed assumes that the cost of living pressure in this PC is given by a weighted average of current, perfectly anticipated, cost of living inflation and the inflationary climate into which this index is embedded. Due to the openness of the considered economy we, therefore, now employ a cost of living index in the money wage PC and this in a

way that does pay attention not only to its current rate of change. Besides cost pressure we have furthermore based the PC Equ. (38) also on demand pressure $V - \bar{V}$ in the usual way, where \bar{V} is the NAIRU rate of employment.

In the price Phillips curve we use as measure of demand pressure of course, the rate of capacity utilization U^c in its deviation from the normal rate of capacity utilization \bar{U}^c , which is given exogenously. Cost pressure is here given by wage inflation (minus productivity growth) and import price inflation (no productivity growth) where we again form a weighted average. For analytical simplicity we use as weight the same parameter as for the consumer price index in the wage PC, see Asada et al. (2002) for a justification. Furthermore, the inflationary climate in which the price PC is operating is given by a corresponding weighted average of domestic inflationary climate and the foreign one, again with the general weight γ_o for simplicity. The weight γ_o is therefore uniformly applied and might – because of this – be reinterpreted as the general accepted measure by which domestic rates of inflation and foreign ones are translated into averages driving domestic wage and price inflation, see again Asada et al. (2002) for further details.

More general concepts for such averaging procedures can easily be adopted from the numerical as well as the empirical perspective, for example by paying attention to the fact that the input cost-structure is in fact variable and given by $c = \frac{wL^d + ep^*J^d}{pY} = w/x + j/\eta$. Note also that labor productivity growth $n_x = \hat{x}$ has been added to the wage and price PC in an appropriate way.

7. Wage–Price Module (adjustment equations and definitions):

$$\hat{w} = \beta_w(V - \bar{V}) + \kappa_w(\hat{p}_c + n_x) + (1 - \kappa_w)(\pi_c^m + n_x) \quad (38)$$

$$\hat{p} = \beta_p(U^c - \bar{U}^c) + \kappa_p\hat{c} + (1 - \kappa_p)\hat{c}^m \quad (39)$$

$$\hat{p}_c = \gamma_0\hat{p} + (1 - \gamma_0)\hat{p}_0^*, \quad \pi_c^m = \gamma_0\pi^m + (1 - \gamma_0)\hat{p}_0^* \quad (40)$$

$$\hat{c} = \gamma_0(\hat{w} - n_x) + (1 - \gamma_0)\hat{p}_0^*, \quad \hat{c}^m = \gamma_0\pi^m + (1 - \gamma_0)\hat{p}_0^* \quad (41)$$

$$\dot{\pi}^m = \beta_{\pi^m}(\hat{p} - \pi^m) \quad (42)$$

$$\hat{p}_0^* = \text{const} = \bar{\pi} \quad (43)$$

The remaining modules concern the openness of the economy. Since the exchange rates¹² for the EMS was pegged we do not need to consider any Dornbusch type exchange rate dynamics in module 8. We therefore have¹³

8. Exchange rate dynamics

$$e = \text{constant} \text{ [DM]/[ECU]} \quad (44)$$

Module 9, finally, describes the balance of payments Z . We first present real net exports NX, measured in terms of the domestic commodity, and then net capital exports, the export of liquidity, in nominal terms. Note here

again that - though we specify all flows in and out of financial assets – they are not yet of relevance in the present model type, since interest and wealth effects are still suppressed in the consumption behavior.

Concerning nominal net interest payments,¹⁴ we assume that they cross borders and thus appear as an item in the current account and in the balance of payments. We stress that the balance of payments must be balanced in our model, due to the assumptions to be made below concerning the flow restrictions of households, firms and the government. They essentially state that the new issue of money and equities are indeed (by assumption) absorbed by domestic households which means that the remainder of asset holders' savings goes into the purchase of domestic and foreign bonds, supplied by the government and foreigners, the latter in the amount necessary for flow consistency. Should domestic households demand more domestic bonds by their savings decision, these bonds are assumed to be supplied out of the stock that foreign asset holders hold, so that domestic households can always realize their concrete saving plans.

Since new asset flows are regulated in this way we can show below that the balance of payments is always balanced, the current account is always the negative of the capital account, without any interference from the monetary authority due to the consistency assumptions made on new money and equity issue. By contrast, the trade account need not be balanced even in the steady state, due to the fact that only domestic prices can adjust in the real exchange rate, which may be too little to achieve a balanced trade account. There is therefore no need to intervene in foreign exchange markets of the part of the world that is here under consideration, if the foreign economy always supplies the amount of bonds that is demanded by asset holders.

9. Balance of Payments:

$$NX = Ex - Im = Y_1^{d*} - (C_2 + G_2 + J^d)/\eta \quad (45)$$

$$NCX = e\dot{B}_2 - \dot{B}_1^*, \quad NFX = er^*B_2 - rB_1^* \quad (46)$$

$$\begin{aligned} Z &= pNX + NFX - NCX \\ &= \{pY_1^{d*} - ep^*(C_2 + G_2 + J^d)\} + \{er^*B_2 - rB_1^*\} - \{e\dot{B}_2 - \dot{B}_1^*\} \\ &= 0 \end{aligned} \quad (47)$$

Lastly, we collect the data needed from the 'foreign' economy. We already have assumed that inflation rates abroad are steady, fully anticipated and consistent with the inflationary target of the domestic central bank, i.e. $\hat{p}_o^* = \pi_o^* = \bar{\pi} = const.$ We assume finally for Y_1^{d*} , the demand of foreigners and thus for the export of the home country, that it is only a function of η if expressed per unit of capital, i.e.,

$$y_1^{d*} = Y_1^{d*}/K = y_1^{d*}(\eta) = \gamma_o^* + \gamma_1^*(\eta_o - \eta).$$

This closes the description of the equations of our Keynesian dynamics with under- or overemployment of labor and capital, with labor *and* goods-market in disequilibrium, but money market equilibrium, for a large open economy within the EU, with a delayed adjustment of quantities as well as wages and prices.

3 Intensive form, steady state determination and stability analysis

The extensive form model of section 2 can be reduced to an autonomous seven-dimensional dynamical system in the state variables $u = \omega/x$ [$\omega = w/p$], the wage share, $l = xL/K$, the full employment output-capital ratio, $m = M/(pK)$, real balances per unit of capital, π^m , the inflationary climate, $y^e = Y^e/K$, sales expectations per unit of capital, $\nu = N/K$, inventories per unit of capital and finally ϵ^m the investment climate variable.¹⁵ The resulting system is set out in equations (48)–(54).

$$\begin{aligned} \hat{u} &= \kappa[(1 - \gamma_o \kappa_p) \beta_w (V - \bar{V}) + (\gamma_o \kappa_w - 1) \beta_p (U^c - \bar{U}^c)] \\ &\quad + \kappa(\kappa_w - \kappa_p) \gamma_o (1 - \gamma_o) (\hat{p}_o^* - \pi^m), \quad \kappa = (1 - \gamma_o^2 \kappa_w \kappa_p)^{-1} \end{aligned} \quad (48)$$

$$\hat{l} = -i_1 \epsilon^m - i_2 (U^c - \bar{U}^c) \quad (49)$$

$$\hat{m} = \hat{M} - \hat{K} - \hat{p} = \bar{\pi} + \hat{l} - \hat{p}, \quad m = \frac{M}{pK} \quad \text{with} \quad (50)$$

$$\begin{aligned} \hat{p} &= \kappa[\beta_p (U^c - \bar{U}^c) + \gamma_o \kappa_p \beta_w (V - \bar{V})] + \kappa(1 + \gamma_o \kappa_p)(1 - \gamma_o) (\hat{p}_o^* - \pi^m) + \pi^m \\ \dot{\pi}^m &= \beta_{\pi^m} (\hat{p} - \pi^m) \end{aligned} \quad (51)$$

$$\dot{y}^e = \beta_{y^e} (y^d - y^e) + \hat{l} y^e \quad (52)$$

$$\dot{\nu} = y - y^d - (n - \hat{l}) \nu \quad (53)$$

$$\dot{\epsilon}^m = \beta_{\epsilon^m} (\epsilon - \epsilon^m), \quad \epsilon = \rho^n - (r + \xi - \hat{p}) \quad (54)$$

Here, output per unit of capital $y = Y/K$ and aggregate demand per unit of capital $y^d = Y^d/K$ are given by

$$y = y^e (1 + n \beta_{n^d}) + \beta_n (\beta_{n^d} y^e - \nu) = b_1 y^e + b_2 \nu \quad (55)$$

$$\begin{aligned} y^d &= \gamma(\eta) [(1 - s_w)(u y - t_w) + (1 - s_c)(\rho^e - t_c) + g] + y_1^{d*}(\eta) \\ &\quad + i_1 \epsilon^m + i_2 (U^c - \bar{U}^c) + n + \delta, \quad \gamma(\eta) = \gamma_o + \gamma_1 (\eta_o - \eta) \end{aligned} \quad (56)$$

In the above we have employed the following abbreviations $V = y/l$, $U^c = y/y^p$, the employment rate and the rate of capacity utilization, $\rho^e = y^e - \delta -$

$uy - jy/\eta$, the currently expected rate of return on capital, $\rho^n = y_o^d - \delta - uy_o - jy_o/\eta$, the normal rate of return on capital, $\epsilon = \rho^n + \hat{p} - (r + \xi)$ normal excess profitability, $r = r_0 + \frac{h_1 y - m}{h_2}$, the nominal rate of interest, $\eta = \frac{p}{ep_o^*} = \frac{m^* l}{m}$, $m^* = \frac{M}{ep^* x L} = const.$, the real exchange rate, and $\kappa = (1 - \gamma_o^2 \kappa_w \kappa_p)^{-1}$.¹⁶

With respect to the aggregate demand function y^d we have the partial derivatives, at the steady state:

$$\begin{aligned} y_{y^e}^d &= \gamma_o[(s_c - s_w)u_o(1 + n\beta_{n^d}) + (1 - s_c)(1 - j(1 + n\beta_{n^d})/\eta_o) \\ &\quad + i_2(1 + n\beta_{n^d})/y^p + i_1\beta_p(\cdot)_{y^e} - i_1r_{y^e}] \\ y_\eta^d &= -\gamma_1[c_o + g] - \gamma_1^* + [\gamma_o(1 - s_c)]jy_o/\eta_o^2 + i_1jy_o/\eta_o^2 \end{aligned}$$

in the case where $\epsilon = \epsilon^m$ holds true. In the case $\beta_{\epsilon^m} < \infty$, however, the i_1 -terms have to be removed from these partial derivatives, since the influence of y^e, η on $i_1(\cdot)$ is then a delayed one. We assume throughout this paper that this latter case is characterized by $y_{y^e}^d < 1$ for $i_2 = 0$ and $y_\eta^d < 0$ which are natural assumptions from a Keynesian perspective.

However, the parameters h_2, β_p can be used in the case $\beta_{\epsilon^m} = \infty : \epsilon^m = \epsilon$, to enforce either $y_{y^e}^d < 1$ for $i_2 > 0$ or $y_{y^e}^d < 1$, if this is desirable in certain more general situations. We also assume throughout the paper that the expected rate of profit ρ^e depends positively on the expected sales volume y^e close to the steady state.

This dynamical system represents in its first block (Eqs. 48, 49) the real growth dynamics, describes with its second block (Eqs. 50, 51) the nominal or inflationary dynamics, provides third (Eqs. 52, 53) the inventory dynamics and lastly (Equ. 54) the adjustment of the investment climate.

Since prices concern the denominator in the real wage and wage share dynamics, the dependence of \hat{u} on the rate of capacity utilization must obviously be negative, while the rate of utilization of the labor force acts positively on the real wage and wage share dynamics. This law of motion, as well as the one for \hat{p} , see Equ. (50), can easily be derived from the wage and price PC of module 7, see Asada et al.(2002) in this regard. Equ. (49) describes the evolution of the full employment output-capital ratio $l = xL/K$ as determined by the difference between natural growth with rate n and net investment per unit of capital $\hat{K} = I/K$. Taken together, Eqs. (48), (49), describe growth and income distribution dynamics in a way closely related to the long-run dynamics considered in Chiarella and Flaschel (2000, Ch.6). Their real origin is however in Rose's (1967) analysis of the employment cycle.

The subdynamics of Eqs. (50), (51) are the monetary dynamics of our model and represents a general representation of Tobin (1975) type dynamics.

Equ. (52) describes the change in sales expectations as being governed by trend growth and by the observed expectational error (between aggregate

demand y^d and expected sales y^e , both per unit of capital). Similarly, Equ. (53) states that actual inventories N change according to the discrepancy between actual output y and actual demand y^d , which in our Keynesian context is never rationed. These subdynamics represent an extension of Metzlerian ideas to a growing economy.

We stress that we want and have kept the model as linear as possible, since we intend to concentrate on its intrinsic nonlinearities at first. In view of the linear structure of the assumed technological and behavioral Equations, the above presentation of our model shows that its nonlinearities are, on the one hand, due to the necessity of using growth laws in various equations and, on the other hand, to multiplicative expressions for some of the state variables of the form uy , y/l and $\hat{l}y$. Though, therefore, intrinsically nonlinear of the kind of the Rössler and the Lorenz dynamical systems, our 7D dynamics may, however, still be of a simple type, since these nonlinearities do not interact with all of its 7 equations.

Eq.n (48) shows that the impact of demand pressures on wage share dynamics is influenced by γ_0 , the share of domestic consumption goods in domestic consumption in the steady state. This influence tends to make the wage share more volatile (as compared to the closed economy), since κ tends to the close to '1' both for the open and the closed economy from the empirical perspective, see below. Lost pressure, as arising from import prices, is passed-through into wage share dynamics in Eq.n (48) in a fairly integrated way and only positively affecting these dynamics if workers are more short-sighted than firms ($\kappa_w > \kappa_p$). The pass-through of import price inflation on the domestic price level is, however, always positive and (likely to be) less than one (since $\kappa \approx 1$ holds from the empirical perspective). Demand pressure on the labor market, representing indirectly cost-pressure (with weight κ_p) for firms, is also diminished by the share γ_0 in this respect. Our reduced form equations therefore clearly show the extend of pass-through of import price inflation \hat{p}_0^* .

This ends the description of the intensive form of our Keynesian monetary growth model, which exhibits sluggish adjustments of prices, wages and quantities in view of the occurrence of over- or under-utilized labor and capital in the course of the cycles that it may generate.

Proposition 1

The dynamical system (48) – (54) has a unique interior steady state given by:

$$V_o = \bar{V}, \quad U_{co} = \bar{U}^c \quad (57)$$

$$y_o = \bar{U}^c y^p \quad l_o = y_o / \bar{V} \quad (58)$$

$$\pi_o^m = \bar{\pi} = \hat{w}_o - n_x = \hat{p}_o = \hat{p}_o^* \quad (59)$$

$$y_o^e = y_o^d = y_o / (1 + n\beta_{n^d}), \quad \nu_o = \beta_{n^d} y_o^e \quad (60)$$

$$r_o = \rho_o^n + \bar{\pi}, \quad m_o = h_1 y_o \quad (61)$$

$$\eta_o = m^* l_o / m_o \quad (62)$$

$$u_o = \frac{\gamma_o [-(1 - s_w)t_w + (1 - s_c) \cdot (y_o^e - \delta - \frac{jy_o}{\eta_o} - t_c) + g] + y_1^{d*}(\eta_o) + n + \delta}{(s_c - s_w)y_o} \quad (63)$$

$$\rho_o^n = \rho_o^e = y_o^e - \delta - u_o y_o - j y_o / \eta_o, \quad \epsilon_o = \epsilon_o^m = 0 \quad (64)$$

We assume throughout this paper that parameters are chosen such that all steady state values shown are economically meaningful. A plausible first condition into this direction is that $s_w < s_c$ holds true which we assume to be the case. We stress that $\eta_o = m^* l / m_o$, $m^* = \frac{M}{ep^* xL}$ is basically supply side determined and is in particular not related to goods market equilibrium conditions (which – dependent on γ_o, η_o – determine domestic income distribution).

Proposition 1 states that the steady state of the dynamics Eqs. (48) – (54) is basically of supply-side nature. Income distribution is adjusted, however, such that the goods market clears which also provides the steady state value of the real rate of return on capital and the interest rate. Demand-side aspects thus only concern the determination of the rate of return on capital, the wage share and the rate of interest and are therefore of secondary importance as far as the steady state behavior of the considered dynamical model is concerned.

We state without proof that the steady state just considered tends to be locally asymptotically stable if price adjustments, inventory adjustments and adjustment of the inflationary climate term are sufficiently sluggish, the Keynes-effect sufficiently strong (h_2 small) and if sales expectations are adjusted sufficiently fast. It will, however, lose this stability property by way of Hopf limit cycle bifurcations when these conditions are made less stringent. Details and proofs for the statements just made are provided in Asada et al. (2002).

We now start to introduce flexible monetary policy rules into the framework just considered, removing thereby the assumption of a constant growth

rate of the money stock so far used for describing the dynamics of the nominal and the real stock of money (the latter per unit of capital in addition).

The question arises whether for our open economy with pegged exchange rates that we are considering the empirically observed adjustment speeds support the asymptotic stability state in proposition two or whether monetary policy rules that react to inflation and output gaps are needed in addition in order to allow for shocks to be absorbed and thus for convergent impulse-response reaction schemes. These topics will be studied in the remainder of the paper.

Let us first consider the case where the monetary authority attempts to control the rate of inflation (and economic activity) by steering the growth rate μ of the money supply. Here we assume general reaction function such as ¹⁷

$$\dot{\mu} = \beta_{\mu_1}(\bar{\mu} - \mu) + \beta_{\mu_2}(\bar{\pi} - \hat{p}) + \beta_{\mu_3}(\bar{U}^c - U^c), \quad \bar{\pi} = \bar{\mu} - n = \hat{p}_0^*. \quad (65)$$

With this rule, the central bank attempts to steer the actual inflation rate \hat{p} towards the target rate $\bar{\pi}$ by lowering the growth rate of money supply if \hat{p} exceeds $\bar{\pi}$ (and vice versa). This restrictive policy is the stronger, the higher economic activity is at present, measured by the (negative of the) capacity utilization gap $U^c - \bar{U}^c$. In order to avoid too strong fluctuations in the growth rate of the money supply, there is also some smoothing of these fluctuations measured by the adjustment parameter β_{μ_1} . Of course, the monetary authority, possibly in cooperation with the other member states of the pegged currency system, must also be concerned to keep the nominal exchange rate constant.¹⁸

Yet, concentrating on the domestic task of the monetary authority, the immediate consequence of a changing growth rate μ of money supply M is that the expression $\frac{M}{ep^*xL} = m^*$ – so far a constant – is no longer constant in time, but now changing according to the law

$$\hat{m}^* = \mu - \hat{p}_0^* - n.$$

The 6D dynamics considered above (with $\epsilon^m = \epsilon$) is thus now 8 dimensional through the above adoption of a money supply rule, by the addition of the new state variables m^* and μ which influence the 6D dynamics through the real exchange rate $\eta = p/(\bar{e}p^*) = m^*l/m$. This situation suggests that it may now be reasonable to use the state variable η in the place of m , since η is representing inflation more directly than $m = \frac{M}{pK}$ (where also capital accumulation is involved). We therefore now use the definition $m = m^*l/\eta$

in the place of $\eta = m^*l/m$ in the 6D dynamics initially considered, which enters these dynamics by way of the LM curve $r = r_0 + (h_1y - m)/h_2$.

The evolution of the real exchange rate $\eta = p/(\bar{e}p^*)$ is in this case given by the following reduced-form expression

$$\hat{\eta} = \frac{1}{1 - (1 - \gamma_0)(1 - \kappa)} [\kappa(\beta_p(U^c - \bar{U}^c) + \kappa_p\beta_w(V - \bar{V})) + \pi_c^m - \hat{p}_0^*]$$

This law of motion replaces the law of motion for m in the now considered dynamical system.

Proposition 2

1. Assume that $\beta_{\mu_2} = \beta_{\mu_3} = 0$ holds. Then: The eigenvalue structure $\lambda_1, \dots, \lambda_6$ of the 6D dynamics is augmented by $\lambda_7 < 0, \lambda_8 = 0$ in the 8D dynamical system.
2. The same holds true, with $\lambda_8 < 0$ now, if $\beta_{\mu_2}, \beta_{\mu_3}$ are made slightly positive, i.e., for a fairly passive monetary rule.

Proof: See Asada et al. (2002). ■

We thus can observe that a too active monetary policy of the type as described by Equ. (65) may be destabilizing. We also want to note that due to the high dimensional nature of the considered dynamics we cannot determine the maximum size of the considered policy parameters for which proposition 2 still holds. We know, however, from numerical simulations of the dynamics that there is a limit for them beyond which monetary policy of this type will imply instability.

Next, we consider a Taylor interest rate policy rule – in the light of the above formulation of monetary policy – of the following closely related type:

$$\dot{r} = \beta_{r_1}(r_0 - r) + \beta_{r_2}(\hat{p} - \bar{\pi}) + \beta_{r_3}i(U^c - \bar{U}^c). \quad (66)$$

This rule states that a positive inflation gap $\hat{p} - \bar{\pi}$ is counteracted by an increase in the nominal rate of interest r (and vice versa) and this the stronger, the more overheated the business climate measured by $U^c - \bar{U}^c$ is. There is again a smoothing term, here interest rate smoothing, that attempts to prevent too large fluctuations in the nominal rate of interest r .

In the case of the above interest rate policy rule, we have to consider the dynamics $\hat{u}, \hat{l}, \hat{\pi}^m, \hat{y}^e, \hat{\nu}$ as provided above (with $\epsilon = \epsilon^m$), now again with $\hat{\eta} = \hat{p} - \hat{p}_0^*$ in the place of \hat{m} and

$$\dot{r} = \beta_{r_1}(r_0 - r) + \beta_{r_2}(\hat{p} - \bar{\pi}) + \beta_{r_2}(U^c - \bar{U}^c) \text{ in the place of } \hat{m}^*, \dot{\mu} \quad (67)$$

and $m = m^*l/\eta$ as an appended equation (or simply $m = h_1y + h_2(r_0 - r)$). Stability results are similar to the ones obtained for the money supply policy rule, but now less restrictive. This result was again obtained to some extent by numerical simulations of the above dynamics using Equ. (67) instead of Equ. (65), see also the empirical studies in the remainder of this paper.

It is, finally, useful to consider the extent of pass-through of import price inflation (or exchange rate dynamics in the case of a flexible exchange rate) on consumer prices p_c . Here we obtain by means of the definitional relationship

$$\hat{p}_c = \hat{p} - (1 - \gamma_0)\hat{\eta}$$

the expression ($\kappa = (1 - \kappa_w\kappa_p)^{-1}$ now):

$$\hat{p}_c = \pi_c^m + \kappa[\beta_p(U^c - \bar{U}^c) + \kappa_p\beta_w(V - \bar{V})] - \kappa(1 - \gamma_0)\hat{\eta}$$

and also

$$\hat{w} = \pi_c^m + \kappa[\beta_w(V - \bar{V}) + \kappa_w\beta_p(U^c - \bar{U}^c)] - \kappa\kappa_w(1 - \gamma_0)\hat{\eta} + n_x$$

where $\hat{\eta} = \hat{p} - \hat{p}_0^*$ holds true. There is thus (nearly) complete pass-through of \hat{p}_0^* on \hat{p}_c and \hat{w} if $\kappa \approx 1$ is again assumed. Besides the trade channel influence of the real exchange rate η on the demand for domestic goods we have here finally provided reduced-form cost-pressure expressions of import price inflation on consumer price and wage inflation. Note finally that the inflationary climate expression for p_c follows the law of motion

$$\dot{\pi}_c^m = \beta_{\pi^m}(\hat{p}_c - \pi_c^m)$$

which is of the same type as the one for domestic price inflation.

4 Estimation of the model parameters

This section discusses how we estimate the structural parameters of the model. These parameters are also used to simulate the model. We first remark that it is technically impossible, and also not necessary, to estimate all the parameters according to the reduced intensive form as expressed in Eqs. (48) - (54). The system includes many expected variables which are not observable. Although the equations are all expressed in linear form, the parameters often appear in multiplicative form and hence are nonlinearly related. What facilitates our estimation is the fact that we treat the entire system as being recursive or block recursive. This allows, whenever possible,

to estimate the parameters by a single equation, either in reduced form or in structural form. Only for those parameters that appear in a simultaneous system, such as in the price-wage dynamics, we use the standard method, for example two stage least square (2SLS) to estimate the parameters.

We can divide all the estimated structural parameters into the 7 subsets. Table 1 provides the estimates and the standard errors.

Table 1 about here

Before we elaborate on how we have estimated these parameters, we shall make several remarks about the estimation. First, most estimates are statistically significant except the parameter β_n , $\beta_{\mu 2}$ and $\beta_{\mu 3}$. We believe the insignificance of β_n is more likely due to the data issue. Here we calculate the inventory change only according to the GDP residual while all investment is assumed to be in capital stock. This certainly ignores the inventory investment which have been introduced in our model. The insignificance in $\beta_{\mu 2}$ and $\beta_{\mu 3}$ ¹⁹ is also consistent with the well-known argument that the German Central Bank, the Bundesbank, was not directly concerned with inflation targeting nor unemployment when targeting its money supply. What the central bank targets, according to this argument, is a growth rate of money supply that could match the demand for money when the economy is at the steady state growth path. In this respect, we consider an alternative reaction function of money supply as below:

$$\mu_t - \mu_{t-1} = \beta_m(\bar{\mu} - \mu_{t-1}) \quad (68)$$

The estimation of β_m is discussed below.

Second, in contrast to previous estimations (see Flaschel, Gong and Semmler 2001, 2002), where closed economies are considered,²⁰ β_p becomes statistically significant. We thus expect that the standard demand-supply force could play a role, along with the cost-push force, in determining prices and wages when we are considering an open economy. Also in contrast to our estimation with U.S. data where the estimated β_x is less than half, the estimate here is close to 1, indicating that benefits from labor productivity growth is significantly absorbed by the growth of wages. This result is consistent with the well-known difference of labor market structure between U.S. and German economies.

4.1 Estimating parameter Set 7, 6 and 5

Next we explain how we have obtained those estimates as expressed in Table 1. We start from below. The parameters in Set (7) are those parameters

that can be either expressed in terms of an average, or are defined in a single structural equation with a single parameter. This allows us to apply the moment estimation by matching the first moments of the model and the related data. The parameters in Set (6) are estimated by applying OLS directly to Eqs. (68) and (67).

To estimate the parameters in Set (5), we use equation (29) and divide both sides by $p_t K_{t-1}$. This allows us to obtain

$$r_{t+1} - r_0 = a_1 y_t + a_2 m_t \quad (69)$$

where r_0 is given in Set 7. The OLS regression on (69), gives us the estimated parameters a_1 and a_2 . By setting $a_1 = \frac{h_1}{h_2}$ and $a_2 = \frac{-1}{h_2}$, we then obtain the estimated h_1 and h_2 . Since the structural parameters h_1 and h_2 appear multiplicatively in a_1 and a_2 , we are not able to obtain the standard deviations directly from the OLS regression. We therefore treat these estimates of h_1 and h_2 as being nonlinear least square (NLS) estimates and use the method as discussed in Judge et al. (1988:508-510) to derive their standard errors. We use the Gauss procedure GRADP to calculate the derivative matrix that is necessary to derive the variance-covariance matrix of the estimated parameters. We shall remark that the same principle is also applied to other similar cases whenever parameters appear in multiplicative form or NLS is applied.

4.2 Estimating the output function

The remaining parameters are more complicated to estimate. For their estimations we need, either directly or indirectly, the expectation variables that are not observables. Let us first discuss how we estimate the parameters related to sales expectation, i.e., Set (1). We estimate this parameter set based on the consideration that actual and predicted y_t can be matched as close as possible via equation (55). This gives

$$y_t = b_1 y_t^e + b_2 v_t \quad (70)$$

Here we should regard the time series y_t^e as being a function of β_{y^e} via the adaptive rule (52)²¹, given the initial condition y_0^e , which we set here to be y_0 . We therefore can construct an objective function $f(\beta_{y^e})$:

$$f(\beta_{y^e}) = e_y(\beta_{y^e})' e_y(\beta_{y^e}) \quad (71)$$

where $e_y(\beta_{y^e})$ is the error vector of OLS regression on equ.(70) at the given β_{y^e} and hence the series y_t^e . Minimizing $f(\beta_{y^e})$ by applying an optimization

algorithm,²² we obtain the estimate of β_{y^e} . Given the estimate of β_{y^e} and hence the series y_t^e the OLS is applied to Equ.(70). This gives us the estimates of b_1 and b_2 . By setting $b_1 = 1 + (n + \beta_n)\beta_{n^d}$ and $b_2 = -\beta_n\beta_{n^d}$ with n given in Set (7), one then obtains the estimates of β_n and β_{n^d} . Apparently, all these estimates can again be regarded as NLS estimates, and therefore the standard errors can be derived in a similar way as discussed in Judge et al. (1988: 508-510).

4.3 Estimating price-wage dynamics

Next, we discuss how we estimate the parameter set in price-wage dynamics. The corresponding structural equations can be expressed as the following form of discrete time dynamics:

$$\hat{w}_t = \beta_w(V_{t-1} - \bar{V}) + \kappa_w(\hat{p}_{c,t} + \beta_x\hat{x}_t) + (1 - \kappa_w)(\pi_{c,t} + \beta_x\hat{x}_t) \quad (72)$$

$$\hat{p}_t = \beta_p(U_{t-1} - \bar{U}) + \kappa_p\hat{w}_{c,t} + (1 - \kappa_p)\pi_{c,t} \quad (73)$$

where

$$\hat{p}_{c,t} = \alpha\hat{p}_t + (1 - \alpha)\hat{p}_{0,t}^* \quad (74)$$

$$\hat{w}_{c,t} = \alpha\hat{w}_t - \beta_x + (1 - \alpha)\hat{p}_{0,t}^* \quad (75)$$

$$\pi_{c,t} = \alpha\pi_{t-1} + (1 - \alpha)\hat{p}_{0,t-1}^* \quad (76)$$

$$\pi_t = \pi_{t-1} + \beta_\pi(\hat{p}_{t-1} - \pi_{t-1}) \quad (77)$$

All the notation follows the sect. 3, except here we use a time subscript. Also note that \hat{x}_t is referred to the growth rate of labor productivity.

Note that the time series $\hat{p}_{c,t}$, $\hat{w}_{c,t}$, $\pi_{c,t}$ and π_t are all unobservable. Yet they can be computed given the observable series \hat{p}_t , \hat{w}_t , $\hat{p}_{0,t}^*$ and the parameters α and β_{π^m} . Let us first assume that we know the parameters α and β_π . The other structural parameters can thus be estimated via the method of two stage least square (2SLS). The first stage is to estimate, separately via OLS, the following reduced form equations:

$$\begin{aligned} \hat{w}_t = & w_1(V_{t-1} - \bar{V}) + w_2(U_{t-1} - \bar{U}) \\ & + w_3\pi_t + w_4\hat{p}_{0,t}^* + w_5\hat{p}_{0,t-1}^* + w_6\hat{x}_t \end{aligned} \quad (78)$$

$$\hat{p}_t = p_1(V_{t-1} - \bar{V}) + p_2(U_{t-1} - \bar{U}) + p_3\pi_t + p_4\hat{p}_{0,t}^* + p_5\hat{p}_{0,t-1}^* + p_6\hat{x}_t \quad (79)$$

This will yield the instrument variables for \hat{w}_t and \hat{p}_t in the right side of the following structural equations to which our second stage of OLS regression

will be applied:

$$\hat{w}_t - \pi_{c,t} = \beta_w(V_{t-1} - \bar{V}) + \kappa_w(\hat{p}_{c,t} - \pi_{c,t}) + \kappa_w\beta_x\hat{x}_t \quad (80)$$

$$\hat{p}_t - \pi_{c,t} = \beta_p(U_{t-1} - \bar{U}) + \kappa_p(\hat{w}_{c,t} - \pi_{c,t}) \quad (81)$$

However, all these estimations are based on the assumption of given α and β_{π^m} , which we shall first estimate. Next, we discuss how we estimate α and β_{π^m} . Note that this time the objective is to match both \hat{w}_t and \hat{p}_t simultaneously, and thus a weighting matrix is required. In this exercise, we shall follow Gallant (1975) to conduct a two step nonlinear least square (2SNLS) estimation. The estimation uses the following objective function:

$$f(\alpha, \beta_{\pi^m}) = e' (\Sigma^{-1} \otimes I_T) e \quad (82)$$

where

$$e = \begin{bmatrix} e_{\hat{w}}(\alpha, \beta_{\pi^m}) \\ e_{\hat{p}}(\alpha, \beta_{\pi^m}) \end{bmatrix} \quad (83)$$

with $e_{\hat{w}}(\cdot)$ and $e_{\hat{p}}(\cdot)$ to be the two error vectors after the second stage of OLS; Σ is the covariance matrix of the two innovations in the structural equations (80) and (81); \otimes refers to Kronecker product; and I_T is the $T \times T$ identity matrix with T to be the number of the observation. Since we do not know Σ in advance, we therefore shall take a two step estimation. The first step is to minimize the objective function:

$$f(\alpha, \beta_{\pi^m}) = e'e \quad (84)$$

based on which we construct $\hat{\Sigma}$, the estimated Σ .²³ The second stage is to find α and β_{π^m} that optimize $e' (\hat{\Sigma}^{-1} \otimes I_T) e$. As proved by Gallant (1975), the estimate is consistent and asymptotically efficient when the innovations are normally distributed. To derive the standard deviation of the estimates, we denote $\hat{\psi}$ to be the vector that contains the 2SNLS estimators $\hat{\alpha}$ and $\hat{\beta}_{\pi^m}$. An estimate of the asymptotic covariance matrix for $\hat{\psi}$ is given by

$$\hat{\Sigma}_{\hat{\psi}} = \left[\frac{\partial e'}{\partial \psi} \left(\hat{\Sigma}^{-1} \otimes I_T \right) \frac{\partial e}{\partial \psi'} \right]^{-1} \Big|_{\psi=\hat{\psi}} \quad (85)$$

We remark that for these two step of estimation, we apply a global optimization algorithm, called simulated annealing,²⁴ to minimize $f(\alpha, \beta_{\pi^m})$.

4.4 Estimating Consumption and Investment Functions

On the assumption that all import goods are used either by private consumption c_t or by government consumption g_t , we can regard $(1 - \gamma_t)(c_t + g_t)$ as

being the total amount of imports (relative to capital stock), where $\gamma_t = \gamma(\cdot)$. Since we do have import data, we thus can compute the time series γ_t . This will allow us to estimate $\gamma(\cdot)$. Assume that

$$\gamma_t = \gamma_0 + \gamma_1\gamma_{t-1} + \gamma_2\eta_{t-1} \quad (86)$$

The OLS regression of (81) will produce the parameters γ_0 , γ_1 and γ_2 as reported in Table 1. Note that γ_1 is highly significant whereas γ_2 has the correct sign but is not significant. We presume as in Krugman (1991) that the short run impact of the real exchange rate on imports is rather weak, there may be, however, a long run effect of the exchange rate on trade, for example, exerting itself with a delay.

Concerning exports we estimate the following export equation, with Ex , exports

$$Ex_t = b_0 + b_1Ex_{t-1} + b_2\eta_{t-1}.$$

The following are the estimated parameters:

$$\begin{aligned} b_0 &= 0.0069 \quad (0.0019); \\ b_1 &= 0.8152 \quad (0.0483); \\ b_2 &= -0.1672 \quad (0.1241); \end{aligned}$$

The number in parentheses are the standard errors. Note that b_2 is not significant. The change of η_{t-1} into η_t does not change the result, b_2 is still non-significant. Here too we see that in the short run export does not depend on the real exchange rate.

The estimation of the other structural parameters in Set 3 will not require the time series γ_t , and estimated by

$$c_t + g_t = c_0 + c_1y_t^e + c_2u_t y_t \quad (87)$$

Note that we have already estimate β_{ye} and thus are able to compute the time series y_t^e . The structural parameters are obtained by setting $c_1 = 1 - s_c$ and $c_2 = s_c - s_w$.

The OLS regression equation for the investment function takes the form:

$$i_t - (n + \delta) = i_1(\rho_t^m - \xi - (r_t^m - \pi_t^m)) + i_2(U_t - \bar{U}) \quad (88)$$

For the above, n, δ and \bar{U} are given in Set 7. ξ is estimated by the method of moments, i.e., setting the mean of $\rho_t^m - \xi - (r_t^m - \pi_t^m)$ to 0. Note that π_t^m here is the medium run expectation, which is different from the short run expectation π_t that has been used in estimating the price-wage dynamics. Also the sample period for estimating the investment function becomes shorter due to our construction of all these medium run time series.

5 Evaluating the Model and the Monetary Policy Rules

Employing our estimated parameters, we report in figures 1-2 the actual and predicted macroeconomic time series generated from some key behavioral functions.²⁵ One can observe that most macroeconomic variables are well predicted.

Figures 1 and 2 about here

The fit, however, is less successful for investment. It is even less successful for the interest rate derived from the money demand function. This may create a difficulty for the exercise to simulate the impact of the money supply rule, which shall be discussed below. However, we shall remark that the parameters that we estimate here for the money demand function are statistically significant. This indicates that the explanatory variables, y_t and m_t , do have some power to explain the interest rate r_{t+1} . Yet, admittedly there may be a better explanation for it (which may take, for example, a nonlinear form). The same argument may also be applied to the investment function.

Yet, whereas the fit for the interest rate derived from the money demand function does not replicate the variation in the interest rate but solely the trend of the interest rate the estimated investment function at least partially captures the variation in investment. Given that empirical estimates notoriously fail to properly capture money demand and investment functions we may view our estimates for those two functions still a relative success given our limited aim to study the effects of monetary policy rules in a simple model. Note, however, that the fraction of domestic consumption in total consumption, the γ -series, is predicted well, see figure 2.

If we simulate our macroeconometric model with the estimated parameters for both policy rules (the money supply rule here is represented by equation (68) rather than (65)) so that the actual interest rate is either determined by the money supply rule or the Taylor rule, we obtain figures 3 and 4. For both policy rules the macroeconomic variables exhibit instability.

Figures 3 and 4 about here

When we slightly increase the interest rate reaction to the output gap and inflation gap, the Taylor rule will lead to a convergence result although cyclically fluctuating (see figure 5). However, if we assume the money supply rule as expressed by (68), there is no possibility to obtain a stable result even

for a very active monetary policy that means even if we strongly increase the reaction of money supply, β_m . This indicates that a simple money supply rule that does not have a feed back to inflation and output gaps is not enough to stabilize an economy when it is out of its steady state. We still obtain instability and thus do not include the corresponding figure here.

Figure 5 about here

The possible instability generated by monetary policy rules have much been the topic of recent studies on monetary policy, see the various contributions in Taylor (1999). Christiano and Gust (1999), for example, show, although in an optimizing framework that if the Taylor rule puts too much emphasis on the output gap, indeterminacy and instability of macroeconomic variables may be generated. Instability also occurs under their version of the money supply rule. Yet, in their formulation of the money supply rule they use an AR(2) process to stylize a money supply process. There is thus, as in our Equ. (68), no feedback of the money supply to other economic variables such as, for example, in our case to the inflation and output gaps. We also have, for reason of comparison, employed such an AR(2) process for the money supply and indeed obtained two completely unstable paths of the macro variables. This complete instability can only be overcome by feedback rules as we have formulated above for our money supply and Taylor interest rate policy rules.²⁶

Finally we want to study whether our model exhibits typical impulse-response functions well known from many recent macroeconomic studies, see for example Christiano, Eichenbaum and Evans (1994), and Christiano and Gust (1999). In those studies macro variables respond to liquidity shocks as follows. In the short run with liquidity increasing the interest rate falls, capacity utilization and output rises, employment rises and, due to sluggish price responses, prices only rise with a delay. Very similar responses can be seen in the context of our model variants for both interest rate shocks (through the Taylor rule), figure 6 and money supply shocks, figure 7. Although, as above discussed, the case of the money supply rule produces instability in the long run, we take a short period for an impulse-response simulation so that we can observe the direction of change of variables if the money supply is changed.

Figures 6 and 7 about here

Note that we here show the trajectories in deviation form from the steady state. For the Taylor rule, depicted in figure 6, we displace the interest rate

through a shock from its steady state value. By impact, the interest rate is decreased but it moves back in the direction of its steady state value. The other variables also respond as one would expect from VAR studies of macroeconomic variables.²⁷ With the fall of the interest rate there is a rise in capacity utilization, output, employment, investment and consumption and, again with a delay, a rise in the inflation rate. The latter can be observed from the fact that the inflation rate peaks later than the utilization of capacity, output and employment.

Similar results can be observed in figure 7, for the money supply rule. For the money supply rule,²⁸ we have assumed that first there is an out of steady state increase in the growth of money supply. This gives rise to an interest rate fall, rise of employment, utilization of capacity, investment, consumption and, with a delay, a rise in the inflation rate. Finally in the long run all variables, although cyclically, move back to their steady state levels.

Another interesting impulse-response study is undertaken for (negative) import shocks, as reported in figures 8 and 9. Here we assume a shock to the domestic price level. The price level is assumed to fall by 5 percent on impact and thus γ is assumed to move up, thereafter the real exchange rate is again set equal to its equilibrium value. As can be observed from the figures 8 and 9 both for the Taylor rule and the money rule holds that, if the import share in consumption goods decreases domestic consumption as well as all other nominal and real variables first rise and then reverting back to their respective equilibrium values. Overall, our model is roughly able to replicate well known stylized facts obtained from VAR studies of macroeconomic variables.

Figures 8 and 9 about here

In sum, as our study shows, the results of the two variants of the monetary rules are not so different concerning inflation and output stabilization. This holds, however, only if the money supply rule is a feedback rule responding to inflation and output and money growth. It does not hold for a simple money supply rule. The Bundesbank has claimed that it has pursued a simple money supply rule and maintains that this rule of the central bank has gained reputation of stabilizing inflation rates in Germany. The Bundesbank has thus suggested to adopt its rule for the European central bank. Yet, as has been shown by Bernanke and Mihov (1997) even the Bundesbank does not seem to have solely pursued the simple money rule, but also had followed an interest rate reaction function. Even though the simple money rule might have worked well for Germany it might not work for the ECB and the euro-area countries. Also, one can guess that the money demand for the Euro

will be more unstable than it had been for Germany in its entire monetary history. The ECB thus recently has indicated that it employs the two pillar concept, namely to directly targeting inflation rates (through interest rates) as well as targeting the inflation indirectly through the instrument of money supply.

An important recent study on the two policy rules can be found in Rudebusch and Svensson (1999a) who compare the two policy rules for U.S. time series data. They also show that the Taylor feedback rule is superior in its stabilizing properties. They draw this specific lesson for the ECB from the U.S. experience. As we have shown, based on our model, and German time series data we come to similar conclusions. In our study the Taylor rule performs superior concerning stability and a money growth rate rule exerts stabilizing effects only if there are sufficient feedbacks to output and inflation.

We want to note that those stabilizing effects of a more active monetary policy for both monetary feedback rules may hold on the basis of our parameter estimates. As, however, shown in section 2, monetary policy feedback rules may also be destabilizing when monetary policy reactions are too strong. Thus our conclusion is that one can expect stabilizing effects of monetary policy feedback rules if the parameters of the feedback rules stay within a certain corridor.

Lastly we want to note that in the context of the pegged exchange rate system, the EMS, the German monetary policy was the dominating one and the other countries had to react with monetary policy, mostly with short term interest rate changes to keep the nominal exchange rate constant which of course created also restrictions for the German monetary policy. Under the condition of a single currency now, the Euro, and a single monetary authority, the ECB, the burden of the other countries to retroactively respond to the German monetary policy has been removed by becoming full members of the decision making body of the monetary authority.

6 Conclusions

In the paper we have chosen a Keynesian disequilibrium open economy framework for studying monetary policy for a large country – for the German economy – under pegged exchange rates. Disequilibrium is allowed in the product and labor markets whereas the financial markets are always cleared. There are sluggish price and quantity adjustments and expectations are a combination of adaptive and forward looking ones. The main objective of the paper was to study the effects of recently discussed alternative monetary policy rules, in the context of an open economy model, where real exchange

rates affect the wage and price Phillips-curves and the macroeconomic dynamics. These policy rules are (1) the money supply rule and (2) the interest rate targeting by the monetary authority. We demonstrate the implication of those policy rules for macroeconomic dynamics, estimate the model employing German macroeconomic time series data from 1970.1-1991.1, and study impulse-response functions for our macrodynamic model.

Based on the estimation of the parameters, obtained partly from subsystems and partly from single equations, we study, using VAR methodology, the proper comovements of the variables by employing either the money supply or the Taylor rule. The results largely confirm what one knows from other, low dimensional, VAR-studies. As we could also show, with respect to containing instabilities, the model variant with the Taylor feedback rule is superior in terms of stabilizing inflation rates and output. Yet, as shown in theoretical study in sections 3 and 5 too strong policy reactions may be destabilizing too.

Finally we want to note that in this paper we were mostly interested in comparing the stabilizing properties of the two monetary policy rules²⁹ and, as Tobin (1975), in the macrodynamics of a large economy resulting from the pegged exchange rate system. We did not enter the controversy whether, from a normative point of view, the monetary policy of the Euro-area countries, given the dominant German monetary policy, has pursued a too tight interest rate policy, see also Tobin (1998). In fact for the 1990s, even with a much higher rate of unemployment in Europe, compared to the U.S., the nominal short term interest rate in the Euro-area was about 6.1 and for the U.S. 5.1 percent. The real interest rate in Europe was 3.2 and for the U.S. 1.8 percent. In Semmler, Greiner and Zhang (2002) it is shown that if the Euro-area countries had applied U.S. response coefficients in the interest rate reaction function the interest rate would have been lower, the output gap smaller, and thus unemployment lower, at roughly the same inflation rate of the Euro-area countries. Such an evaluation of the monetary policy of the Euro-area countries is, however, still subject to current academic discussions. A more elaborate view on this topic can be found in the paper by Blanchard in this volume.

Endnotes

- ¹This is a question in which James Tobin was particular interested in, see, for example, Tobin (1975).
- ²For more details of such a framework, see Flaschel et al (1997) and Chiarella et al (2000)
- ³Of course, we want to note that our analysis appears to be valid only if there are no major currency attacks which can lead either to major realignments of the currencies or to the abolition of the pegged system. Such a major currency attack has occurred for the EMS in September 1992 and produced a considerable currency crisis for the EU member states with subsequent realignment and a larger band.
- ⁴Measured as the amount of foreign goods currently traded for one unit of the domestic good.
- ⁵See the steady state calculations in section 3 for the derivation of the expressions for y_o^d, y_o .
- ⁶See Rødseth (2000) for the same type of assumption. We could discuss fiscal policy in the context of our model. Yet we will focus on monetary policy since this is the more controversial issue in the context of pegged exchange rates.
- ⁷The formulation of money demand can be derived from a money demand function of type $M^d/p = m^d(Y, W, r)$, assumed as homogeneous of degree one in (Y, W) . A Taylor expansion of $M^d/(pW) = m^d(Y/W, r)$ would yield (5). For analytical simplicity we replace W by K in (5) in the developments below.
- ⁸Or, alternatively one could assume that the interest rate is steered through an assumed EU-wide Taylor rule controlling the nominal rate of interest for the EU countries.
- ⁹We, however, neglect any influence of the real exchange rate on investment plans and thus the import of investment goods in this paper.
- ¹⁰In fact, only a traditional LM-equation for the domestic rate of interest.
- ¹¹We note that demand for foreign goods $Y_2^d = C_2 + J^d + G_2$ is well defined, but does not feed back into the domestic dynamics and can thus be neglected in their investigations.
- ¹²Note that under the EMS the national currencies were converted into ECU as a Euro-wide unit of account.
- ¹³Yet we want to note that sometimes realignment were necessary and, after the currency attack in September 1992, the exchange rate band was widened.
- ¹⁴which are normally interpreted as net ‘factor’ exports NFX.
- ¹⁵We note that ϵ^m is measured as a 12 quarter moving average of $\epsilon = \rho - (r + \xi - \hat{p})$ in the empirical application of the model, ρ the actual rate of profit, see also below.
- ¹⁶We have assumed that $y_1^{d*}(\eta)$ is given by $\gamma_o^* + \gamma_1^*(\eta_o - \eta)$
- ¹⁷choosing $\beta_{\mu_1} = \beta_{\mu_2} = \beta_{\mu_3} = 0$ and $\mu = \bar{\mu}$ leads us back to the 6D dynamics considered initially.
- ¹⁸For this purpose the monetary authority could also use a sterilizing monetary policy, for an extensive discussion on this point, see Krugman and Obstfeld (1994, ch. 18).
- ¹⁹Note that β_{μ_2} is even negative.

²⁰There, β_p is negative and statistically insignificant when we use U.S. time series. In the case of using German time series, β_p is close to zero while statistically insignificant.

²¹with $i(\cdot)$ set to 0, a steady state condition.

²²Since there is only one parameter β_{y^e} here, we employ a grid search algorithm

²³Note this indicates that the weighting matrix takes the form of I_{2T} . Considering that both \hat{w}_t and \hat{p}_t are measured in terms of growth rates, it may not be quite unreasonable to assume an equal weight in matching \hat{w}_t and \hat{p}_t .

²⁴For description of simulated annealing, see Semmler and Gong (1996).

²⁵Note that in this exercise the fitted line is obtained by simulating not the entire system of equations, but the corresponding behavioral functions using the estimated parameters.

²⁶We want to note, however, that strong feedback rules resulting in a very active monetary policy can also lead to (local) instability. This is demonstrated in Benhabib et al, (2001). Yet, this is shown in a model where the Taylor rule only responds to inflation rates.

²⁷See, for example, Christiano, Eichenbaum and Evans (1994) and Christiano and Gust (1999).

²⁸Note that here we use the money supply rule as represented by (65).

²⁹For an evaluation of these two policy rules in the context of macroeconomic theory, see Tobin (1998).

7 Appendices

Appendix 1: Notations:

$Y > 0$	Output
$Y^e > 0$	Expected sales
$Y_w^D, Y_c^D > 0$	Disposable income of workers and asset-holders
$L^d > 0$	Employment
$C_1 > 0$	Consumption of the domestic good (index 1: good originates from country 1 = domestic economy)
$C_2 \geq 0$	Consumption of the foreign good (index 2: good originates from country 2 = foreign economy)
I	Intended (= realized) fixed business investment
$\mathcal{I} \geq 0$	Planned inventory investment (existing stock = N)
I^p	Planned total investment $I + \mathcal{I}$
$I^a = I + \dot{N}$	Actual total investment
$r > 0$	Nominal rate of interest (price of bonds $p_b = 1$)
$p_e > 0$	Price of equities
$S = S_p + S_f + S_g$	Total savings
$S_p > 0$	Private savings
S_f	Savings of firms (= Y_f , the income of firms)
S_g	Government savings
$T > 0$	Real taxes
$G > 0$	Government expenditure
ρ^e	Expected rate of profit (before taxes)
$V = L^d/L$	Rate of employment (\bar{V} the employment-complement of the NAIRU)
$K > 0$	Capital stock
$w > 0$	Nominal wages
$p > 0$	Price level
$p_c > 0$	Consumers' price index
π	Expected rate of inflation
e	Exchange rate (units of domestic currency per unit of foreign currency)
ϵ	Expected rate of depreciation of the exchange rate e
$M > 0$	Money supply (index d: demand, growth rate μ_0)
$L > 0$	Labor supply
$B > 0$	Domestic bonds, of which B_1 and B_1^* are held by domestic and foreign asset-holders, respectively (index d: demand)
$B^* > 0$	Foreign bonds, of which B_2 and B_2^* are held by domestic and foreign asset-holders, respectively (index d: demand)

$E > 0$	Equities (index d: demand)
$W > 0$	Real domestic wealth
$\omega > 0$	Real wage ($u = \omega/x$ the wage share)
$R \geq 0$	Stock of foreign exchange
$\Delta Y^e = Y^e - Y^d$	Expectations error on the goods market
$Ex \geq 0$	Exports in terms of the domestic good
$Im \geq 0$	Imports in terms of the domestic good
$NX = Ex - Im$	Net exports in terms of the domestic good
NFX	Net factor export payments
NCX	Net capital exports
Z	Surplus in the balance of payments
$\eta = p/(ep^*)$	Real exchange rate (measured in Goods*/Goods)
T_c	$= \tau_c(\rho K + rB_1/p) + \tau_c^*er_o^*B_2/p$
t^n	$= (T_c - rB_1/p - er_o^*B_2/p)/K$
	Taxes on domestic capital income
	net of domestic interest receipts per unit of capital
$nx = NX/K$	Net exports per unit of capital

Appendix 2: Proof of flow consistency

We here consider and prove the following identities:

1. $S = I + \dot{N} + NCX/p$
2. $S = I + \dot{N} + NX + NFX/p, \quad \text{i.e.}$
3. $Z = NX + NFX/p - NCX/p = 0$

on the basis of the budget constraints provided in the modules on household, firm and government behavior. We first consider the relationships between real saving and its allocation to financial asset, and consider thereafter the sources of aggregate savings and its relationships to total investment and the current account. With respect to the definitions of NX , NFX , NCX the reader is referred to module 9 above. We stress that Y^d denotes the total demand for the domestically produced good and Y the domestic output of

this commodity.

$$\begin{aligned}
S_p &= Y_w^D + Y_c^D - C \\
&= s_w Y_w^D + s_c Y_c^D \\
&= (\dot{M} + \dot{B}_1 + e\dot{B}_2 + p_e \dot{E})/p \\
S_f &= Y_f = Y - Y^e = \mathcal{I} = I + \dot{N} - p_e \dot{E}/p \\
S_g &= T - rB/p - G = -(\dot{M} + \dot{B})/p \\
S &= S_p + S_f + S_g = I + \dot{N} + [e\dot{B}_2 - (\dot{B} - \dot{B}_1)]/p = I + \dot{N} + NCX/p \\
&= \text{Actual investment} + \text{Capital Account Balance}
\end{aligned}$$

$$\begin{aligned}
S_p &= \omega L^d + \rho^e K - T + rB_1/p + er^* B_2/p - (C_1 + C_2/\eta) \\
&= Y^e - \delta K - T - J^d/\eta + rB_1/p + erB_2/p - C \\
S_f &= Y - Y^e \\
S_g &= T - rB/p - G \\
S &= S_p + S_f + S_g \\
&= Y - Y^d + Y^d - C - G - \delta K - J^d/\eta + er^* B_2/p - r(B - B_1)/p \\
&= \dot{N} + I + Y_1^{d*} - (C_2 + G_2 + J^d)/\eta + er^* B_2/p - r(B - B_1)/p \\
&= \text{Actual investment} + \text{Current Account Balance} \\
&= I + \dot{N} + NX + NFX/p
\end{aligned}$$

Appendix 3: Sources of Macroeconomic Time Series Data

The time series data for the variables employed in the model are available at the web-site: www.wiwi.uni-bielefeld/~semmler/cem. The data set contains also time series data for France, U.K. and Italy.

ASCII-file	Time Series Data	Source
eu.cs.txt	Business capital stock, quarterly mn. currency units	OECD 1997, BSDB
eu.cu.txt	Capacity utilization, in %, quarterly	OECD Statistics, ISY 1997
eu.e.txt	total employment, persons, quarterly	OECD 1997, BSDB
eu.exc.txt	exchange rate index, 1990 = 100, quarterly	IMF Statistics, ISY 1997
eu.gd.txt	GDP - Deflator, quarterly Western Germany (before 3. Okt. 1990)	OECD 1997, BSDB
eu.gdp.txt	GDP at market prices, quarterly mn. currency units	OECD 1997, BSDB
eu.id.txt	indirect taxes, annual mn. currency units	ISY 1997
eu.m1.txt	monetary aggregate M1, quarterly mn. currency units	OECD Statistics, ISY 1997
eu.nc.txt	private consumption, half year	BSDB, OECD 1997,

eu_pfi.txt	mn. currency units private fixed investments, excl. stockbuild. mn. currency units, quarterly, Western Germany (before 3. Okt. 1990)	OECD 1997, BSDB
eu_rc.txt	deflator private consumption, quarterly	OECD 1997, BSDB
eu_tax.txt	annual tax receipts as % of GDP	ISY 1997
eu_tbr.txt	treasury bill rates as % per year, quarterly	IMF Statistics, ISY 1997
eu_wage.txt	wage index, 1990 = 100, quarterly	IFS Statistics, 12.97
eu_exp.txt	exports of goods and services, quarterly constant prices, mn. 1991 currency units, seas. adjusted	ISY 1997
eu_imp.txt	imports of goods and services, quarterly (see eu_exp.txt)	ISY 1997
eu_ge.txt	government expenditures, % of gdp annual	OECD 1997, BSDB

Whereby, ISY 1997 stands for the "International Statistical Yearbook", CD-release 1997, OECD 1997 includes the "OECD - Statistical Compendium", CD-release 1997 and IFS 1997 are the "International Financial Statistics". The following databases of the named CD-Roms were used : BSDB³⁰ of the OECD 1997, Eurostatistics, IMF Statistics and OECD Statistics of the ISY³¹ 1997 CD-Rom.

Tables

Table 1: The Estimates of Structural Parameters
(standard errors are in the parenthesis)

Set 1	Sales Expectation	$\beta_{y^e} = 0.8814$ (0.1042)	$\beta_n = 0.0031$ (0.0041)
		$\beta_{n^d} = 0.5435$ (0.2304)	
Set 2	Price-Wage Dynamics	$\beta_w = 0.0892$ (0.0207)	$\beta_p = 0.0279$ (0.0081)
		$\beta_x = 0.8223$ (0.0415)	$\kappa_w = 0.9773$ (0.4540)
		$\kappa_p = 0.0327$ (0.0230)	$\beta_\pi = 0.3218$ (0.0609)
		$\alpha = 0.9254$ (0.0377)	
Set 3	Consumption Function	$c_0 = 0.0169$ (0.0011)	$s_c = 0.5062$ (0.0313)
		$s_w = 0.2573$ (0.0437)	$\gamma_0 = 0.0371$ (0.0223)
		$\gamma_1 = 0.9544$ (0.0233)	$\gamma_2 = -1.1591$ (0.9036)
Set 4	Investment Function	$i_1 = 0.5388$ (0.0930)	$i_2 = 0.0131$ (0.0115)
		$\xi = 0.0471$ (0.0046)	
Set 5	Money Demand Function (money supply rule only)	$h_1 = 0.06638$ (0.0034)	$h_2 = 0.8144$ (0.3012)
Set 6	Reaction Functions of Monetary Authority	$\beta_{r_1} = 0.0854$ (0.0331)	$\beta_{\mu_1} = 0.6402$ (0.0781)
		$\beta_{r_2} = 0.0811$ (0.0339)	$\beta_{\mu_2} = 0.0013$ (0.2127)
		$\beta_{r_3} = 0.0111$ (0.0045)	$\beta_{\mu_3} = -0.0027$ (0.0309)
		$\beta_m = 0.6397$ (0.0774)	
Set 7	Other Parameters	$r_0 = 0.0140$ (0.0061)	$y_p = 0.1432$ (0.0246)
		$\bar{\pi} = 0.0109$ (0.0211)	$\mu = 0.0195$ (0.0159)
		$\bar{U} = 0.8405$ (0.0403)	$\bar{V} = 0.9515$ (0.0350)
		$\delta = 0.0121$ (0.0058)	$n_l = 0.0027$ (0.0273)
		$n_x = 0.0058$ (0.0159)	$n = 0.0086$ (0.0149)
		$\bar{y}_d^* = 0.0317$ (0.0031)	$\bar{p}_0^* = 0.0132$ (0.0083)

Figures

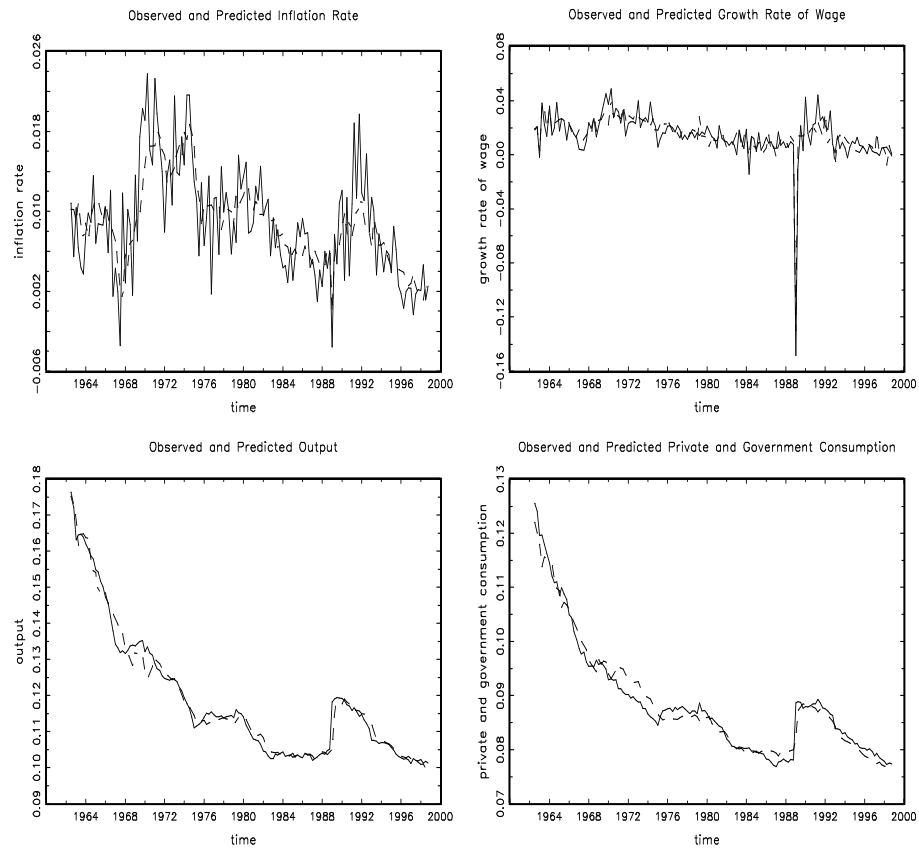


Figure 1: Observed (solid) and predicted (dashed) variables

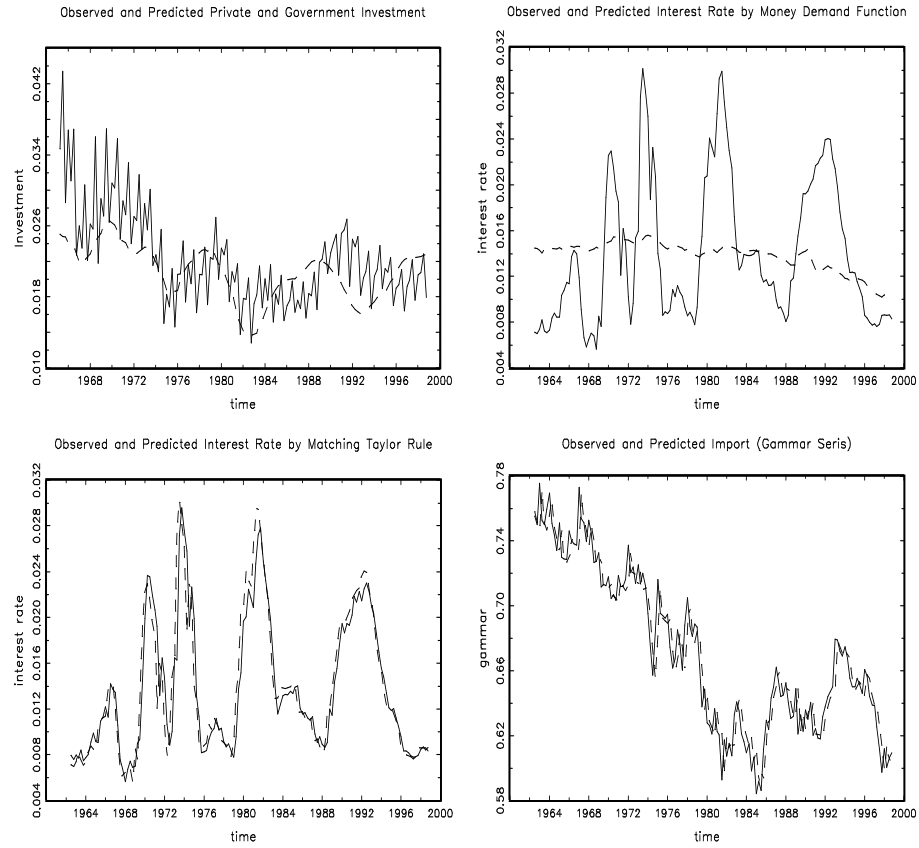


Figure 2: Observed (solid) and (dashed) predicted variables

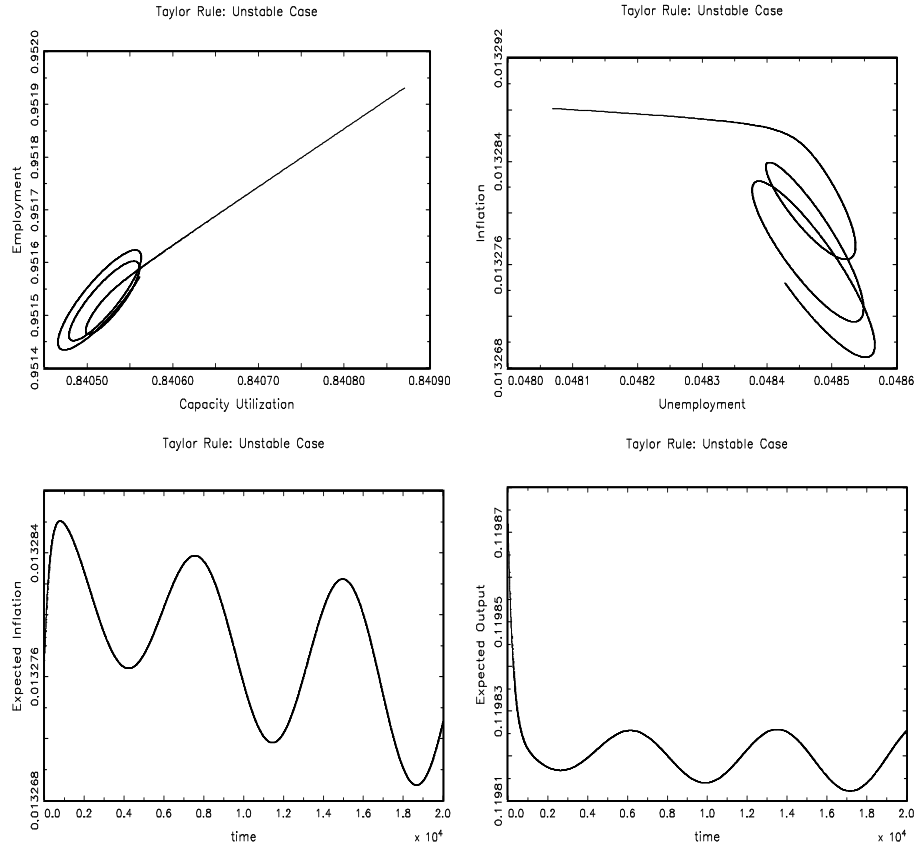


Figure 3: Simulation of the model with Taylor rule(unstable case)

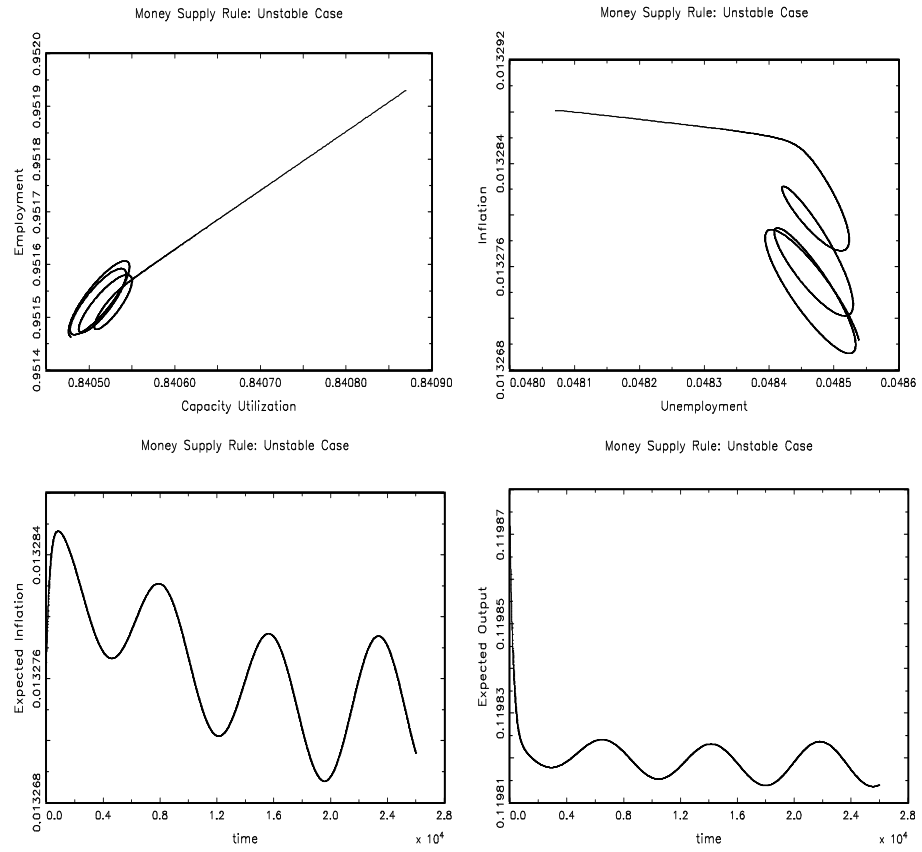


Figure 4: Simulation of the model with money supply rule(unstable case)

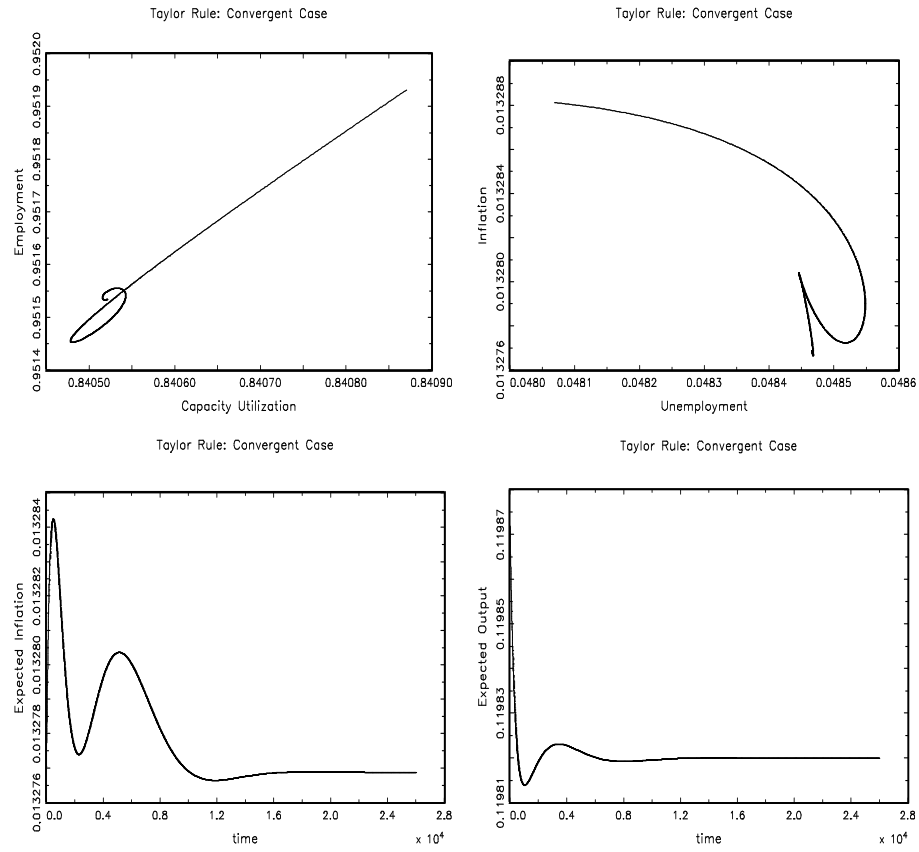


Figure 5: Simulation of the model with Taylor rule (stable case)

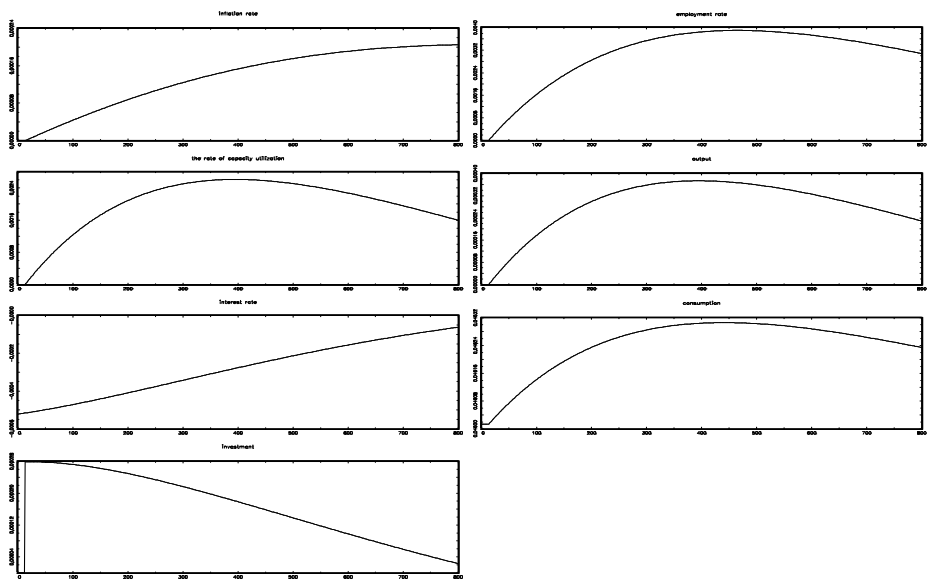


Figure 6: Impulse-responses for Taylor rule

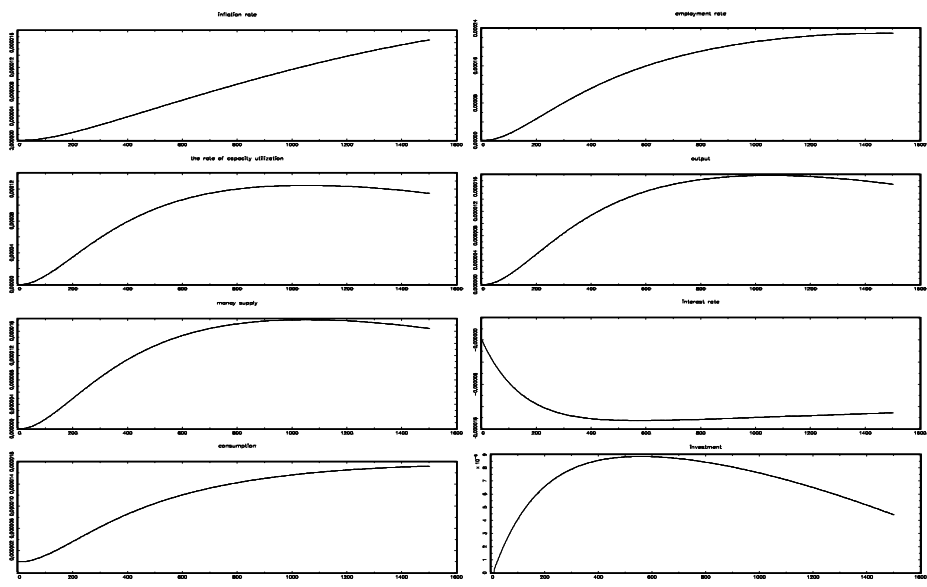


Figure 7: Impulse-responses for money supply rule

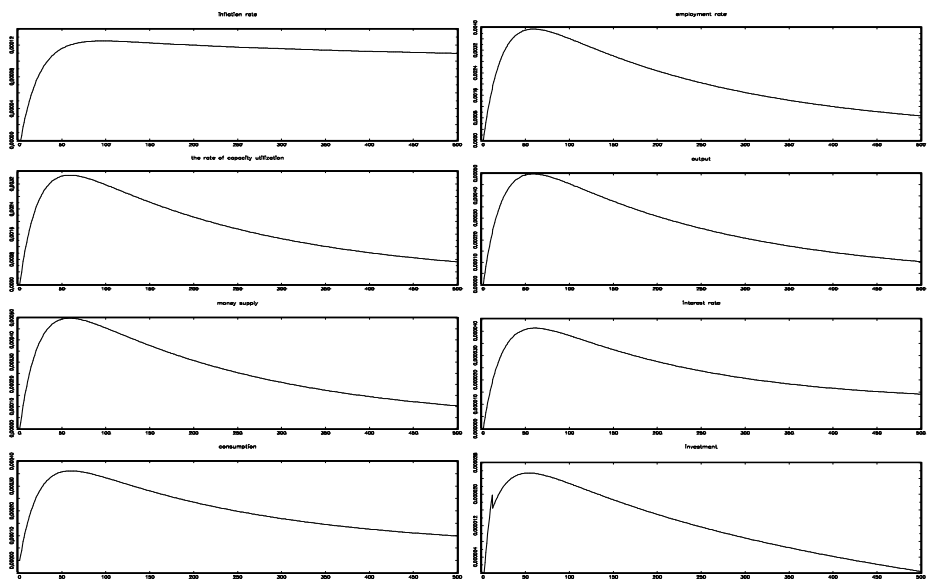


Figure 8: Impulse-responses: domestic price fall and negative import shock (money supply rule)

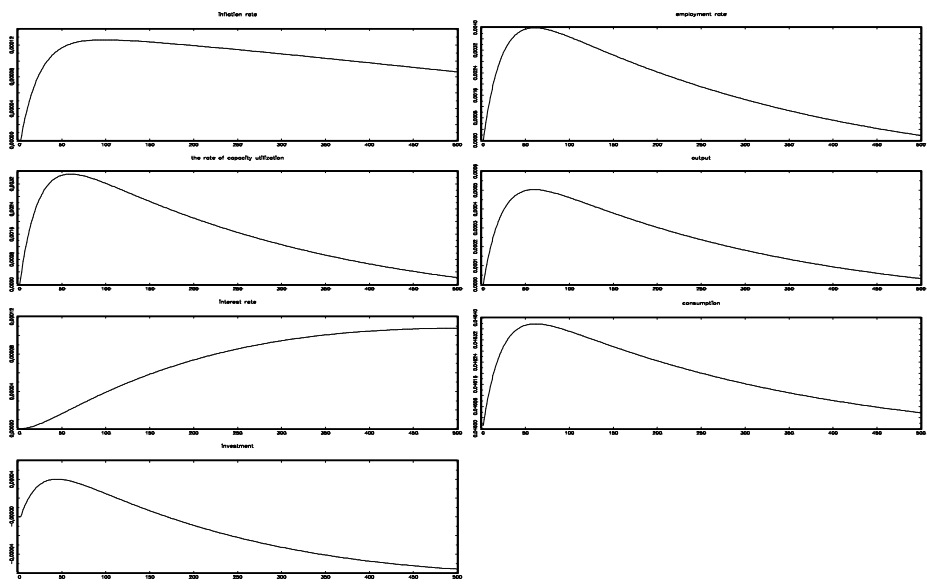


Figure 9: Impulse-responses: domestic price fall and negative import shock (Taylor Rule)

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