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International Policy Transmissions Before and After Establishing a Monetary Union

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Abstract

This paper analyzes the effects of the implementation of a monetary union on the international transmission of monetary and fiscal policies. A dynamic three-country general equilibrium model, exhibiting monopolistic competition and sticky prices, is used to show how asymmetric monetary and fiscal policy shocks affect the production and consumption decisions in the three countries. The international effects of asymmetric monetary and fiscal policy shocks are then compared with respect to the two situations – before and after the implementation of a (two-country) monetary union. It is shown that all key economic variables of the two countries forming a monetary union react completely symmetrically to no longer independent monetary and fiscal policy shocks. Even the fiscal policies of the countries forming a monetary union themselves turn out to become symmetric, although, in principle, there is no particular need for government spending levels to be fully synchronized within a monetary union.

Keywords
Macroeconomic policy transmissions, exchange rate arrangements, EMU

JEL Classifications
E63, F33, F42

Comments

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Contents

The participants of the European Monetary Union (EMU), which has become effective at the beginning of 1999, have committed themselves to replace their national currencies by a common currency, the Euro. This includes giving up their national monetary policy autonomy in favor of a common monetary policy implemented by the European Central Bank (ECB). Concerning fiscal policy, EMU contains a set of fiscal stringency criteria that were designed to enhance the discipline of national fiscal authorities and to avoid countries running unsustainable budget deficits. The implications of EMU can be distinguished into internal and external implications, with internal implications comprising all effects of EMU on the interactions between the participating countries and the external implications comprising all effects on the interactions of the EU economy with the rest of the world[1].

International transmission issues of macroeconomic policies have mostly been analyzed in the framework of the classical textbook Mundell-Fleming model. While appealing for their empirical plausibility, the lack of microfoundations in the "Keynesian" models presents problems in many respects, e.g. they ignore the intertemporal budget constraints and do not clearly describe how macroeconomic policies influence production decisions. Only recently intertemporal optimizing models, additionally incorporating market imperfections, have emerged in the field of open-economy macroeconomic policy analysis. For a survey of static and dynamic open-economy models based on imperfect competition see Dixon (1993). It is, however, common to both types of models, to recent intertemporal models as well as to traditional Keynesian-style models[2], that asymmetric macroeconomic policy shocks are identified to be especially important in open-economy macroeconomic analysis. For it is this type of shocks that leads to internationally asymmetric dynamics of output, consumption and the current account. Thus, also the analysis in this paper is focused on the international effects of asymmetric rather than symmetric monetary and fiscal policy shocks.

The implementation of a monetary union – especially the EMU –, however, imposes considerable constraints on the nature and feasibility of asymmetric macroeconomic policies: There is absolutely no scope for asymmetric monetary policy anymore, once the common monetary authority (ECB) has centralized the monetary policy of the whole monetary union. Fiscal policy, on the other hand, need, in principle, not be synchronized as a consequence of the monetary union, since the responsibility for fiscal issues remains in the hands of national authorities. In the concrete case of EMU, however, a set of fiscal stringency criteria has been specified ("stability pact"), which substantially restricts the scope of asymmetric fiscal policies within the monetary union. Hence, these constraints on asymmetric policies have to be taken into account when analyzing the implications of establishing a monetary union on the international transmission of macroeconomic policies.

The aim of this paper is to analyze if and how the implementation of EMU affects the international transmission of monetary and fiscal policies. To do so, a non-stochastic three-country general

[1] For further discussions of internal and external implications of EMU, see Van Aarle, Garretsen and van Moorsel (1998).

[2] For the case of the Mundell-Fleming model, see Dornbusch (1980, Chapter 11).

equilibrium model is developed where we assume that the world economy consists of three different countries which we label Germany for country 1, France for country 2 and the United States for country 3. According to Obstfeld and Rogoff (1995), who first introduced a two-country version of this model[3], the model is intended to combine the modern intertemporal approach to the current account and fiscal policy with the "Keynesian" assumption of short-run output price rigidities[4]. Furthermore, the supply sector of the model features imperfect competition (in the form of monopolistic competition) which in combination with short-run price stickiness creates a transmission mechanism from monetary policy to the real side of the economy. In particular, combining the assumptions of sticky prices and monopolistic competition implies that output becomes demand-determined in the short run, thereby allowing monetary and fiscal policy shocks to affect endogenous output. Above all, it is very interesting to note that the real effects of the policy shocks last substantially longer than the nominal rigidities are assumed to be effective, which is due to the induced international transfer of wealth via the current account.

The three-country structure of the model enables us to compare the international transmission of monetary and fiscal policy shocks before and after the implementation of EMU. For this purpose, the international transmission along with the channels of transmission of the policy shocks as well as the macroeconomic adjustment following these shocks are analyzed under two different regimes: First, when the three countries are completely independent with respect to their monetary and fiscal policies, and, second, when two of the three countries decide to form a monetary union. The three-country structure of the model, furthermore, implies that the internal and external implications of EMU, which have so far been considered separately in the literature, can be analyzed jointly in this study. The internal implications have already been discussed extensively in the framework of the Optimum Currency Area theory, which is concerned with evaluating the costs and benefits of tighter monetary integration. The analysis of the external implications, which compared to the internal implications seem to be less present in the current discussion about EMU, is concerned, above all, with the determination of the external value of the Euro and its potential future role in foreign exchange and capital markets.

The paper is organized as follows: Section I develops a three-country general equilibrium model with monopolistic competition that serves as our main workhorse. In section II the short-run dynamics of the model under the assumption of preset output prices are explored. This includes solving for the short-run variables as functions of the monetary and fiscal shocks. In section III we discuss how the international transmission of monetary and fiscal policies is affected by the implementation of a monetary union and compare those transmissions and their implications in the two situations, before and after the monetary union is established. Section IV, finally, concludes our analysis.

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[3] Their model was the first attempt to analyze international transmission of macroeconomic policies in a rigorous and coherent way by incorporating explicit microfoundations of aggregate supply.

[4] Obstfeld and Rogoff (1996) show that the central results of the model are equivalent, regardless of whether it is output prices or nominal wages that are assumed to be sticky in the short run.

I. A Three-Country General Equilibrium Model with Monopolistic Competition

This section develops a perfect-foresight three-country general equilibrium monetary model with monopolistic competition[5]. First, an equilibrium is derived for the case of flexible output prices before the equilibrium relations are reconsidered with the assumption of one-period predetermined output prices being imposed.

I.A. Preferences, Technology and Market Structure

Let the world be inhabited by a continuum of infinitely-lived producer-consumers ("yeoman farmers"), indexed by $z \in [0,1]$, each of whom specializes in the production of a single differentiated good, also indexed by z. Thus, each producer is a monopoly supplier of the good he produces in a way that he has the power to set the price of his product, following Blanchard and Kiyotaki (1987)[6]. Country 1 consists of producers on the interval $[0,n_1]$, country 2 on $(n_1, n_2]$ and the remaining producers $(n_2,1]$ reside in country 3. Although the model is rather stylized (no capital/investment, no asset markets except private bonds), it is not an endowment economy because labor supply is perfectly elastic.

All individuals in all countries are assumed to have identical preferences, dependent upon a real consumption index, real money balances and the work effort. Since all individuals have symmetric preferences and constraints, the maximization problem can be analyzed for a representative consumer. As far as notation is concerned, we have to note that all the expressions and variables which will be introduced below, are, in fact, threefold, referring to the three different countries. This implies that each variable has to be indexed with reference to the country it belongs, e.g. C_t1, C_t2 and C_t3 denote private consumption at time t of the representative individual residing in country 1, 2 and 3, respectively. To save space, we will, however, drop these indices in most cases and develop the model for a representative country, which we call "home", and use the indices only where absolutely necessary. The latter is the case, for instance, when we define one of the three exchange rates by making use of the law of one price.

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[5] The model is mainly based on Obstfeld and Rogoff (1995) and Obstfeld and Rogoff (1996, Chapter 10). In deriving the supply side of the model we follow along the lines of Ball and Romer (1989) and Blanchard and Kiyotaki (1987). The closest precursor to this model is probably Svensson and van Wijnbergen (1989), who explore international transmissions of monetary disturbances in a two-country setting with monopolistic competition and sticky prices.

[6] The main difference between this model and the static closed-economy model in Blanchard and Kiyotaki (1987) is, that in the latter, both, output and labor markets are assumed to be monopolistically competitive. In order to focus more clearly on the equilibrium relations that are of interest here and to simplify the exposition, this paper does not explicitly model firms and the labor market. There is no problem in doing so, because the assumption of many monopolistically supplying producer-consumers allows us to derive the pricing/supply decision without having explicitly to introduce firms and factor markets.

Let the intertemporal utility function of a representative home agent be given by[7]

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t} \left[u(C_s) + v\left(\frac{M_s}{P_s} \right) - w(y_s(z)) \right] \tag{1}$$

where u and v are increasing concave functions, w is an increasing convex function and $0 < \beta < 1$ is a discount factor. The real consumption index, C, is given by a constant-elasticity-of substitution (CES) subutility specification

$$C = \left[\int_0^1 c(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} \tag{2}$$

where $c(z)$ denotes the representative home individual's consumption of good z and $\theta > 1$ representing the (constant) elasticity of substitution between various goods[8]. The price deflator for nominal money balances is the consumption-based money price index of the home country which is given by

$$P = \left[\int_0^1 p(z)^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \tag{3}$$

where $p(z)$ is the home-currency price of product z[9]. Thus, the home price index takes into account also home-currency prices of foreign goods and vice versa, since the bounds of integration are [0,1] and not only $[0,n_1]$ or $[n_1, n_2]$ or $[n_2,1]$. The same applies to the private consumption index, C. The w function in the period utility function (1) captures the disutility of work, which is positively related to output.

It is assumed that there are no impediments to trade, so that the law of one price holds for each individual good across all countries. Let E12 be the nominal exchange rate of country 1 vis-à-vis country 2, defined as the price of country 2 currency measured in units of the currency of country 1[10], $p1(z)$ and $p2(z)$ the price of good z in country 1 and country 2 currency, respectively. The law of one price then implies that

$$p1(z) = E12\, p2(z)\,. \tag{4}$$

[7] Here a money-in-the-utility approach is chosen in order to introduce currency. It can be shown, though, that a model embedding a cash-in-advance constraint for consumers and the government would yield qualitatively similar results (see Obstfeld and Rogoff 1996, Chapter 8). Also Feenstra (1986) discusses the equivalence of money-in-the-utility-function and cash-in-advance constraint approaches to money demand. Blanchard and Kiyotaki (1987) argue that in money-in-the-utility models money can be interpreted to play the role of a non-produced good and as such provides liquidity services.

[8] By assuming constant elasticity of substitution specifications in utility and consumption, we followed the lines of Dixit and Stiglitz (1977). These specifications eventually lead to a constant price elasticity of demand (which will turn out to be equal to θ as can be seen from (13)) and a constant markup of price over marginal cost. As marginal revenue becomes negative when the elasticity of demand is less than 1, θ has to be greater than 1 in order to ensure a well behaved equilibrium solution with positive output.

[9] The consumption-based price index is defined as the minimum expenditure of money required to purchase one unit of C, which is equivalent to purchasing goods that yield a consumption index of C by a minimum expenditure of PC. This minimization problem is explicitly solved in Obstfeld and Rogoff (1996, Chapter 4).

[10] Thus a rise (fall) in E12 implies a depreciation (appreciation) of the country 1 currency versus the currency of country 2.

Since the preferences of all countries' residents are identical, the law of one price, also called purchasing power parity (PPP), holds also for consumption-based price indices, such that[11]

$$P1 = E12\,P2\,. \tag{6}$$

Of course, due to the law of one price, the analogous relations $p1(z) = E13p3(z)$ and $p2(z) = E23p3(z)$ have to be equally true which implies that also

$$P1 = E13P3 \qquad \text{and} \tag{6}$$

$$P2 = E23P3\,. \tag{7}$$

It is assumed that the only internationally traded asset is a riskless real bond denominated in terms of the composite consumption good. Assuming this, each representative home individual faces the following period budget constraint (written in nominal terms)[12]:

$$P_t B_{t+1} + M_t = P_t\left(1+r_t\right)B_t + M_{t-1} + p_t(z)y_t(z) - P_tC_t - P_t\boldsymbol{t}_t \tag{8}$$

where r_t denotes the real rate of interest earned on bonds between t-1 and t, M_t and B_{t+1} are the demands for nominal money balances and real bonds in period t, $y_t(z)$ is the output produced by agent *z* at time t and sold at the price $p_t(z)$ of good *z*, and τ_t denotes real lump-sum taxes[13]. Due to the assumption that home as well as foreign residents derive utility exclusively from their respective domestic currency, there is no currency substitution in this model and individuals only demand the respective domestic currency.

By integrating forward the period budget constraint (8) one can derive the intertemporal or lifetime budget constraint[14] from which we can obtain the transversality condition

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[11] This can easily be seen from an extension of a country 1 and 2 version of equation (3)

$$P1 = \left[\int_0^{n_1} p1(z)^{1-q}\,dz + \int_{n_1}^{n_2}\left[E12p2(z)\right]^{1-q}dz + \int_{n_2}^{1}\left[E13p3(z)\right]^{1-q}\right]^{\frac{1}{1-q}} \text{ and}$$

$$P2 = \left[\int_0^{n_1}\left[\frac{p1(z)}{E12}\right]^{1-q}dz + \int_{n_1}^{n_2} p2(z)^{1-q}\,dz + \int_{n_2}^{1}\left[E23p3(z)\right]^{1-q}\right]^{\frac{1}{1-q}}$$

. From this we can also see that the exchange rate of country 1 versus country 3 becomes redundant, as it can be defined in terms of the other two exchange rates: $E13 = E12E23$. We will make use of this relation where appropriate. While PPP holds for the consumption-based price index, it does not for national output deflators since relative prices of various goods need not remain constant in all countries. Indeed, changes in the terms of trade – the relative price of home and foreign goods – will play a major role in this model.

[12] The P_tC_t term in (8) would be $\int_0^1 p_t(z)c_t(z)dz$ before symmetry of agents is imposed. In principle p(*z*) need not be the same for all *z* due to price discrimination between goods, but in equilibrium symmetric producers will find it optimal to choose the same price for their differentiated goods.

[13] Introducing income taxes would add another distortion to the model from which we want to abstract in order to focus on effects of monetary and fiscal policy shocks only.

[14] Following this we get the lifetime budget constraint

$$\sum_{s=t}^{\infty} R_{t,s}\left[C_s + \frac{M_s}{P_s}\left(\frac{i_{s+1}}{1+i_{s+1}}\right)\right] \le \frac{M_{s-1}}{P_s} + \left(1+r_t\right)B_t + \sum_{s=t}^{\infty} R_{t,s}\left(\frac{p_s y_s}{P_s} - \boldsymbol{t}_s\right)$$

where $R_{t,s}$ denotes the discount factor

$$\lim_{T \to \infty} R_{t,t+T}\left(B_{t+T+1} + \frac{M_{t+T}}{P_{t+T}} \right) = 0\,. \tag{9}$$

The transversality condition is imposed to rule out unbounded borrowing and is required in order to fully characterize the equilibrium, together with the first-order conditions (16)-(18) and the period budget constraint (8). In a finite-lives framework this condition could be interpreted as follows: Optimality implies that individuals, who cannot pass on debt when they leave the world, have to have consumed all their wealth, composed of bonds and real money holdings, at the end of their lives.

Since Ricardian equivalence holds in this model[15], we can, without loss of generality, simply assume that the government runs a balanced budget each period. Hence, the government budget constraint specifies that government purchases are totally financed by taxes and seignorage revenues, i.e.

$$G_t = \mathbf{t}_t + \frac{M_t - M_{t-1}}{P_t}\,. \tag{10}$$

$$\text{where } G = \left[\int_0^1 g(z)^{\frac{q-1}{q}} dz \right]^{\frac{q}{q-1}} \tag{11}$$

and g(z) denotes the home government’s consumption of good z.

In order to derive the representative home individual's consumption demand for good z, c(z), the monopolistically competitive equilibrium in the output market has to be found. An optimizing agent will allocate his consumption spending across alternative differentiated goods so as to maximize the CES consumption index C (2) subject to any fixed value of total nominal expenditures Z, where $Z = \int_0^1 p(z)c(z)dz$. Following this procedure, a home individual's demand for z at date t is given by[16]

$$c_t(z) = \left(\frac{p_t(z)}{P_t} \right)^{-q} C_t \tag{12}$$

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defined as $\frac{1}{\prod_{v=t+1}^{s}(1+r_v)}$, and i_{t+1} the nominal interest rate for home-currency loans between t and t+1 defined as $1 + i_{t+1} = \frac{P_{t+1}}{P_t}(1 + r_{t+1})$.

[15] By combining the lifetime budget constraint (in footnote 14) and an intertemporal version of the government budget constraint (equation (10)) we get an expression for the overall lifetime resource constraint of the home economy $\sum_{s=t}^{\infty} R_{t,s}(C_s) = (1+r_t)B_t + \sum_{s=t}^{\infty} R_{t,s}\left(\frac{p_s y_s}{P_s} - G_s \right)$. From this we can see that Ricardian equivalence holds because taxes do not enter the previous equation implying that the time path of taxes does not affect consumption choices and output.

[16] This is also the classical monopolistically competitive equilibrium result obtained by Dixit and Stiglitz (1977).

where it turns out that θ, being the elasticity of substitution in (2), now represents also the elasticity of demand with respect to relative price. Foreign residents have analogous demand functions. If we assume that also the government allocates its expenditures so as to minimize the cost of production, an equation equivalent to (12) also applies to the government demand for good *z*. The world demand for a particular good *z* can be derived now by integrating the sum of private consumption demand and government demand for this good over all individuals and making use of (4), (5), (6) and (7) which imply that p1(*z*)/P1 = p2(*z*)/P2 = p3(*z*)/P3 for any good *z*, thus

$$y_t^d(z) = \left(\frac{p_t(z)}{P_t}\right)^{-q}\left(C_t^W + G_t^W\right) \tag{13}$$

where

$$C^W = n_1 C1 + \left(n_2 - n_1\right)C2 + \left(1 - n_2\right)C3, \tag{14}$$

$$G^W = n_1 G1 + \left(n_2 - n_1\right)G2 + \left(1 - n_2\right)G3 \tag{15}$$

are the world demands for private consumption and government spending respectively, given by a population weighted average of demands in country 1, 2 and 3 (if agents are symmetric within each country).

I.B. Individual Maximization

It is assumed that each agent takes the aggregate price index, P_t , as well as the world output demand, $C_t^W + G_t^W$, as given when making his own pricing and spending decisions, since individual decisions represent only a neglegible contribution to the aggregate indices. In order to eliminate $p_t(z)$ from the period budget constraint (8)[17] we make use of the above demand equation (13), implying $p_t(z)y_t(z) = P_t y_t(z)^{\frac{q-1}{q}}\left(C_t^W + G_t^W\right)^{\frac{1}{q}}$, and use the resulting expression to substitute for C_t in the *u* function. Thus we get an unconstraint maximization problem and can find the first-order conditions with respect to B_{t+1} , M_t , and $y_t(z)$:

$$u'\left(C_t\right) = b\left(1 + r_{t+1}\right)u'\left(C_{t+1}\right), \tag{16}$$

$$v'\left(\frac{M_t}{P_t}\right) = \left(\frac{i_{t+1}}{1 + i_{t+1}}\right)u'\left(C_t\right), \tag{17}$$

$$w'\left(y_t(z)\right) = u'\left(C_t\right)\left(\frac{q-1}{q}\right)y_t(z)^{-\frac{1}{q}}\left(C_t^W + G_t^W\right)^{\frac{1}{q}} \tag{18}$$

where the nominal interest rate i_{t+1} is as in footnote 14. Equation (16) is the standard first-order consumption Euler equation. The money market equilibrium condition (17) equates the marginal utility of consuming a unit of consumption good to the opportunity cost of holding real balances measured in consumption units. Notice that money demand here depends on consumption rather than income. The labor-leisure trade-off condition (18) states that the marginal utility cost of

[17] In Woodford (1996) the pricing decision of the monopolistic supplier is modeled explicitly.

producing an extra unit of output equals the marginal utility from consuming the revenue of the extra unit of output (marginal cost = marginal revenue).

In order to get simpler expressions, let us introduce now the specific functional forms of the *u*, *v*, *w* functions in the individual's utility function. Let $u(C_t)$ be given by $\log(C_t)$ implying an elasticity of intertemporal substitution of unity, let $v(M_t/P_t)$ be $\chi\log(M_t/P_t)$ where χ is a factor determining the importance of real balances in the utility function, and let $w(y_t(z))$ be quadratic of the form $\frac{\kappa}{2} y_t(z)^2$ with an elasticity of disutility from output being equal to two[18]. According to the functional form of the *w* function, a fall in κ would imply a rise in productivity. Plugging these expressions into the first-order conditions (16)–(18), we can find the corresponding specific first-order conditions:

$$C_{t+1} = \beta(1+r_{t+1})C_t, \tag{16A}$$

$$\frac{M_t}{P_t} = \chi \frac{1+i_{t+1}}{i_{t+1}} C_t, \tag{17A}$$

$$y_t^{\frac{\theta+1}{\theta}} = \left(\frac{\theta-1}{\theta\kappa}\right)\frac{1}{C_t}\left(C_t^W + G_t^W\right)^{\frac{1}{\theta}}. \tag{18A}$$

I.C. Global Equilibrium and A Symmetric Steady State (with flexible prices)

A global equilibrium in this model implies that all markets of the global economy, i.e. the money market, the asset market and the goods market, have to be in equilibrium. Thus, the market-clearing conditions for the three markets are as follows: Aggregate money demand must equal money supply in each country, since individuals wish to hold only domestic currency. World net foreign asset holdings must be zero, hence

$$n_1 B_t 1 + (n_2 - n_1) B_t 2 + (1 - n_2) B_t 3 = 0, \qquad \forall t. \tag{19}$$

The output-market-clearing condition can be derived by making use of the individual country versions of the representative individual's period budget constraint (8) and the government budget constraint (10) and finally imposing condition (19) to obtain

$$C_t^W + G_t^W = n_1 \frac{p_t(1)y_t(1)}{P_t 1} + (n_2 - n_1)\frac{p_t(2)y_t(2)}{P_t 2} + (1-n_2)\frac{p_t(3)y_t(3)}{P_t 3} \equiv Y_t^W \tag{20}$$

where y(1) and p(1) denote output and price – measured in the respective domestic currency – of a representative country 1 good[19]. Analogously, y(2), y(3) and p(2), p(3) are the output levels and prices of the representative goods produced in countries 2 and 3, respectively. Equation (20)

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[18] These functional forms of the *u*, *v*, *w* subutility functions do also ensure that the required sufficiency condition for the existence of equilibrium is fulfilled. This can be verified by computing the Hessian of the individual's utility function which has to be negative semi-definite for the solution to be a maximum.

[19] It is the assumption of completely symmetric producers within each country which implies that in equilibrium they set the same price and produce the same quantity of their good. Therefore, each good may be called a "representative good".

states that in equilibrium global "total" (i.e. private and government) real consumption equals global real income.

Due to monopoly pricing and endogenous output this model does not yield simple closed-form solutions for general paths of the exogenous variables[20]. Examining a linearized version of the above equilibrium relations does yield simple closed-form solutions and is also sufficient for the purpose of our analysis. In order to compute the linearizations, we first have to find a well-defined flexible-price steady state around which to approximate. We therefore look for a steady state in which all exogenous variables are constant. In this case the steady state world real interest rate, $\bar{r}$, is determined by the Euler equation (16A):

$$\bar{r} = \frac{1-b}{b} \tag{21}$$

where overbars here and in the following always indicate steady state values. After imposing constant bond holdings and constant money supply in the steady state, one can find – by making use of (8) – that steady state real per capita consumption is equal to real interest earnings from bonds plus steady state real income less real per capita government spending:

$$\bar{C} = \bar{r}\bar{B} + \frac{\overline{py}}{\bar{P}} - \bar{G}\ . \tag{22}$$

A simple closed-form solution does exist for the case of symmetric initial conditions with respect to the distribution of wealth, specifically, net foreign assets are assumed to be zero in all countries in the initial steady state, implying that $\bar{B}_0 1 = \bar{B}_0 2 = \bar{B}_0 3 = 0$. In this special case the relation $\bar{p}_0(1) / \bar{P}_0 1 = \bar{p}_0(2) / \bar{P}_0 2 = \bar{p}_0(3) / \bar{P}_0 3 = 1$ holds and the equilibrium turns out to be completely symmetric across the three countries. From this and from the demand equation (13) it follows that

$$\bar{y}_0 1 = \bar{y}_0 2 = \bar{y}_0 3 = \bar{C}_0 1 + \bar{G}_0 1 = \bar{C}_0 2 + \bar{G}_0 2 = \bar{C}_0 3 + \bar{G}_0 3 = \bar{C}_0^W + \bar{G}_0^W\ . \tag{23}$$

The labor-leisure condition (18A) and the money market equilibrium relation (17A) then imply that in equilibrium

$$\bar{y}_0 1 = \bar{y}_0 2 = \bar{y}_0 3 = \left(\frac{q-1}{qk}\right)^{\frac{1}{2}} \quad \text{(if also } \bar{G}_0 1 = \bar{G}_0 2 = \bar{G}_0 3 = 0\text{)} \qquad \text{and} \tag{24}$$

$$\frac{\bar{M}_0 1}{\bar{P}_0 1} = \frac{\bar{M}_0 2}{\bar{P}_0 2} = \frac{\bar{M}_0 3}{\bar{P}_0 3} = c\frac{(1+\bar{r})}{\bar{r}}\bar{y}_0\ . \tag{25}$$

Equation (24) indicates that the producer's monopoly power pushes global output below the level that would obtain in a perfectly competitive equilibrium, which is indeed approached as the various goods become closer and closer substitutes (i.e. as $\theta \to \infty$)[21]. Since we are assuming a zero-inflation steady state, it is the real rather than the nominal interest rate on which the steady state level of real money balances is depending in equation (25).

[20] The effects of macroeconomic policies could also be analyzed by numerical simulations, which is not the approach followed in this paper, but is done in Rumler (1999).

[21] The inefficiently low level of output in our decentralized economy is an important result of this model. In Obstfeld and Rogoff (1995) it drives most of their welfare results. An analogous result is obtained also in the static closed-economy model of Blanchard and Kiyotaki (1987); cf. equation (5), p. 650.

I.D. The Log-Linearized System

This section develops an approximate linear system by log-linearizing all of the model's equilibrium conditions around the initial symmetric steady state with $\overline{B}_0 1 = \overline{B}_0 2 = \overline{B}_0 3 = 0$ and $\overline{G}_0 1 = \overline{G}_0 2 = \overline{G}_0 3 = 0$. For this purpose all variables are expressed as percent deviations from their initial steady state, denoted by hats and defined as the logarithmic derivative: $\hat{X}_t \equiv d\log X_t = dX_t / \overline{X}_0$ where $\overline{X}_0$ represents the initial (pre-shock) steady state value[22]. The technique of log-linearizing is straightforward and requires only basic differential calculus.

Again, in order to save space, the log-linearizations are displayed here only for one representative country called "home", which, in general, allows us to drop country indices. When exchange rates are involved – as in equations (26)–(31) – we cannot, however, drop the country indices, since we want to be able to distinguish between the different exchange rates. Thus, manipulating equations (3), (5), (6), (7), (13), (16A), (17A), (18A) and (20) in the way described above yields the following relations:

$$\hat{P}_t 1 = n_1 \hat{p}_t(1) + (n_2 - n_1)\left[\hat{E}_t 12 + \hat{p}_t(2)\right] + (1 - n_2)\left[\hat{E}_t 13 + \hat{p}_t(3)\right], \tag{26}$$

$$\hat{P}_t 2 = n_1\left[\hat{p}_t(1) - \hat{E}_t 12\right] + (n_2 - n_1)\hat{p}_t(2) + (1 - n_2)\left[\hat{E}_t 23 + \hat{p}_t(3)\right], \tag{27}$$

$$\hat{P}_t 3 = n_1\left[\hat{p}_t(1) - \hat{E}_t 13\right] + (n_2 - n_1)\left[\hat{p}_t(2) - \hat{E}_t 23\right] + (1 - n_2)\hat{p}_t(3), \tag{28}$$

$$\hat{P}_t 1 = \hat{E}_t 12 + \hat{P}_t 2, \tag{29}$$

$$\hat{P}_t 1 = \hat{E}_t 13 + \hat{P}_t 3, \tag{30}$$

$$\hat{P}_t 2 = \hat{E}_t 23 + \hat{P}_t 3, \tag{31}$$

$$\hat{y}_t = \theta\left[\hat{P}_t - \hat{p}_t\right] + \hat{C}_t^W + \hat{G}_t^W, \tag{32}$$

where $\hat{G}_t^W$ is defined as $dG_t^W / \overline{C}_0^W$ because $\overline{G}_0^W = 0$; the same, of course, applies to $\hat{G}_t$;

$$\hat{C}_{t+1} = \hat{C}_t + \frac{\overline{r}}{1+\overline{r}}\hat{r}_{t+1}, \tag{33}$$

$$\hat{M}_t - \hat{P}_t = \hat{C}_t - \frac{\hat{P}_{t+1} - \hat{P}_t}{\overline{r}} - \frac{\hat{r}_{t+1}}{1+\overline{r}}, \tag{34}$$

$$(\theta + 1)\hat{y}_t = -\theta\hat{C}_t + \hat{C}_t^W + \hat{G}_t^W, \tag{35}$$

$$\hat{C}_t^W + \hat{G}_t^W = n_1 \hat{y}_t 1 + (n_2 - n_1)\hat{y}_t 2 + (1 - n_2)\hat{y}_t 3. \tag{36}$$

This last equation follows from the linearization of equation (20) and by imposing flexible prices or making use of (26), (27) and (28). With these linearizations in hand, we can now solve the model for a flexible price steady state (i.e. when $\hat{p}_t = \hat{P}_t$, ∀t), and then also for the dynamics due to short-run price rigidities. Before solving for the steady state, we still need to linearize equation (22) which is valid only in the steady-state so that time subscripts can be dropped:

$$\hat{\overline{C}} = \overline{r}\hat{\overline{B}} + \hat{\overline{p}} - \hat{\overline{P}} + \hat{\overline{y}} - \hat{\overline{G}} \tag{37}$$

---

[22] Technically speaking, the term $dX_t / \overline{X}_0$ is a continuous approximation of the discrete-time quotient $\left(X_t - \overline{X}_0\right) / \overline{X}_0$, which indeed defines a percent deviation from the initial value $\overline{X}_0$, or also a growth rate over the specified time horizon.

where $\hat{\bar{X}} = d\bar{X}/\bar{X}_0 = \left(\bar{X} - \bar{X}_0\right)/\bar{X}_0$ denotes the percentage change in the variable's steady-state value, and $\hat{\bar{B}}$ is normalized by initial consumption since $\bar{B}_0 = 0$.

I.E. Solving for the Steady State

To solve for the steady state we have to note that equations (26)–(36) hold at all points in time, thus also for steady-state changes. Together with equation (37) and the respective foreign analogs these yield a system of 22 simultaneous equations in 24 barred variables which can be solved quite easily by making use of the model's symmetry. This approach requires solving first for differences between per capita variables – which yields three equations for each variable due to the three possible combinations (X1-X2, X1-X3, X2-X3) – and then for population-weighted world aggregates[23]. Following this and making use of equations (29)–(31) and (32), (35), (37) together with their foreign analogs, the difference between steady-state (percent) consumption changes of country 1 and country 2 can be written as a function of the differences in net foreign asset and government spending changes:

$$\hat{\bar{C}}1 - \hat{\bar{C}}2 = \frac{1+q}{2q}\left[\bar{r}\left(\hat{\bar{B}}1 - \hat{\bar{B}}2\right) - \left(\hat{\bar{G}}1 - \hat{\bar{G}}2\right)\right]. \tag{38}$$

(Of course, two equivalent equations apply to the consumption differentials between country 1 and 3 and between country 2 and 3 but are left out to save space, as will always be done from now on.) Similar manipulations lead to the steady-state change in the terms of trade of country 1 vis-à-vis country 2 which is then given by

$$\hat{\bar{p}}(1) - \hat{\bar{E}}12 - \hat{\bar{p}}(2) = \frac{1}{2q}\left[\bar{r}\left(\hat{\bar{B}}1 - \hat{\bar{B}}2\right) - \left(\hat{\bar{G}}1 - \hat{\bar{G}}2\right)\right]. \tag{39}$$

By aggregating equation (35) and combining it with (36) we get a relationship between steady-state world consumption and steady-state world income:

$$\hat{\bar{y}}^W = \frac{1}{2}\hat{\bar{G}}^W, \tag{40}$$

$$\hat{\bar{C}}^W = -\frac{1}{2}\hat{\bar{G}}^W. \tag{41}$$

A permanent rise in world government spending raises steady-state world output, since the individuals on the aggregate level respond by substituting into work and out of leisure. For the same reason, world consumption falls by less than the rise in world government spending (partial crowding-out). Given the solutions for differences and world aggregates, the changes in steady-state values of individual variables can be found by making use of the identities $\hat{X}1 = \hat{X}^W + \left(n_2 - n_1\right)\left(\hat{X}1 - \hat{X}2\right) + \left(1 - n_2\right)\left(\hat{X}1 - \hat{X}3\right)$ and $\hat{X}2 = \hat{X}^W - n_1\left(\hat{X}1 - \hat{X}2\right) + \left(1 - n_2\right)\left(\hat{X}2 - \hat{X}3\right)$ and $\hat{X}3 = \hat{X}^W - n_1\left(\hat{X}1 - \hat{X}3\right) - \left(n_2 - n_1\right)\left(\hat{X}2 - \hat{X}3\right)$. Combining (38) with the corresponding expression for $\hat{\bar{C}}1 - \hat{\bar{C}}3$ and (41) in this way yields

[23] This solution approach has been introduced by Aoki (1981).

$$\hat{\bar{C}}1 = \left(\frac{1+q}{2q}\right)\bar{r}\hat{\bar{B}}1 - \left(\frac{1-n_1+q}{2q}\right)\hat{\bar{G}}1 + \left(\frac{n_2-n_1}{2q}\right)\hat{\bar{G}}2 + \left(\frac{1-n_2}{2q}\right)\hat{\bar{G}}3. \qquad (42)$$

Equations (38), (39) and (42) show that any country's per capita consumption and terms of trade rise or improve when it receives a transfer of wealth – in the form of increased net foreign asset holdings – and deteriorate or fall when the home government increases its spending relative to the foreign governments. The former is due to the permanently higher interest income received from increased asset holdings, while the latter stems from the fact that, according to the individual's budget constraint, higher government spending in the home country has to be borne fully by home residents, whereas the benefits – in the form of higher demand and output – fall on foreigners as well. In the home country, however, the positive output effect is more than offset by the increased tax burden, thereby inducing private consumption to fall, but to fall by less than the associated tax increase.

Moreover, we can observe that – with flexible prices – real steady-state world aggregates, like steady-state world output and world consumption, are determined independent of monetary factors, which establishes the classical result of long-run monetary neutrality on a world-wide level in this model. On a country level, however, we have a long-run non-neutrality of monetary policy, which is due to the permanently higher interest income in one of the countries induced by the international transfer of wealth. The solution for changes in the steady state price level follows directly from the linearized money-demand equation (34), imposing zero inflation and constant interest rates across steady states:

$$\hat{\bar{P}} = \hat{\bar{M}} - \hat{\bar{C}}. \qquad (43)$$

II. Short-Run Dynamics with Preset Prices

So far, we have investigated only the long-run equilibrium behavior of the model. In this section we want to turn to the short-run disequilibrium dynamics following unanticipated monetary and fiscal shocks. Before doing this, let's introduce one further assumption, namely short-run nominal price rigidity. For this purpose, assume that the prices of representative domestic and foreign goods, i.e. p(1), p(2), p(3), are set one period in advance but adjust only in the second period, absent new shocks[24]. Thus, what this eventually amounts to can be described as monopoly with lagged (by one period) price setting behavior. In order to rationalize the underlying source of price stickiness, which will not be explicitly modeled here, we could refer to the menu cost approach of Mankiw (1985) and Akerlof and Yellen (1985). One important implication of the assumption of preset nominal prices is the finding that output becomes demand determined in the short-run, since producers in a monopolistic market, who set prices above marginal cost, will – for small enough shocks – find it profitable to meet additional surprise demand at these prices[25].

[24] Alternatively, one could allow for richer price adjustment mechanisms, like staggered price setting, which would just lead to a longer persistence of nominal shocks without modifying the central results of our analysis. In Woodford (1996), for example, only a fraction of producers adjust their prices every period, while the rest keep their actual prices also in the following period.

[25] This is also the reason why monetary shocks have real effects in our setup.

In the short-run, therefore, output is determined entirely by the demand equation (32), whereas (35), equating marginal cost and marginal revenue, does not bind in the short run.

In this section we will examine the effects of one-time unanticipated monetary and fiscal shocks on exchange rates, the current account and other key variables. In order to find simple analytical solutions, we shall assume that the system will reach the new long-run steady state just one period after the shock has occurred, because that is how long nominal prices take to adjust. Hence, the first period can be interpreted as the short-run disequilibrium response and the second period as the long-run equilibrium response to some exogenous policy shock. This allows us to simplify the notation from now on by dropping time subscripts completely, with barred variables denoting long-run (period 2 and beyond) variables and variables without bars denoting short-run (period 1) variables.

One further difference between the short-run disequilibrium and the long-run equilibrium is that in the period when a shock occurs, the current accounts need not be balanced, whereas in the steady state (22) must hold for each country. Thus, in the short run a country's per capita current account imbalance is given by

$$B_{t+1} - B_t = r_t B_t + \frac{p_t y_t}{P_t} - C_t - G_t . \tag{44}$$

Log-linearizing this short-run current account equation for country 1 yields

$$\hat{\bar{B}}1 = \hat{y}1 - \hat{C}1 - (1-n_1)\hat{E}12 - (1-n_2)\hat{E}23 - \hat{G}1 \tag{45}$$

where we have made use of equation (26) and of the fact that p(1), p(2) and p(3) are preset in the short run, implying $\hat{p}(1) = \hat{p}(2) = \hat{p}(3) = 0$. Furthermore, in deriving equation (45) we imposed the assumption that $B_0 = 0$ which implies that also $B_1 = 0$ and $B_2 = \hat{\bar{B}}$.

II.A. Solving the Short-Run System in Terms of Monetary and Fiscal Shocks

Now we want to solve the model for short-run variables like exchange rates, consumption differentials, the first-period current accounts and the world real interest rate as functions of monetary and fiscal policy shifts, in order to investigate the effects of the policy shifts on these variables. The policy shocks we will consider are temporary and permanent changes to the relative money supply (e.g. $\hat{M}1 - \hat{M}2$ for temporary and $\hat{\bar{M}}1 - \hat{\bar{M}}2$ for permanent shocks) as well as temporary and permanent changes to relative government spending (e.g. $\hat{G}1 - \hat{G}2$ and $\hat{\bar{G}}1 - \hat{\bar{G}}2$ as before).

II.A.1. Graphical Interpretation of the Exchange Rate

An interesting feature of the model is that the effects of macroeconomic policy shifts on the exchange rate can be analyzed also graphically. For this purpose, we need to derive two equations giving the exchange rate as a function of consumption differentials and the monetary and fiscal policy shocks. To derive the first equation, which we label MM schedule, we need to combine the money demand equation (34) with the consumption Euler equation (33)[26]. As a first step, subtracting the consumption Euler equation (27) of, say, country 2 from the corresponding equation of country 1 yields:

$$\hat{\bar{C}}1-\hat{\bar{C}}2=\hat{C}1-\hat{C}2\,. \tag{46}$$

Equation (46) shows that all shocks have permanent effects on the consumption differential between the two countries, which stems from the fact that residents in both countries face the same real interest rate. Analogously, subtract the money demand equation of country 2 from the corresponding equation of country 1[27], lead it by one period, combine the resulting expression with (46) and substitute it for $\hat{\bar{E}}12$ into the original equation (of footnote 27) to obtain the MM schedule:

$$\hat{E}12=-\left(\hat{C}1-\hat{C}2\right)+\frac{\bar{r}}{1+\bar{r}}\left[\left(\hat{M}1-\hat{M}2\right)+\frac{1}{\bar{r}}\left(\hat{\bar{M}}1-\hat{\bar{M}}2\right)\right]. \tag{47}$$

The MM schedule in Figure 1 has slope -1 and is downward sloping because an increase in relative consumption in country 1 also raises relative money demand in this country, requiring the price level to fall to restore equilibrium in the money market, thus inducing an appreciation of the currency of country 1 vis-à-vis the currency of country 2.

A second relation between the exchange rate on the one hand, and the consumption differential and monetary and fiscal policy shocks on the other hand, labeled GG schedule, is obtained by combining essentially two expressions giving the above variables as functions of net-foreign asset positions. Subtract the short-run current account equation (45) of country 2 from the corresponding equation of country 1, eliminate the output differential by making use of country 1 and country 2 versions of the demand equation (32) – with p(1) and p(2) preset – and eliminate the short-run current account differential with the help of equation (38), additionally, making use of (46) to eventually find the GG schedule:

$$\hat{E}12=\frac{2q+(1+q)\bar{r}}{\left(q^{2}-1\right)\bar{r}}\left(\hat{C}1-\hat{C}2\right)+\frac{1}{q-1}\left[\left(\hat{G}1-\hat{G}2\right)+\frac{1}{\bar{r}}\left(\hat{\bar{G}}1-\hat{\bar{G}}2\right)\right]. \tag{48}$$

The GG schedule has a positive slope because in the short run relative consumption of country 1 must rise, if relative output of country 1 rises, which again is only possible if relative demand for output of country 1 is increased as a consequence of a depreciation of the exchange rate of country 1 vis-à-vis country 2.

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[26] We follow the labeling introduced by Obstfeld and Rogoff (1995), who obviously intended to build a bridge to the textbook Mundell-Fleming model, where, analogous to our MM schedule, the LM schedule also represents equilibrium in the money market.

[27] This yields $\left(\hat{M}1-\hat{M}2\right)-\hat{E}12=\left(\hat{C}1-\hat{C}2\right)-\frac{1}{\bar{r}}\left(\hat{\bar{E}}12-\hat{E}12\right)$, which is virtually identical to the central equation of the flexible-price Cagan-type monetary model, except that here consumption differentials appear in place of output differentials in the monetary model.

We can observe from equations (47) and (48) that it is the discounted sum of present and future monetary and fiscal shocks rather than their temporary or permanent values alone, that determine the post-shock path of the exchange rate. For the purpose of our graphical analysis, however, assume that all shocks are permanent, thus implying that $\hat{M}1-\hat{M}2=\hat{\bar{M}}1-\hat{\bar{M}}2$ and $\hat{G}1-\hat{G}2=\hat{\bar{G}}1-\hat{\bar{G}}2$. From (47) it then follows that $\hat{E}12=\hat{\bar{E}}12$, i.e. the exchange rate jumps immediately to its new long-run level following a permanent relative money supply shock[28]. Let us now consider monetary and fiscal shocks separately in order to isolate the effects of the two types of shocks. In Figure 1, which displays the effects of a relative rise in the money supply of country 1 vis-à-vis country 2, the initial pre-shock MM schedule shifts upward when the shock occurs, with the intersection of M'M' and GG representing the new short- and also long-run equilibrium. We can observe that the exchange rate of country 1 depreciates, but by an amount proportionally smaller than the relative money supply increase (see also equation (49)). The reason for this is that – as Figure 1 suggests – also relative consumption of country 1 must rise, which again is due to the temporary rise in relative income of country 1 caused by the depreciation.

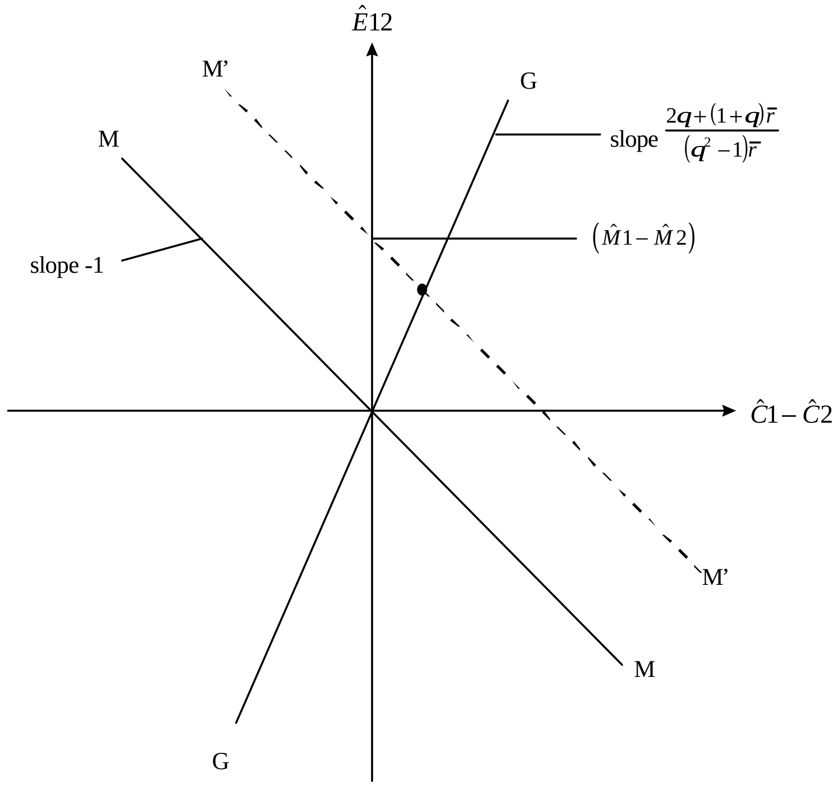

Figure 1: A permanent (positive) relative money supply shock

[28] There is no exchange-rate overshooting à la Dornbusch in this model. In Obstfeld and Rogoff (1996, Chapter 10) a variant of this model, including non-traded goods, is considered where overshooting can occur.

In Figure 2 we examine the short-run effects of a permanent shock to relative government spending. As the dynamics in this Figure suggest, a relative rise in government spending of country 1 leads to a decrease in the relative consumption of country 1 and at the same time to a decrease in money demand in this country. Lower money demand – together with constant money supply, i.e. $\hat{M}1 - \hat{M}2 = 0$ – requires the price level of country 1 to increase to restore equilibrium in the money market, thus inducing the exchange rate of country 1 vis-à-vis country 2 to depreciate. The reason why the consumption differential declines here in the short as well as in the long run has already been discussed in I.E.

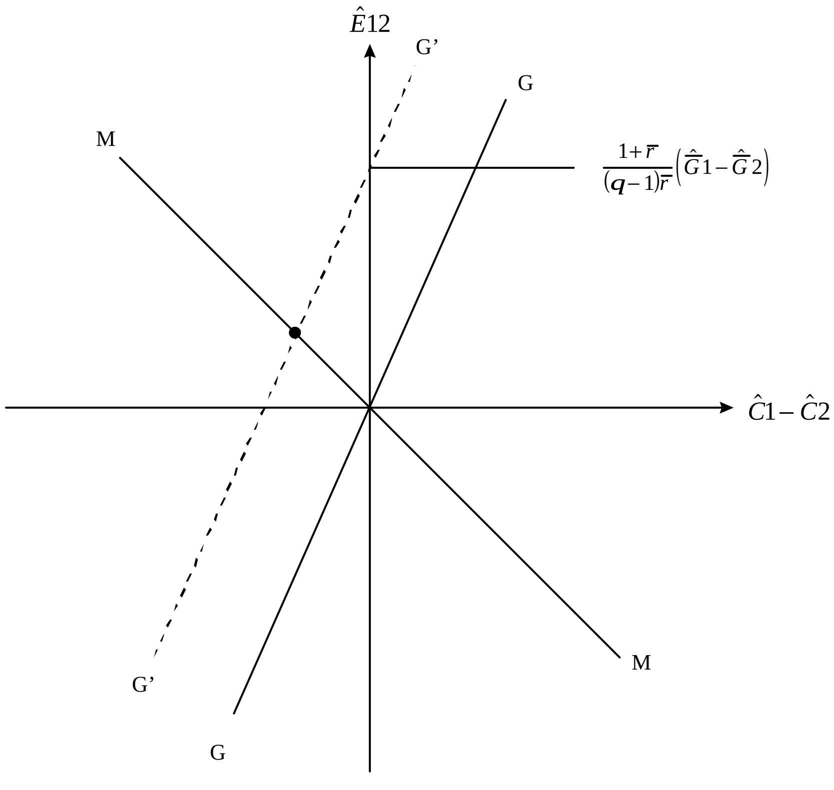

Figure 2: A permanent (positive) relative government spending shock

II.A.2. Analytical Solution of the Model for Exchange Rates, Consumption Differentials, Current Accounts, Terms of Trade, and the World Real Interest Rate

To solve for the short-run change in the exchange rate of country 1 vis-à-vis country 2 as a function of the monetary and fiscal policy shocks we have to combine equations (47) and (48). In addition, let's assume from now on that money supply shocks are permanent, i.e. $\hat{M}1 - \hat{M}2 = \hat{\overline{M}}1 - \hat{\overline{M}}2$, while allowing for temporary and permanent government spending shocks. Analogous manipulations lead to the corresponding expressions for the exchange rate between country 1 and country 3 and between country 2 and country 3:

$$\hat{E}12 = \frac{(1+q)\bar{r}+2q}{(1+q)q\bar{r}+2q}\left(\hat{M}1-\hat{M}2\right)+\frac{(1+q)\bar{r}}{(1+q)q\bar{r}+2q}\left[\left(\hat{G}1-\hat{G}2\right)+\frac{1}{\bar{r}}\left(\hat{\hat{G}}1-\hat{\hat{G}}2\right)\right], (49)$$

$$\hat{E}13 = \frac{(1+q)\bar{r}+2q}{(1+q)q\bar{r}+2q}\left(\hat{M}1-\hat{M}3\right)+\frac{(1+q)\bar{r}}{(1+q)q\bar{r}+2q}\left[\left(\hat{G}1-\hat{G}3\right)+\frac{1}{\bar{r}}\left(\hat{\hat{G}}1-\hat{\hat{G}}3\right)\right], (50)$$

$$\hat{E}23 = \frac{(1+q)\bar{r}+2q}{(1+q)q\bar{r}+2q}\left(\hat{M}2-\hat{M}3\right)+\frac{(1+q)\bar{r}}{(1+q)q\bar{r}+2q}\left[\left(\hat{G}2-\hat{G}3\right)+\frac{1}{\bar{r}}\left(\hat{\hat{G}}2-\hat{\hat{G}}3\right)\right]. (51)$$

The finding, that the exchange rate between country A and B is determined exclusively by monetary and fiscal parameters of these two countries, is due to the fact that we are considering only equilibria that are completely symmetric across all countries. Asymmetric equilibria would yield expressions with much more complex policy combinations as determinants of the exchange rate between any two countries. Next, we combine equations (47) and (49) to solve for the difference between (short- and long-run) changes in per capita consumption in country 1 and country 2:

$$\hat{C}1-\hat{C}2 = \frac{\left(q^2-1\right)\bar{r}}{(1+q)q\bar{r}+2q}\left(\hat{M}1-\hat{M}2\right)-\frac{(1+q)\bar{r}}{(1+q)q\bar{r}+2q}\left[\left(\hat{G}1-\hat{G}2\right)+\frac{1}{\bar{r}}\left(\hat{\hat{G}}1-\hat{\hat{G}}2\right)\right]. (52)$$

To find the short-run current account of, say, country 1 – which here equals the long-run change in net-foreign assets of country 1 – we proceed as follows: Subtract a country 2 version of (45) from (45), make use of country 1 and country 2 versions of the demand equation (32), imposing preset prices, and substitute equations (49) and (52) into the resulting expression to obtain an expression for the current account differential between country 1 and 2, $\hat{\hat{B}}1-\hat{\hat{B}}2$. Next, find the corresponding expression for $\hat{\hat{B}}1-\hat{\hat{B}}3$, remember that $\hat{\hat{B}}^W = 0$, and plug these expressions into the identity we already used in deriving equation (42) and, finally, assume – for simplicity – that the government spending shock is permanent to obtain

$$\hat{\hat{B}}1 = \frac{(q-1)}{(1+q)\bar{r}+2}\left[\left(1-n_1\right)\left(2\hat{M}1+\hat{G}1\right)-\left(n_2-n_1\right)\left(2\hat{M}2+\hat{G}2\right)-\left(1-n_2\right)\left(2\hat{M}3+\hat{G}3\right)\right]. (53)$$

We can observe from (53) that monetary and fiscal expansions in country 1 tend to drive the short-run current account of country 1 into surplus, while fiscal and monetary expansions in country 2 and 3 tend to drive it into deficit. For the simple case of a permanent monetary or fiscal expansion in country 1 vis-à-vis country 2 – which we considered in the graphical analysis of the previous subsection – the interpretation goes that the depreciation of the currency of country 1 temporarily raises relative income of country 1 so that it runs a current account surplus with country 2, due to consumption smoothing behavior of country 1 residents[29]. Furthermore, equation (53) indicates that the size of the current account imbalance is dependent on the relative size of the countries, with larger countries' current accounts being affected less by monetary and fiscal shocks than the current accounts of smaller countries.

[29] A temporary expansion, on the other hand, leads to a current account deficit in the expanding country. For a thorough discussion of this point see Obstfeld and Rogoff (1995).

By substituting the expression for $\hat{\bar{B}}1-\hat{\bar{B}}2$, which we already derived above, into (39) we can express the change in the long-run terms of trade of country 1 vis-à-vis country 2 as a function of the monetary and fiscal policy disturbances:

$$\hat{\bar{p}}(1)-\hat{\bar{E}}12-\hat{\bar{p}}(2)=\frac{(\theta-1)\bar{r}}{(1+\theta)\theta\bar{r}+2\theta}\left(\hat{M}1-\hat{M}2\right)-\frac{\bar{r}}{(1+\theta)\theta\bar{r}+2\theta}\left[\left(\hat{G}1-\hat{G}2\right)+\frac{1}{\bar{r}}\left(\hat{\bar{G}}1-\hat{\bar{G}}2\right)\right].\quad(54)$$

A (positive) relative monetary shock emanating from country 1 generates an improvement in its long-run terms of trade vis-à-vis country 2, whereas a (positive) relative government spending shock in country 1 generates a fall in its terms of trade. By comparing (54) with equation (49), which gives (the negative value of) the short-run change in the terms of trade of country 1, since p(1) and p(2) are preset in the short run, we can see that the long-run change is an order of magnitude smaller than the short-run change and that the short-run and the long-run terms of trade effects go in opposite directions.

To see how monetary and fiscal expansions affect the short-run world real interest rate, aggregate the consumption Euler equation (33) over all individuals, plug (41) into the resulting expression and combine it with an aggregated version of the money demand equation (34), after making use of equations (26)–(28) and (36) as well as of country 1,2 and 3 versions of (43) and imposing preset prices, to eventually obtain:

$$\hat{r}=-\left(\frac{1+\bar{r}}{\bar{r}}\right)\left(\hat{M}^{W}+\frac{1}{2}\hat{\bar{G}}^{W}\right)\qquad(55)$$

where also $\hat{M}^{W}=n_1\hat{M}1+\left(n_2-n_1\right)\hat{M}2+\left(1-n_2\right)\hat{M}3$.

A monetary as well as fiscal expansion emanating from either country temporarily lowers world real interest rates in proportion to the size of the expanding country. This implies that short-run world consumption expands following a monetary expansion and remains constant following a fiscal expansion. One further implication of (55) is the finding that only permanent government spending shocks affect the short-run real interest rate, while temporary changes in world government spending have no liquidity effect.

Finally, we solve for the impact of permanent monetary and fiscal shocks on the short-run change in per capita output of country 1 by effecting a manipulation similar to the one that led to (53):

$$\hat{y}1=\frac{1}{(1+\theta)\bar{r}+2}\begin{bmatrix}\left((1+\theta)\bar{r}+2\left[n_1(1-\theta)+\theta\right]\right)\hat{M}1+\left((1+\theta)\left(\bar{r}+1-n_1\right)+2n_1\right)\hat{G}1\\+\left(n_2-n_1\right)(1-\theta)\left(2\hat{M}2+\hat{G}2\right)+\left(1-n_2\right)(1-\theta)\left(2\hat{M}3+\hat{G}3\right)\end{bmatrix}.\quad(56)$$

Interestingly, equation (56) indicates that a unilateral foreign (country 2 or 3) monetary or fiscal expansion has a negative net effect on output of country 1 (as $\theta > 1$), since with relatively increased consumption levels (from 52) the home individuals can afford to substitute out of work and into leisure to maintain a constant level of utility.

III. Discussion

To analyze the effects of a monetary union, we compare our three-country world economy with respect to monetary and fiscal policy impulses under two different regimes. The first regime describes a situation in which three independent countries with independent monetary and fiscal authorities coexist. In this case, the three bilateral exchange rates fully display their role as a stabilizing force and as channels of transmission of the monetary and fiscal shocks. In the second regime two of the three countries form a monetary union with a common monetary authority but still independent fiscal authorities[30]. A monetary union between country 1 and country 2 implies that the internal exchange rate becomes irrevocably fixed and that, by definition, the exchange rates of country 1 vis-à-vis country 3 and of country 2 vis-à-vis country 3 coincide and represent what is then called the external exchange rate. Under this regime, the external exchange rate can still adjust in response to monetary and fiscal shocks that emanate from the two remaining economic blocs.

We will first discuss the international implications of stylized monetary and fiscal impulses under the regime of three completely independent countries. In what follows, we will assume – for convenience – that the relative size of the countries Germany, France and the USA are ¼, ¼, ½ Obviously, our model is very restrictive in analyzing different types of monetary and fiscal shocks, since the long-run equilibrium is assumed to prevail at all times, except for the period when a one-time unanticipated policy shock hits the economy. Thus, the path of most of the key economic variables is disturbed just for a single period. Although we surely know that this is a rather crude and unrealistic way of introducing monetary and fiscal disturbances, we can nevertheless justify this approach by arguing that our analysis is aimed at merely giving some indication of the mechanisms at work and of the direction rather than the exact magnitude of the impact of monetary and fiscal shocks. Hence, following the design of our model, we explicitly assume that the policy shocks we are going to analyze in this section are unanticipated, permanent and non-recurring. The stylized monetary and fiscal policy shocks, which will be defined below as policy combinations of the three countries conditional on the prevailing regime, will also be defined in an "empirically relevant" way, i.e. inspired by real-world observations during the past few years. So, if the model is correct, it should provide also "empirically relevant" results.

III.A. Before the Monetary Union (Three Independent Countries)

When the three countries are completely independent, one could find various combinations of monetary and fiscal policy shocks that generate all kinds of effects on the exchange rates, consumption differentials, current accounts, etc. We restrict the possible combinations of policy shocks by trying to incorporate the idea of the European integration into our analysis, i.e. the economies of France and Germany are more integrated than either of these with the US economy. For this reason and due to related factors, like the constraints imposed by the

[30] We have chosen this most general formulation of a monetary union. More specifically, one could interpret the first regime as a stylized representation of the EMS period where the internal exchange rates of the EU countries were allowed to float, within certain pre-specified bands, of course. The second regime, on the other hand, can be interpreted as a stylized representation of the EMU once completed and replacing the EMS.

Maastricht criteria and the EMS, there is little scope for asymmetric fiscal and monetary policy shocks in these two countries. We will account for this in the definition of the stylized monetary and fiscal policy shocks below.

The effects of international transmissions of general monetary and fiscal shocks for the case of three independent countries have already been discussed in the previous section. The difference is that here we consider stylized monetary and fiscal policies, which we assume to be as follows: Germany pursues a very tight monetary policy followed by France ("Franc fort") and the USA, so that the following differentials are all negative and $\hat{M}1 - \hat{M}2 > \hat{M}2 - \hat{M}3 > \hat{M}1 - \hat{M}3$. On the other hand, the fiscal policy is assumed to be tightest in the USA followed by Germany and France, so that $\hat{G}2 - \hat{G}3 > \hat{G}1 - \hat{G}3 > \hat{G}1 - \hat{G}2$, with the former two differentials being positive and the latter small (Maastricht criteria) and negative[31]. Note again, that monetary and fiscal policies are of this form only once, namely in the period when the shock occurs, while in all other periods all exogenous variables are assumed to be constant. The framework of our model unfortunately prevents the analysis of other types of shocks, like perturbations to the growth path of fiscal and monetary variables.

Given the stylized monetary and fiscal policies as defined above, let us first consider the effects on the three exchange rates: Evaluating equations (49), (50) and (51) according to our stylized policy shocks one obtains an appreciation of the German currency versus the French currency, an appreciation of the German versus the American currency and, in general, an ambiguous net-effect on the third exchange rate. For reasonable parameter values, however, we get a slight depreciation of the French versus the American currency. Furthermore, the appreciation of the Dmark vis-à-vis the Franc turns out to be an order of magnitude smaller than the appreciation of the Dmark vis-à-vis the Dollar. Likewise, for the (short- and long-run) difference between German and French per capita consumption changes the net-effect due to our stylized monetary and fiscal shocks is ambiguous, which can easily be seen from (52). Again considering reasonable parameter values for θ and β, the effect on the consumption differential of Germany and France becomes positive and rather small, though, i.e. per capita consumption is increased slightly more in Germany than in France. On the other hand, per capita consumption differentials between Germany and the USA and between France and the USA are found to be clearly negative, which implies that per capita consumption expands most in the USA, followed by comparatively small changes in Germany and France.

The effect of our monetary and fiscal policy shocks on the German current account can be found by evaluating equation (53): In general, the effect on the German current account is ambiguous, but turns out to be negative for reasonable parameter values. Moreover, the USA runs a current account surplus as a consequence of our stylized shocks, while the effects on the French current account of the monetary shock, which tends to drive it into deficit, and the fiscal shock, which tends to drive it into surplus, largely compensate each other, so that the net-effect is ambiguous

[31] In contrast to the graphical analysis, we'll now analyze the effects of monetary and fiscal policy shocks jointly and not separately.

and rather small. Last but not least, evaluating (56) gives us the short-run effect of the monetary and fiscal shocks on real per capita output in Germany: Hence, German output is expected to increase as a result of our stylized policy shocks. By exploring also the respective expressions for the other countries' output as well as the expressions for short-run output differentials, we observe that also French and American real output should increase, with French output expanding most followed by US output and – far behind – German output.

III.B. A Two-Country Monetary Union

The interesting part, however, is to analyze the implications of a monetary union on the international transmission of monetary and fiscal policies. For this purpose, we assume that two of the three countries decide to form a monetary union, i.e. to share a common currency. This includes assuming that a common monetary authority is responsible for the management of the common currency, while there is, in principle, no particular need to completely synchronize fiscal policies in the two countries. It is, however, desirable to achieve a certain degree of economic convergence within the monetary union, including also government debt levels, for the monetary union to be effective. This implies that fiscal policies should not be left at the complete discretion of the national governments, but should be restricted to be more or less symmetric in order to achieve convergence in debt levels[32]. In terms of our model, assuming a two-country monetary union implies that we fix the internal exchange rate, while the external exchange rate is still free to adjust in response to asymmetric fiscal and monetary shocks[33]. Asymmetric monetary policy is now possible only between the monetary union and the third country, since the common monetary authority centralizes the monetary policy for the whole monetary union. Asymmetric fiscal policy, on the other hand, is of course possible between the monetary union and the third country but also within the monetary union, in a very restricted way, though.

In order to be able to analyze the international transmissions of monetary and fiscal policy shocks under the new regime, we first have to incorporate the modifications for the case of a monetary union into our three-country model. Specifically, we assume that country 1 and country 2 (Germany and France) form a monetary union by fixing the internal exchange rate, E12. In this case it is convenient to normalize the internal exchange rate to 1, which implies that the exchange rates of country 1 and 2 vis-à-vis country 3 now coincide and equal the external exchange rate. The latter can be verified by combining equations (5), (6) and (7) to obtain the relation E13 = E12E23, so that, if E12 = 1, it follows that E13 = E23[34]. Normalizing the internal exchange rate to 1 can also be interpreted as adopting a common currency, which we call "Euro", with the

[32] In the case of the EMU the so called "stability pact" has been adopted which is intended to impose a restriction on the fiscal deficits of the participating countries in order to keep the debt levels in line and to avoid countries running unsustainable deficits.

[33] In denoting the bilateral exchange rate of the countries which form the monetary union "internal exchange rate" and the exchange rate of the currency of the monetary union and the third country's currency "external exchange rate" we follow van Aarle, Garretsen and van Moorsel (1998).

[34] One further consequence of assuming E12 = 1 is that $\hat{E}12 = 0$, which again confirms that a depreciation of the internal exchange rate is no longer feasible.

external exchange rate representing the new Euro/Dollar rate, simply denoted by E (instead of E13 or E23).

What are the consequences of establishing a two-country monetary union in terms of our model? From (4) and (5) we can see that purchasing power parity implies that the price levels in the two countries become identical:

$$P1 = \left[\int_0^{n_2} p1(z)^{1-q} dz + \int_{n_2}^{1} \left[Ep3(z) \right]^{1-q} \right]^{\frac{1}{1-q}} = P2 = EP3 . \tag{57}$$

From the fact that in the case of a monetary union $\hat{E}12 = 0$ and $\hat{M}1 - \hat{M}2 = 0$, since asymmetric monetary shocks between country 1 and 2 are no longer possible, it immediately follows that the short- as well as long-run per capita consumption and consequently also output differentials, $\hat{C}1 - \hat{C}2$, $\hat{\bar{C}}1 - \hat{\bar{C}}2$, $\hat{y}1 - \hat{y}2$ and $\hat{\bar{y}}1 - \hat{\bar{y}}2$, are all equal to zero. Exploring the model further and taking these results into account, we observe that also $\left(\hat{G}1 - \hat{G}2\right) + \frac{1}{\bar{r}}\left(\hat{\bar{G}}1 - \hat{\bar{G}}2\right)$ is equal to zero, which implies that in either case, for temporary and permanent government spending shocks, we have $\hat{G}1 - \hat{G}2 = 0$ and $\hat{\bar{G}}1 - \hat{\bar{G}}2 = 0$ and therefore also $\hat{\bar{B}}1 - \hat{\bar{B}}2 = 0$. The important implication of the previous result is the fact that, although the two governments could, in principle, pursue divergent fiscal policies, they don't do it, but instead fully synchronize their government spending. Why do the governments act this way? If we subtract the overall resource constraint of the economy of country 2 – as indicated in footnote 15 – from the corresponding expression of country 1 and make use of the above results, stating that the two countries are completely symmetric in consumption and output levels in all periods, we get the relation:

$$\left(1 + r_t\right)\left(B_t 1 - B_t 2\right) = \sum_{s=t}^{\infty} R_{t,s}\left(G_s 1 - G_s 2\right). \tag{58}$$

Equation (58) states that the present discounted value of all future differential government spending levels (in a two-country monetary union) has to equal the difference in their initial net-foreign asset positions. This implicitly follows from the assumption of Ricardian equivalence in our model, which ensures that government budgets have to be balanced in the long run, and, therefore, also the differential government spendings in a federal state (or a monetary union) have to be zero in the very long run. Log-linearizing (58) and making use of the usual assumption, $\bar{B}_0 1 = \bar{B}_0 2 = 0$, yields

$$\hat{B}_t 1 - \hat{B}_t 2 = \frac{1}{1+\bar{r}} \sum_{s=t}^{\infty} \left(\frac{1}{1+\bar{r}} \right)^{s-t} \left(\hat{G}_s 1 - \hat{G}_s 2 \right). \tag{59}$$

This implies that, in principle, the two governments could run divergent fiscal policies in any period, given that the differential government spendings are balanced by future differentials of the opposite sign, such that the discounted infinite sum of these differentials equals the initial net-foreign asset differential – which in our case is assumed to be zero. Thus, evaluating (59) under the assumption that the system reaches the new steady state following an unanticipated government spending shock after one period and remembering that $B_0 = 0$ and $B_1 = 0$, we get (to confirm the above result)

$$0 = \left(\hat{G}1 - \hat{G}2\right) + \frac{1}{\bar{r}}\left(\hat{\overline{G}}1 - \hat{\overline{G}}2\right). \tag{60}$$

Hence, the key finding of this paper follows that, according to our model, the countries forming a monetary union become completely symmetric also with respect to the dynamics following monetary and fiscal policy shocks which, both, can no longer be asymmetric. The intuition is that, when exogenously fixing the exchange rate and restricting monetary policy to be symmetric, fiscal policy in the two countries becomes the endogenous variable which has to adjust in order to keep the exchange rate fixed[35]. In fact, the three-country model collapses to a two-country model as a consequence of establishing a monetary union, with the monetary union and the third country now representing the remaining two countries in the model. This is, indeed, what politicians expect the EMU to amount to, when they proclaim that it represents the completion and crowning of the European Internal Market.

Now let us consider the effects of monetary and fiscal policy shocks on various economic variables for the case of a monetary union. For reasons we have already explored above, asymmetric monetary and fiscal policy shocks are only feasible between the monetary union as a whole and the third country. Paralleling our analysis of section II, we observe that these asymmetric policy shocks affect the world-wide distribution of wealth and consequently lead to asymmetric adjustment dynamics of the key economic variables in the remaining two economic blocs. In particular, we want to explore the effects of asymmetric monetary and fiscal shocks on the short-run dynamics of the exchange rate, the current account and the long-run terms of trade. Modifying equations (50) – or (51) -, (53) and a country 1-3 or 2-3 version of (54) for the case of a monetary union, yields

$$\hat{E} = \frac{(1+\boldsymbol{q})\bar{r} + 2\boldsymbol{q}}{(1+\boldsymbol{q})\boldsymbol{q}\bar{r} + 2\boldsymbol{q}}\left(\hat{M}E - \hat{M}3\right) + \frac{(1+\boldsymbol{q})\bar{r}}{(1+\boldsymbol{q})\boldsymbol{q}\bar{r} + 2\boldsymbol{q}}\left[\left(\hat{G}E - \hat{G}3\right) + \frac{1}{\bar{r}}\left(\hat{\overline{G}}E - \hat{\overline{G}}3\right)\right], \tag{61}$$

$$\hat{\overline{B}}E = \frac{\left(1-n_2\right)(\boldsymbol{q}-1)}{(1+\boldsymbol{q})\bar{r} + 2}\left[2\left(\hat{M}E - \hat{M}3\right) + \left(\hat{G}E - \hat{G}3\right)\right], \tag{62}$$

$$\hat{\overline{p}}(E) - \hat{\overline{E}} - \hat{\overline{p}}(3) = \frac{(\boldsymbol{q}-1)\bar{r}}{(1+\boldsymbol{q})\boldsymbol{q}\bar{r} + 2\boldsymbol{q}}\left(\hat{M}E - \hat{M}3\right) - \frac{\bar{r}}{(1+\boldsymbol{q})\boldsymbol{q}\bar{r} + 2\boldsymbol{q}}\left[\left(\hat{G}E - \hat{G}3\right) + \frac{1}{\bar{r}}\left(\hat{\overline{G}}E - \hat{\overline{G}}3\right)\right] \tag{63}$$

where $\hat{E}$ denotes the change in the Euro/Dollar exchange rate and $\hat{M}E$, $\hat{G}E$, $\hat{\overline{B}}E$ and $\hat{\overline{p}}(E)$ denote the changes in the monetary union's (E for European) money supply, government spending, net-foreign assets and representative good's price.

We can repeat now the interesting experiment of investigating the effects of stylized monetary and fiscal policy shocks, as we did in the previous subsection. Of course, the stylized monetary and fiscal policies have to be redefined for the case of a monetary union: We assume that the authorities in the monetary union pursue monetary and fiscal policies that are somehow an average

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[35] This is similar to the result obtained in the Mundell-Fleming model under fixed exchange rates, where monetary policy becomes ineffective since it is constrained to adjust in order to maintain monetary equilibrium.

mix of the former German and French policies, that is to say, that the monetary union runs a tighter monetary policy but easier fiscal policy than the USA. This is equivalent to assuming that the differential of monetary policies, $\hat{M}E - \hat{M}3$, is negative and that the differential of fiscal policies, $\hat{G}E - \hat{G}3$, is positive, with the two differentials being of approximately equal size.

An interesting question that is frequently asked in the current discussion about EMU is, if the Euro is more likely to appreciate or depreciate vis-à-vis the Dollar, assuming that current policy stances are perpetuated into the future. Given our stylized monetary and fiscal policies – which we do not consider too far from reality -, we find that, by evaluating (61), the Euro should appreciate slightly vis-à-vis the Dollar in response to the stylized policy shocks. The net-effect of the two counteracting policies on $\hat{E}$ is negative, because, according to (61), the impact of monetary policy on the exchange rate is stronger than the impact of fiscal policy. Evaluating also (62) with respect to our stylized policy shocks indicates that the appreciation of the Euro leads to a current account deficit in the monetary union in the short run – which equals the long-run change in the union's net-foreign asset position. Finally, by evaluating (63) we realize that the effect of our stylized monetary and fiscal policy shocks on the long-run terms of trade of the monetary union is unambiguously negative, i.e. the European terms of trade deteriorate substantially in the long run in response to the policy shocks. The intuition behind this becomes apparent from a modified version of (52), which indicates that lower European consumption implies lower money demand which requires the European price level to fall in order to restore equilibrium in the money market.

IV. Conclusions

We have just explored the implications of the implementation of a (two-country) monetary union on the international transmission of monetary and fiscal policy shocks in the previous section. We have to be aware, though, that this analysis is quite restrictive in, at least, two different senses. First and most importantly, our key result that the countries forming a monetary union become completely symmetric with respect to all per capita variables – including government spending levels – hinges mainly on the fact that we are considering only a one-time fiscal shock in our analysis. Ever-recurring differential government spending shocks would, however, lead to frequent imbalances of the current account, since the differential government spendings have to be balanced only in the very long run. Our key result can, therefore, be interpreted as indicating that the countries forming a monetary union, in essence, face a situation that is equivalent to the situation of independent regional governments within a federal state, that are allowed to run different fiscal policies.

Second, the effects of our stylized policy shocks on the exchange rate, the current account and the terms of trade as described above, are sensitive to the assumptions about the specific form and combination of the policy shocks. It is clear that, assuming policy shocks of a different kind can yield completely different, sometimes even opposing, reactions of these variables to the shocks.

It is one further limitation of this rather stylized monetary model that it does not consider capital and investment decisions and that it ignores non-traded goods in the analysis of price levels and exchange rates. While the former can be justified by arguing that our model is not intended to be a growth model, there is, however, no particular reason to omit the latter. Allowing for non-traded goods does indeed represent a potentially interesting extension of our analysis, since in this case price levels need not become identical as a consequence of the monetary union, which leads to quite different short-run dynamics in the model. Moreover, considering only one-period nominal rigidities, as a convenient simplification, clearly represents a restriction to the analysis of macroeconomic adjustment. Allowing for richer price dynamics – as in Woodford (1996) – would lead to a longer persistence of monetary and fiscal policy shocks. One further direction in which our analysis can be extended by future work is to compute numerical simulations along with impulse-response functions of macroeconomic policy shocks for the case of staggered price adjustment.

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