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Abstract

In this paper, I argue that international policy coordination requires to include both monetary as well as fiscal policy because both sides include policy instruments that allow the strategic manipulation of the country's terms of trade. Hence, the coordination of one part of national macroeconomic policies through an international agreement still leaves room for national authorities to still unilaterally manipulate the terms of trade by means of different policy instruments. In a simple and tractable dynamic stochastic two-country sticky-wage model in line with the recent New Open Economy Macroeconomics it is demonstrated that potential gains from international policy coordination are squandered if policymakers only cooperate on monetary policy. Moreover, by letting the fiscal policy instruments be chosen non-cooperatively, monetary policy coordination might even create welfare losses as compared to no macroeconomic policy coordination at all.

Keywords: International Policy Coordination; General Short-Run Monetary Policy; Distorting Fiscal Policy; Beggar-Thy-Neighbor; New Open Economy Macroeconomics

JEL classification: F41, F42, E62, E63

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1 Introduction

Throughout the last couple of decades the world has experienced a strong and steady increase in the economic interdependence among national economies. Accordingly, national macroeconomic policies are also subject to a steady increase in mutual interdependence. As a consequence, because conflicting national policy objectives might lead to international disagreements, the necessity of the international coordination of macroeconomic policies has become a central postulation within both the public as well as the academic debate: Countries should coordinate macroeconomic policies in order to incorporate externalities of national policies on other countries and - more importantly - to overcome inefficiencies arising from strategic considerations to exploit the international transmission of national macroeconomic policies in one country's own favor. In the international macroeconomics literature, these game-theoretic arguments formed the basis for the theoretical rationale in favor of policy coordination. Following the natural separation of national macroeconomic policymaking into monetary and fiscal policy, the academic literature evolved along two major strands: Beginning with Hamada (1974, 1976), the larger body of the literature focuses on the analysis of monetary policy.[1] The role of fiscal policy is largely ignored in these models. The other strand of the literature as in Hamada (1986), Kehoe (1987), and Chari and Kehoe (1990) analyzes fiscal policy where the international monetary policy regimes are taken as given.[2] By uncoupling the analysis of the international monetary policy domain and the fiscal policy domain, however, a crucial question cannot be addressed: How does the international coordination of only a part of national macroeconomic policies change the strategic behavior of the independently conducted remaining part of national policies. Put differently, how does independent national fiscal policy, for example, shift in response to the international coordination of monetary policy?

In this paper, I seek to close the gap in the literature and ask how the strategic incentives shift in one policy field where authorities still act independently when national policies move to coordination within the other policy field. In particular, I argue that the analysis of international policy coordination requires to include both the monetary and the fiscal side because either monetary or fiscal policy coordination alone does not suffice to extract gains from international coordination of national macroeconomic policies. The intuition for this proposition is straight forward: The necessity of international policy coordination is based on the fact that national policy entities can exert monopoly power on macroeconomic variables in general and the terms of trade in particular. Crucially then, both monetary and fiscal policy can be used to strategically manipulate the terms

[1] The most prominent contributions to the early stage of the literature are Oudiz and Sachs (1984), Rogoff (1985), and Canzoneri and Gray (1985). More recent contributions include Obstfeld and Rogoff (2000, 2002), Clarida et al. (2002), Devereux and Engel (2003), Cooley and Quadrini (2003), Benigno (2001), Benigno and Benigno (2003, 2006), Pappa (2004), Liu and Pappa (2005), Galí and Monacelli (2005), Corsetti and Pesenti (2005), and Evers (2007), where this list is far from complete. Overviews are provided by Cooper (1985), Canzoneri and Henderson (1991), Persson and Tabellini (1995), and Canzoneri et al. (2005).

[2] Other contributions are Hamada (1986), Devereux (1987), Turnovsky (1988), Backus et al. (1988), Kehoe (1989), Devereux (1991), Persson and Tabellini (1995) (who also provide an overview), and Kim and Kim (2006) who all consider real economies. More recent contributions rather focus on the strategic interaction of monetary and fiscal policymaking in monetary unions as in Dixit and Lambertini (2001, 2003). Among others, Beetsma and Uhlig (1999), Beetsma and Bovenberg (1998), Beetsma and Bovenberg (1999), Chari and Kehoe (1998, 2002) analyze the strategic interaction of public debt in monetary unions. More related to ours are Beetsma and Jensen (2005) and Andersen and Spange (2006) who consider strategic interaction of fiscal policies within a monetary union in a New Open Economy Macroeconomics (NOEM) framework. Again, this list is not exhaustive.

of trade. Hence, the coordination of a single policy stance through an international agreement still leaves room for national authorities to still unilaterally manipulate the terms of trade by means of different policy instruments. As a consequence, potential gains from, say, international monetary policy coordination are squandered or may even turn negative by letting the fiscal policy instruments be chosen non-cooperatively.

The economic setup to address this question builds on the standard framework of the New Open Economy Macroeconomics as in Corsetti and Pesenti (2001) and Obstfeld and Rogoff (2002) and augments the model in Evers (2007) with fiscal policy. It is a simple stochastic two-country general equilibrium model without capital. Goods prices are assumed to be perfectly flexible, but workers have to set monopolistic wages one period in advance. Furthermore, households make their consumption decision in face of a cash-in-advance restriction. In this environment, monetary authorities can affect the terms of trade by conducting a general short-run monetary policy using both the nominal interest rate and the money supply: The nominal interest rate directly alters the worker's wage setting condition and thereby the goods prices ex-ante. The period's actual money supply alters the nominal exchange rate and thus the terms of trade ex post.[3] Fiscal authorities, on their part, can influence the terms of trade ex ante by using distortionary taxes on labor income and ex post by changing distortionary taxes on consumption. The key property of the different policy instruments is that the labor income tax and the nominal interest rate on the one hand and the consumption tax and money supply on the other hand are perfectly substitutable national policy instruments. To be specific, when authorities want to exert, say, a positive impact on the workers' wage setting so as to raise the expected terms of trade ex ante, they can do so either by increasing the nominal interest rate which implicitly also raises the inflation tax on labor income or directly by increasing the labor income tax. Both interventions cause the workers to ask higher nominal wages. This, in turn, implies an increase in goods prices and ceteris paribus to an appreciation of the terms of trade. Factually, only the compound effect of national policy intervention matters for the consequences on the workers' optimal wage setting. The same is true for the ex post interventions to the nominal exchange rate. Changes in the money supply induce changes in relative international nominal goods demand and hence in the nominal exchange rate. In fact, the same movement in nominal spending can be achieved by adjusting the consumption tax. Thus, the identical ex post innovation to the nominal exchange rate and thereby to the terms of trade can be attained by fiscal policy. The important consequence is that the joint monetary and fiscal policy conduct determines the national impact on the terms of trade. Hence, taking up the arguments developed in favor of policy coordination and seeking an international cooperation of either monetary or fiscal policy alone will only leave room for policymakers to still follow national interests by exploiting their monopolistic power on the terms of trade via the respective other policy instruments.

In the next section, the model is described and the equilibrium conditions are derived. I discuss the equilibrium allocation and its distribution in Section 3. In this section, it is also shown that respective national monetary and fiscal policy instruments are perfect substitutes and derive the national policymakers' objective in closed form. In Section 4,

[3]Ireland (1996) already recognized that monetary policy can be conducted by using both the expected money growth rate and the state-dependent deviations from the expected level. Adao et al. (2003) take up his point and analyze general short-run monetary policies where the authors directly argue by means of the nominal interest rate as controlled by the expected level of money supply and the actual money supply as the state-dependent deviation from the expected level. Evers (2007) introduces the generalization of the short-run monetary policy conduct into a standard NOEM framework as in Obstfeld and Rogoff (2002) and Devereux and Engel (2003).

I consider optimal public policy coordination and the Nash equilibria of independently set national policy interventions. The analysis of cooperating monetary authorities under fiscal independence is carried out in Section 5. In Section 6 I give a numerical example in order to assess the relevance of policy coordination. In Section 7 I conclude. The derivations of the equilibrium and the of the results are delegated to an Appendix which is available upon request.

2 The Model

In the model, the world consists of two countries, denoted as Home (H) and Foreign (F). Each country produces two types of consumption goods, one that is traded with foreigners, and one that is demanded only within the country. In all, there are thus four goods. These goods are produced with labor as the only input factor. Furthermore, goods are traded in perfectly competitive markets and at perfectly flexible prices. Both countries are populated by a continuum of households with size one. Each household is characterized by a specific variety of labor of which it is the monopolistic supplier. Households can choose their wages individually. However, they have to be set one period in advance. In order to identify a particular household, the household will be indexed by a superscripted i.[4]

2.1 The Firms

Within countries, technologies to produce the tradable and the non-tradable goods are assumed to be identical:

$$Y_{j,s} = A_s \mathcal{L}_{j,s} \quad \text{with} \quad \mathcal{L}_{j,s} = \left(\int_0^1 {L_{j,s}^i}^{\frac{\theta-1}{\theta}} \mathrm{d}i \right)^{\frac{\theta}{\theta-1}}, \tag{1}$$

where $\theta > 1$. For both sectors, a typical firm j producing either the Home tradable good (HT) or the Home non-tradable good (HN) employs labor that is composed according to a CES aggregator over all domestic varieties of labor. The aggregate productivity of labor A_s in (1) is subject to shocks. The associated demand for a specific type of labor is

$$L_s^i = \left(\frac{W_s^i}{W_s} \right)^{-\theta} L_s, \tag{2}$$

where L_s is Home aggregate demand for labor. W_s^i denotes the monopolistic money wage claimed by household i and $W_s = \left(\int_0^1 W_s^{i(1-\theta)} \mathrm{d}i \right)^{\frac{1}{1-\theta}}$ defines the aggregate home wage level. Foreigners share an analogous aggregation technology and therefore the corresponding equations apply.

[4] Superscripts denote where a variable belongs to, foreign variables are distinguished by an asterisk *. Subscripts identify the characteristics of that variable, e.g. whether it's the home non-tradable or the foreign tradable good.

2.2 Households

Households within a country have identical preferences over consumption and labor effort. They are described by

$$U_t^i = E_t \sum_{s=t}^{\infty} \beta^{s-t} u_s^i, \quad \text{where} \tag{3}$$

$$u_s^i = \left(\frac{{C_s^i}^{1-\rho} - 1}{1-\rho} - \frac{1}{\nu} {L_s^i}^{\nu} \right) \qquad \text{with} \qquad C_s^i = \frac{{C_{T,s}^i}^{\gamma} {C_{HN,s}^i}^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{(1-\gamma)}},$$

where $0 < \beta < 1$, $\rho > 0$, $\nu \leqq 1$, and $0 \leq \gamma \leq 1$. The real consumption index C_s^i is given by a CES aggregator over the Home non-tradable good $C_{HN,s}^i$ and a composite of tradable goods $C_{T,s}^i$. The elasticity of substitution is equal to one. The composite of tradable goods $C_{T,s}^i$ is given by a CES aggregator over the Home tradable good $C_{HT,s}^i$ and the Foreign tradable good $C_{FT,s}^i$, where the elasticity of substitution is equal to one, too. Foreign households have the same preferences over tradable goods but differ with respect to their own non-tradable good.

Asset Markets

Households can trade nominal bonds with other households within borders. However, households cannot trade any assets internationally. It turns out that incomplete international risk sharing has an important implication: in contrast to most other contributions that assume households to have access to a full set of state-contingent claims, Obstfeld and Rogoff (2002) and Evers (2007) point out that the lack of private consumption risk sharing indeed leads to the non-optimality of replicating flexible wage and price allocation. In particular, they identify the optimal nominal exchange rate management to face the trade-off between replicating the flexible wage allocation and the efficient consumption risk sharing. It is this trade-off on which national policymakers will seek to manipulate the terms of trade through ex post market interventions to improve domestic welfare that is absent under complete asset markets.

Individual Budget and Cash Constraints

Household i starts out in period s with nominal wealth $\mathbb{W}_s^i$. First, the asset markets open. Household i receives money transfers X_s^i, decides about nominal domestic bond holdings B_s^i that repay $R_s B_s^i$ at a gross nominal return R_s in next period, and about cash holdings M_s^i. The asset market constraint reads

$$M_s^i + B_s^i \quad \leq \quad \mathbb{W}_s^i + X_s^i. \tag{4a}$$

Thereafter, the goods markets open. Purchases of consumption goods that are taxed at a rate $t_{C,s}$ must not exceed initial cash holdings, ie.

$$(1 + t_{C,s}) P_s C_s^i \quad \leq \quad M_s^i. \tag{4b}$$

At the end of the period, household i receives net wage earnings $(1 - t_{L,s}) W_s^i L_s^i$, where $t_{L,s}$ denotes a proportional tax on labor income, and a lump-sum transfer T_s^i that rebates the receipts of consumption and labor income taxes. Thus, the nominal wealth at the beginning of the next period is

$$\mathbb{W}_{s+1}^i \quad = \quad M_s^i + R_s B_s^i - (1 + t_{C,s}) P_s C_s^i + (1 - t_{L,s}) W_s^i L_s^i + T_s^i. \tag{4c}$$

Optimal Decisions

The household's problem is to maximize its expected lifetime utility (4) by deciding over bond and cash holdings, consumption, and their monopolistic wages subject to the constraints (4a-4c), the demand for their specific type of labor (2), and subject to the constraint that they have to set wages one period in advance. Optimal bond holdings implies the intertemporal Euler equation,

$$\frac{1}{R_s} = \beta \frac{E_s\left(\frac{{C_{s+1}}^{-\rho}}{(1+t_{C,s+1})P_{s+1}}\right)}{\frac{{C_s}^{-\rho}}{(1+t_{C,s})P_s}}. \tag{5a}$$

The net nominal interest rate is assumed to be strictly positive and reaches zero only in the limit. Consequently, the cash constraint is binding and optimality implies that the household uses all its initial cash for consumption goods purchases.[5] Individual optimization yields for any person i the standard composition of consumption between the tradable goods basket and the non-tradable good and between Home and Foreign tradable goods. The corresponding Home consumption-based price indices are given by $P_s = P_{T,s}^{\gamma} P_{HN,s}^{(1-\gamma)}$ and $P_{T,s} = P_{HT,s}^{\frac{1}{2}} P_{FT,s}^{\frac{1}{2}}$. The optimal money wage claim is constrained to be set one period in advance. Optimality requires the money wage posted for period s to be set such that the expected marginal utility loss implied by labor effort equals the expected marginal utility from consumption in period $s+1$ that additional labor income in s allows but which cannot be spent before $s+1$. Making use of the intertemporal Euler equation, we end up with

$$W_s^i = \frac{\theta}{\theta - 1} \frac{E_{s-1}\left({L_s^i}^{\nu}\right)}{E_{s-1}\left(\frac{(1-t_{L,s})}{(1+t_{C,s})R_s} \frac{L_s^i}{P_s {C_s}^{\rho}}\right)} \tag{5b}$$

as the optimal wage claim. For Foreign households, the corresponding equations apply.

2.3 Governments' Budget Constraints

At the beginning of a period, national governments make money transfers to the households. At the goods markets, they collect state-contingent proportional consumption taxes. At the end of the period, national governments collect state-contingent labor income taxes and rebate the receipts of all taxes lump-sum to the households. The two associated constraints for the Home government read

$$\begin{gathered} \int_0^1 M_s^i \mathrm{d}i = \int_0^1 M_{s-1}^i \mathrm{d}i + \int_0^1 X_s^i \mathrm{d}i \\ \text{and} \quad t_{C,s} P_s \int_0^1 C_s^i \mathrm{d}i + t_{W,s} \int_0^1 W_s^i L_s^i \mathrm{d}i = \int_0^1 T_s^i \mathrm{d}i, \end{gathered} \tag{6}$$

respectively. Money supply and state-dependent tax rates will be set according to policy rules that we specify later in the discussion of monetary and fiscal policy conduct. The Foreign policy authorities share the same budget constraints.

3 Equilibrium in Closed Form

All households within a country are identical except for their own special type of labor. Specifically, they are assumed to start out with identical initial nominal wealth. Hence,

[5] As it is well known, the cash-in-advance constraint with the Lucas timing protocol (Lucas (1982)) is binding if the net nominal interest rate is positive. Here I follow Adao et al. (2003) and Evers (2007) and assume that the interest rate is positive but is arbitrarily close to zero.

as these households face ex ante the same optimality conditions and since there is no asymmetric redistribution of wealth among households within a country on behalf of the governments at all, households will take identical actions. For the rest of the analysis the superscript i is dropped.

3.1 Equilibrium Prices and the Terms of Trade

By perfectly competitive goods markets, prices for home and foreign goods are

$$P_{HT,s} = P_{HN,s} = \frac{W_s}{A_s} \quad \text{and} \quad P^*_{FT_s} = P^*_{FN_s} = \frac{W^*_s}{A^*_s}, \tag{7}$$

respectively. In (7), W_s and W^*_s denote the preset Home and Foreign wage levels which cannot be adjusted to any period innovations. Therefore, the realization of the productivity shocks fully determines goods prices when wages are set the period before. The terms of trade, ToT_s, are defined as the price of home imports in terms of home exports, ie. in money prices $ToT_s = \left(\frac{P_{H,s}}{\mathcal{E}_s P_{F,s}}\right)$, where $\mathcal{E}_s$ denotes the nominal exchange rate. In terms of relative wage levels, we can restate the terms of trade as

$$ToT_s = \frac{A^*_s}{A_s}\left(\frac{W_s}{\mathcal{E}_s W^*_s}\right). \tag{8}$$

The real exchange rate, RER_s, is then by the consumption-based price indices $RER_s = ToT_s^{(1-\gamma)}$. The implication of effectively predetermined prices is that only the nominal exchange rate alters the current terms of trade and thereby relative consumption spending.

3.2 Ex Post Equilibrium Allocation

As a consequence, given monetary and fiscal policies, the ex post realized equilibrium allocation is uniquely determined by the cash-in-advance constraints and the market clearing conditions for goods and financial assets. To be more precise, because the current account must be balanced (as there is no international trade in financial assets) and Home and Foreign households equally split their expenditures between the Home and the Foreign tradable goods, the market clearing of tradable goods implies $P_{H,s}Y_{HT,s} = \mathcal{E}_s P^*_{F,s} Y^*_{FT,s}$, ie. both countries earn the same revenue on tradable goods production. Moreover, the law of one price and identical preferences over tradable goods imply that the purchasing power parity holds for tradable consumption goods. Consequently, home and foreign households will consume the same amount of tradable goods in equilibrium, ie. $C_{T,s} = C^*_{T,s}$. If we follow Obstfeld and Rogoff (2000) and express overall consumption expenditures in terms of tradable goods consumption, ie.

$$Z_s \equiv \frac{P_s}{P_{T,s}} C_s \quad \text{and} \quad Z^*_s \equiv \frac{P^*_s}{P^*_{T,s}} C^*_s, \tag{9}$$

we can use Home and Foreign optimal divisions of tradable and non-tradable goods consumption to find the equilibrium ratio of overall Home and Foreign consumption spending in terms of tradable goods to be unity, ie. $Z_s = Z^*_s$. Next, asset market clearing requires nominal bonds to be in zero net supply. Since households are identical in wealth, there will be zero net trade in nominal bonds. Consequently, households' nominal wealth consists of equilibrium cash holdings only. Furthermore, because nominal consumption spending is given by the cash-in-advance constraint, goods market clearing and the equalized trade balance requires the nominal exchange rate to adjust so that consumption spending

in terms of tradable goods is equalized across countries. Since the equilibrium nominal consumption spending, in turn, depends on the money supply and the consumption taxes, it turns out to be very useful to express money supply and taxes on consumption expenditures as a compound policy intervention.

Definition 1 (National public policy intervention to ex post consumption spending). Let $\mathrm{I}_{C,s}$ and $\mathrm{I}^*_{C,s}$ denote the respective compound national public policy intervention to goods markets via the cash-in-advance constraint with

$$\mathrm{I}_{C,s} = \frac{M_s}{1+t_{C,s}} \quad \text{and} \quad \mathrm{I}^*_{C,s} = \frac{M^*_s}{1+t^*_{C,s}}. \tag{10}$$

The ratio of Home and Foreign nominal consumption spending which are determined by the cash holdings therefore delivers the nominal exchange rate. With Definition 1 it follows that

$$Z_s = Z^*_s \quad \text{and} \quad \mathcal{E}_s = \frac{\mathrm{I}_{C,s}}{\mathrm{I}^*_{C,s}}. \tag{11}$$

With a uniquely determined nominal exchange rate, consumer prices P_s and P^*_s and the real exchange rate are given. Consequently, by the cash-in-advance constraint, Home and Foreign equilibrium consumption levels are given. Hence, goods market clearing determines the equilibrium employment levels because labor is fully demand determined. Table 1 summarizes Home and Foreign ex post equilibrium levels of consumption, output and labor. As a result, the ex post equilibrium allocation is uniquely determined for given common consumption level Z_s and the terms of trade ToT_s. It is important to observe that the differences between Home and Foreign consumption and output are entirely captured by the terms of trade. Consequently, the impact of a shift in the terms of trade on Home and Foreign variables are orthogonal. It proves useful to follow the method proposed by Aoki (1981) to express these variables in terms of world averages and differences. Accordingly, let subscript "w" denote the "world" average level of a variable which is the geometric mean of Home and Foreign variables and let subscript "d" denote the "difference" component which is the ratio of Home over Foreign variables.[6] The equilibrium consumption spending in terms of the tradable goods Z_s and the terms of trade ToT_s can then be written as

$$Z_s = \frac{A_{w,s}}{W_{w,s}} I_{C_{w,s}} \quad \text{and} \quad ToT_s = \left(\frac{W_{d,s}}{A_{d,s} I_{C_{d,s}}}\right)^2. \tag{12}$$

3.3 Ex Post Public Policy Intervention to Consumption Spending: Money Supply and Consumption Taxes

The innovations to the ex post equilibrium allocation can be summarized by the deviations of spending Z_s and the terms of trade ToT_s from their expected values. Letting small letters denote logs, ie. $x = \log X$, and letting a hat denote the deviation from the expected level, ie. $\hat{x} = x - \mathrm{E}x$, it follows that

$$\hat{z}_s = \hat{a}_{w,s} + \hat{\mathrm{i}}_{C_w,s} \quad \text{and} \quad \hat{\mathrm{tot}}_s = -2\left(\hat{a}_{d,s} + \hat{\mathrm{i}}_{C_d,s}\right). \tag{13}$$

[6] For a Home variable X and a Foreign variable X^*, the decomposition in levels is $X = X_w X_d$ and $X^* = \frac{X_w}{X_d}$ where $X_w = (XX^*)^{\frac{1}{2}}$ and $X_d = (\frac{X}{X^*})^{\frac{1}{2}}$. The exponents are relative country sizes which in our case are identical.

Table 1

	Home	Foreign
Consumption	$C_s = Z_s(ToT_s)^{-\frac{1}{2}(1-\gamma)}$	$C_s^* = Z_s(ToT_s)^{\frac{1}{2}(1-\gamma)}$
Output	$Y_s = Z_s(ToT_s)^{-\frac{1}{2}}$	$Y_s^* = Z_s(ToT_s)^{\frac{1}{2}}$
Labor	$L_s = A_s^{-1} Z_s ToT_s^{\frac{-1}{2}}$	$L_s^* = A_s^{*-1} Z_s ToT_s^{\frac{1}{2}}$

The ex post period equilibrium allocation given monetary and fiscal policy.

When wages are predetermined and given the realization of productivity shocks, the ex post allocation can only be altered by changes in Home and Foreign money supplies or consumption tax rates as captured by $\hat{\imath}_{C_w,s}$ and $\hat{\imath}_{C_d,s}$. The world consumption spending Z_s can only be changed ex post by altering the average money supply or the average consumption tax rate which reflects in equilibrium a one-to-one change in real balances available for consumption purchases. The terms of trade, in turn, can only be changed ex post by the nominal exchange rate which is determined by relative money supplies and relative consumption tax rates as in (11). Hence, the terms of trade can only be moved by $\hat{\imath}_{C_d,s}$ ex post.

Importantly, the effects of changes in the national money supply and the consumption tax rate on the ex post allocation are perfectly equivalent. In particular, an expansion of Home money supply leads to an increase in cash holdings dedicated to consumption purchases and hence to an increase in consumption spending. An equivalent change in net spending is achieved, however, by a reduction of the consumption tax rate. The same applies for nominal exchange rate and therefore for the terms of trade. A relative increase in Home money supply over Foreign money supply causes a depreciation of the nominal exchange rate. The determination of the nominal exchange rate by relative money supplies is standard in the NOEM literature (compare Obstfeld and Rogoff (1995, 1996)). However, an equivalent manipulation to the nominal exchange rate can be achieved by lowering Home consumption taxes relative to Foreign consumption taxes since this increases relative Home consumption spending relative to Foreign consumption spending, too. Goods market clearing then requires the nominal exchange rate to depreciate, as in case of a money supply increase. As a result, the following holds true:

Lemma 1. *The money supply and the consumption tax are perfectly substitutable national policy instruments. Relevant for consumption spending and the exchange rate determination is only the compound intervention to consumption spending.*

Consequently, since the ex post innovations depend only on productivity shocks and the ex post policy interventions to spending, the variance and covariance terms of the equilibrium allocation can be solved for once the joint distribution of productivity shocks and policy interventions is specified. This allows the explicit calculation of the ex ante expected levels of the equilibrium allocation and hence the preset nominal wage levels.

3.4 Distribution of the Ex Post Equilibrium Allocation

Productivity shocks are assumed to be iid log-normal with the following properties: Ea = Ea^* and $Var(a) = \sigma_a^2 = \sigma_{a^*}^2 = Var(a^*)$. For ease it is assumed that E$a = 0$. In terms of world and difference components it follows for the variances and covariances that

$$Var(a_s) = \sigma_a^2 = \sigma_{a_w}^2 + \sigma_{a_d}^2 \qquad \text{since} \qquad Cov(a_{w,s}, a_{d,s}) = \sigma_{a_{w,s},a_{d,s}} = 0.$$

By *iid* productivity shocks and given that public policies are stationary, the optimal choices of households and firms are stationary. As a consequence, the equilibrium of the infinite horizon setup is simply a repetition of a single period. For the rest of the paper, we therefore leave out time-subscripts for convenience. Moreover, if Home and Foreign public policy interventions to consumption spending i_C and i_C^* and productivity shocks are jointly log-normal, the distribution of the ex post equilibrium allocation turns out to be log-normal, too.

3.5 Ex Ante Public Policy Intervention to Wage Setting: Nominal Interest Rate and Labor Income Tax

In equilibrium, households within a country choose the same wage levels. Therefore, Home and Foreign equilibrium wage levels W and W^* are given by the aggregate versions of individual optimal wage setting as in (5b) and its Foreign counterpart. Recall that the nominal interest rate on the one hand and the labor income tax on the other hand affect the households' optimal wage setting in the same way. Similar to the first definition, we express the nominal interest rate and the labor income tax relative to the consumption tax as a compound policy variable.

Definition 2 (National public policy intervention to ex ante wage setting). Let $\mathrm{I}_{W,s}$ and $\mathrm{I}_{W,s}^*$ denote the respective compound national public policy intervention to wage setting with

$$\mathrm{I}_W = \frac{1+t_C}{1-t_W} R \quad \text{and} \quad \mathrm{I}_W^* = \frac{1+t_C^*}{1-t_W^*} R^*. \tag{14}$$

The aggregate Home and Foreign wage levels are thus determined by

$$W = \frac{\theta}{\theta-1} \frac{E\left(L^{\nu}\right)}{E\left(\frac{1}{\mathrm{I}_W} \frac{L}{PC^{\rho}}\right)} \quad \text{and} \quad W^* = \frac{\theta}{\theta-1} \frac{E\left(L^{*\nu}\right)}{E\left(\frac{1}{\mathrm{I}_W^*} \frac{L^*}{P^*C^{*\rho}}\right)}. \tag{15}$$

Consequently, the equilibrium wage levels can then be explicitly solved for in terms of the distribution of the ex post equilibrium allocation. The determination of the ex post allocation, however, yields an important implication for nominal interest rates and the distorting labor income taxes: These two policy instruments are completely ineffective if it is to alter the equilibrium allocation ex post. Consequently, the endogenous variability of consumption spending and the terms of trade are independent of Home and Foreign nominal interest rates and labor income taxes. Nevertheless, they do have an important impact ex ante because they change the environment for the households to set nominal wage claims as they shift expected levels of consumption spending and the terms of trade. In particular, Home and Foreign aggregate wage levels in (15) can be used to express the expected consumption spending and the terms of trade by means of the expected levels of the respective policy choices and the variances and covariances of endogenous

and exogenous variables. Accordingly, the expected consumption spending measured by tradable goods reads

$$\mathrm{E}z = -\frac{1}{\mathcal{X}}\left(\mathrm{i}_{W_w} + \ln\frac{\theta}{\theta-1} + \Sigma_z\right) \tag{16}$$

where $\mathcal{X} = \nu - (1-\rho) > 0$. The addend Σ_z collects the endogenous and exogenous variance and covariance terms of the equilibrium allocation[7], ie.

$$\begin{aligned}\Sigma_z = {} & \frac{1}{2}(\nu^2 - (1-\rho)^2)\sigma_z^2 + \frac{1}{8}(\nu^2 - (1-\rho)^2(1-\gamma)^2)\sigma_{tot}^2 \\ & -\frac{\nu^2}{2}(2\sigma_{z,a_w} - \sigma_{tot,a_d}) + \frac{\nu^2}{2}\left(\sigma_{a_w}^2 + \sigma_{a_d}^2\right).\end{aligned}$$

In equilibrium, expected consumption spending can be raised ex ante either by lowering expected world nominal interest rates or by cutting the expected world labor income taxes. The expected terms of trade are given by

$$\mathrm{Etot} = \frac{2}{\mathcal{Y}}\left(\mathrm{i}_{W_d} - \Sigma_{\mathrm{tot}}\right) \tag{17}$$

where $\mathcal{Y} = \nu - (1-\rho)(1-\gamma) > 0$, and

$$\Sigma_{\mathrm{tot}} = \frac{1}{2}(\nu^2 - (1-\rho)^2(1-\gamma))\sigma_{z,tot} + \frac{\nu^2}{2}\left(2\sigma_{z,a_d} - \sigma_{tot,a_w}\right).$$

The terms of trade depend on differences in both the nominal interest rates and the labor income taxes. A relative rise of the expected Home nominal interest rate or Home labor income taxes leads to higher Home wage claims and hence higher Home goods prices. Consequently, the expected terms of trade rise.

It is important to observe that similar to the public policy interventions to the ex post spending the effects of expected national nominal interest rate policy and the labor income taxation on the equilibrium allocation ex ante are perfectly equivalent. For instance, an increase of the expected Home nominal interest rate and thus higher expected inflation rates imply a higher Home nominal wage level. Since labor income becomes available for consumption only with a delay of one period, higher inflation imposes a tax on labor income. The equilibrium consequences are on the one hand that ceteris paribus world average consumption spending decreases because the expected inflation tax on labor income worsens Home households' incentive to supply labor and therefore production becomes more expensive. On the other hand, higher Home wage levels improve the expected terms of trade because Home goods become more expensive relative to Foreign goods. The same shift in Home households' wage setting and hence Home wage level, however, can be achieved by an appropriate change in the labor income tax because this has the identical distorting effect on the aggregate wage level. As a result, higher expected nominal interest rates and higher labor income taxes have identical implications on the equilibrium allocation as it is established in the following lemma:

[7]Observe that there is no loss of generality to treat the levels of intervention i_W and i_W^* to be non-stochastic because the compound national public policy intervention to the optimal wage setting cannot alter the realization of the allocation ex post. All that matters are expected levels of i_W and i_W^*, not the distribution around expected levels. Note also that because the consumption taxes will be set state-contingent, labor taxes must be set so as to be perfectly negatively correlated with the consumption taxes in order to keep the ratio constant at its desired level.

Lemma 2. *The nominal interest rate and the labor income tax are perfectly substitutable national policy instruments. Relevant for the wage level determination is only the compound intervention to households' wage setting.*

Lemma 1 and Lemma 2 form the backbone of this analysis. There are two ways in which public policy can be used to affect the equilibrium allocation: ex post by market interventions and ex ante by giving incentives for households to change their wage setting. In either way, both monetary and fiscal policy instruments have a counterpart that constitutes a perfect substitute.[8] As an immediate consequence, it follows that if national policymakers face the incentive to exploit their monopoly power on the terms of trade, they will do so either ex ante by changing the conditions for households to set wages or ex post by market interventions in order to manipulate the nominal exchange rate. Considering international policy coordination to surmount inefficiencies arising from non-cooperatively set public policies, either monetary or fiscal, policymakers must take into account that the compound monetary and fiscal policy intervention is decisive, not a single policy instrument. As we will see, this has important implications for the choice of international policy domains: For instance, suppose national monetary authorities coordinate and set nominal interest rates and money supply to the globally optimal level but they myopically consider the fiscal stance not to be responsive to the change in monetary policy conduct whatsoever. Self-oriented national fiscal policies then will determine the degree of interventions by choosing their target level and thereby render monetary policy coordination completely gainless. Before starting with the analysis of the different policy domains, however, first the policymakers' objectives are derived in closed form.

3.6 The Objectives in Closed Form

National authorities aim at maximizing their respective residents' expected utility. By making use of the equilibrium wage levels in equation (15) and aggregate budget constraints it follows that Home and Foreign expected period utility can be written as

$$\mathrm{E}u = \left(\frac{1}{(1-\rho)} - \frac{(\theta-1)}{\nu\theta}\frac{1}{\mathrm{I}_W}\right)\mathrm{E}C^{1-\rho} \quad \text{and} \tag{18}$$

$$\mathrm{E}u^* = \left(\frac{1}{(1-\rho)} - \frac{(\theta-1)}{\nu\theta}\frac{1}{\mathrm{I}^*_W}\right)\mathrm{E}C^{*1-\rho}.$$

Recall that in equilibrium the only difference between Home and Foreign consumption stems from the terms of trade. Consequently, if Home or Foreign authorities deviate from the jointly optimal policy, they will do so only as they face the incentive to manipulate the terms of trade in their own favor. In this case, independently and strategically conducted monetary and fiscal policy must be "beggar-thy-neighbor".

Expected utility written in terms of the equilibrium distribution of consumption permits a particularly convenient separation of the public policy interventions to the wage

[8] The equivalence result in Lemma 1 resembles a recent finding in Adao et al. (2006) who also demonstrate that a state-dependent consumption tax might be used as an alternative expenditure-switching instrument in a monetary union where the flexibility of the nominal exchange rate is sacrificed. The equivalence of the nominal interest rate and the labor income tax as policy instruments is well known in closed economy setups (compare eg. Chari and Kehoe (1999)) but it has been so far ignored in the analysis of open economies.

setting that only affect the expected consumption level from the public policy interventions to consumption spending that alter the variability of consumption. To be specific, Home expected utility can then be written as

$$\begin{aligned} Eu &= \left(\frac{1}{(1-\rho)} - \frac{\theta-1}{\theta\nu}\frac{1}{\mathrm{I}_W}\right)\left(\frac{\theta-1}{\theta}\frac{1}{\mathrm{I}_{W_w}}\right)^{\frac{(1-\rho)}{\mathcal{X}}} \mathrm{I}_{W_d}^{-\frac{(1-\gamma)(1-\rho)}{\mathcal{Y}}} \cdot \exp\left\{\frac{\nu(1-\rho)}{2\mathcal{X}}\Omega(\mathrm{i}_C;\mathrm{i}_C^*)\right\} \\ &\equiv \bar{u}(\mathrm{I}_W;\mathrm{I}_W^*)\cdot\exp\left\{\frac{\nu(1-\rho)}{2\mathcal{X}}\Omega(\mathrm{i}_C;\mathrm{i}_C^*)\right\}. \end{aligned} \tag{19}$$

In (20), the term $\bar{u}(\mathrm{I}_W;\mathrm{I}_W^*)$ depicts the part of expected utility that is independent of consumption variability and which can only be controlled through ex ante policy interventions to households' wage setting. The term $\Omega(\mathrm{i}_C;\mathrm{i}_C^*)$, in turn, summarizes the part of expected utility which depends on uncertainty only and which is a function of ex post public policy interventions to consumption spending. It is given by

$$\begin{aligned} \Omega(\mathrm{i}_C;\mathrm{i}_C^*) &= -\mathcal{X}\sigma_z^2 - \tfrac{1}{4}\mathcal{Z}\sigma_{tot}^2 + \tfrac{(1-\gamma)}{2\mathcal{Y}}\mathcal{X}^2\sigma_{z,tot} + \nu(2\sigma_{z,a_w} - \sigma_{tot,a_d}) \\ &\quad + \tfrac{\nu(1-\gamma)}{\mathcal{Y}}\mathcal{X}(2\sigma_{z,a_d} - \sigma_{tot,a_w}) + \nu\mathcal{X}\left(\sigma_{a_w}^2 + \sigma_{a_d}^2\right) \end{aligned}$$

where $\mathcal{Z} = \nu - (1-\rho)(1-\gamma)^2 > 0$.[9]

It is important to observe that the ex ante interventions differ from the ex post interventions in the order of magnitude with respect to their welfare implications. As already emphasized in Evers (2007), ex post interventions are stabilization responses to deviations of productivity levels. Enhancing expected utility thus entails that risk aversion enforces the minimization of fluctuations in consumption and labor. These welfare effects are, however, generically of second order (compare the discussion by Lucas (2003)). Hence, gains from coordinating ex post stabilization policies are of second order. On the other hand, ex ante interventions to the wage setting are of first order because the distortions resulting from policies drive an inefficient wedge between the optimal labor-leisure tradeoff on average. Consequently, gains from coordinating ex ante wage setting distortions are of first order.

4 International Cooperation of Public Policies

Monetary and fiscal policymakers are assumed to be able to perfectly commit to the policy they announce. In case of ex post market interventions that will alter the nominal

[9] Foreign expected utility can be stated as

$$\begin{aligned} \mathrm{E}u^* &= \bar{u}^*\left(\mathrm{I}_W;\mathrm{I}_W^*\right)\exp\left\{\frac{\nu(1-\rho)}{2\mathcal{X}}\Omega^*(\mathrm{i}_C;\mathrm{i}_C^*)\right\}, \qquad \text{where} \\ \bar{u}^* &= \left(\frac{1}{(1-\rho)} - \frac{\theta-1}{\theta\nu}\frac{1}{\mathrm{I^*}_W}\right)\left(\frac{\theta-1}{\theta}\frac{1}{\mathrm{I}_{W_w}}\right)^{\frac{(1-\rho)}{\mathcal{X}}} \mathrm{I}_{W_d}^{\frac{(1-\gamma)(1-\rho)}{\mathcal{Y}}}, \qquad \text{and} \\ \Omega^*(\mathrm{i}_C;\mathrm{i}_C^*) &= -\mathcal{X}\sigma_z^2 - \frac{\mathcal{Z}}{4}\sigma_{tot}^2 - \frac{(1-\gamma)}{\mathcal{Y}}\mathcal{X}^2\sigma_{z,tot} + \nu(2\sigma_{z,a_w} - \sigma_{tot,a_d}) \\ &\quad - \frac{\nu(1-\gamma)}{\mathcal{Y}}\mathcal{X}(2\sigma_{z,a_d} - \sigma_{tot,a_w}) + \nu\mathcal{X}\left(\sigma_{a_w}^2 + \sigma_{a_d}^2\right). \end{aligned}$$

exchange rate, monetary policy follows a money supply feedback rule that conditions on productivity shocks. They are given by

$$\hat{m} = \mu_w \hat{a}_w + \mu_d \hat{a}_d \quad \text{and} \quad \hat{m^*} = \mu^*_w \hat{a}_w - \mu^*_d \hat{a}_d.$$

Fiscal policy follows a similar feedback rule for consumption taxes, namely

$$\hat{\tau_c} = \tau_{c,a_w} \hat{a}_w + \tau_{c,a_d} \hat{a}_d \quad \text{and} \quad \hat{\tau^*_c} = \tau_{c^*,a_w} \hat{a}_w - \tau_{c^*,a_d} \hat{a}_d,$$

where $\tau_c = \log(1 + t_C)$ and $\tau^*_c = \log(1 + t^*_C)$. The compound public policy reactions to productivity shocks can therefore be written as

$$\hat{\mathrm{i}}_C = \mathrm{i}_{C_{a_w}} \hat{a}_w + \mathrm{i}_{C_{a_d}} \hat{a}_d \quad \text{and} \quad \hat{\mathrm{i}}^*_C = \mathrm{i}^*_{C_{a_w}} \hat{a}_w - \mathrm{i}^*_{C_{a_d}} \hat{a}_d, \tag{20}$$

where $\mathrm{i}_{C_{a_w}} = \mu_{a_w} - \tau_{a_w}$, $\mathrm{i}^*_{C_{a_w}} = \mu^*_{a_w} - \tau^*_{a_w}$, $\mathrm{i}_{C_{a_d}} = \mu_{a_d} - \tau_{a_d}$, and $\mathrm{i}^*_{C_{a_d}} = \mu^*_{a_d} - \tau^*_{a_d}$.

In case of ex ante policy interventions to the optimal wage setting, the monetary policy is to set the expected gross nominal interest rate. Implicitly, this is achieved by the choice of the mean money supply for the next period, ie. by Em and Em^*.[10] Fiscal policy chooses the labor income tax rates which must be perfectly negatively correlated to the consumption taxes so that the ratio of both is at the desired level.

4.1 Optimal Public Policy Coordination

The analysis begins with the consideration of single national policymakers who choose both the monetary and the fiscal policy instruments, ie. there is a single Home authority that chooses $\{\mathrm{I}_W, \mathrm{i}_{C_{a_w}}, \mathrm{i}_{C_{a_d}}\}$ and a single Foreign authority that chooses $\{\mathrm{I}^*_W, \mathrm{i}^*_{C_{a_w}}, \mathrm{i}^*_{C_{a_d}}\}$. When single national policymakers coordinate their respective policy interventions, they do so as to maximize the joint welfare of Home and Foreign residents.

Ex Ante Intervention to Wage Setting

The first proposition establishes the globally optimal policy intervention to ex ante wage setting:

Proposition 1. *The optimal public policy intervention to the wage setting is*

$$\mathrm{I}^{Opt}_W = \frac{\theta - 1}{\theta},$$

and $\mathrm{I}^*_W{}^{Opt} = \mathrm{I}^{Opt}_W$ *by symmetry.*

Proof. See Appendix. □

The optimal public policy to the wage setting is to offset both distortions that prevent ex ante efficient wages: first, the markup of monopolistic suppliers of specific labor types, and second, the inflation tax caused by the cash-in-advance distortion. The combination of the fiscal and monetary policy instrument to achieve this is indeterminate. However, the most prominent combination to achieve the optimal level of ex ante intervention to the wage setting is to use labor income taxes to offset monopolistic distortions and to run the nominal interest rates according to the Friedman rule.

[10] See also the detailed discussion in Evers (2007).

Ex Post Intervention to Consumption Spending

The next proposition states the optimal ex post intervention to spending:

Proposition 2. *The optimal ex post public policy intervention to consumption spending follows*

$$\mathrm{i}^{Opt}_{C_{a_w}} = \frac{(1-\rho)}{\mathcal{X}} \quad \textit{and} \quad \mathrm{i}^{Opt}_{C_{a_d}} = \frac{(1-\rho)(1-\gamma)^2}{\mathcal{Z}},$$

and $\mathrm{i}^{*Opt}_{C_{a_w}} = \mathrm{i}^{Opt}_{C_{a_w}}$ *and* $\mathrm{i}^{*Opt}_{C_{a_d}} = \mathrm{i}^{Opt}_{C_{a_d}}$ *by symmetry.*

Proof. See Appendix. □

When both countries are hit by a common productivity shock, the only friction that matters are preset wages. Indeed, optimal public policy then replicates the flexible wage allocation by closing the gap between the marginal utility of consumption and the marginal disutility of labor in each instance. Under flexible wages, $\frac{(1-\rho)}{\nu}$ determines the efficient intra-temporal elasticity of substituting labor for consumption.[11] Under rigid wages, however, labor is fully demand determined and hence uncoupled from the consumption decision. Optimal public policy must therefore be used to imitate the optimal trade-off between consumption and labor. A positive aggregate productivity shock and subsequently lower goods prices lead to an increase in consumption spending. Without intervention, equilibrium employment would stay unaffected. Following, if $\rho > 1$, the optimal policy rule corrects the inefficiently high consumption level by counter-cyclically reducing nominal consumption spending up to the level that equates marginal utility of consumption and marginal disutility of labor. If $\rho < 1$, optimality requires a positive reaction of labor to an increase in consumption. Hence, the optimal policy rule has then to be pro-cyclical. Only in case of log-utility, it is in fact optimal having labor not to respond to consumption fluctuations at all.

Things are different when the two countries are hit by fully asymmetric productivity shocks. Then, in addition to rigid wages, the incomplete risk sharing places the policymakers to tackle another source of inefficiency. In particular, efficient risk sharing requires the ratio of Home over Foreign marginal utilities of tradable goods consumption to be unity.[12] In general, however, closing the domestic gap between the marginal rate of substituting consumption and labor and the marginal rate of transformation by replicating the flexible wage allocation leaves an international gap between Home and Foreign marginal utilities of consumption. Hence, there exists a trade-off between closing domestic and international gaps. To be more precise, consider an asymmetric productivity shock that increases Home productivity over Foreign, say, which implies the terms of trade and thereby the real exchange rate to depreciate. Consequently, relative Home over Foreign nominal consumption spending increases by one-to-one to the fall in the real exchange rate. This leaves employment unaffected. In case of $\rho > 1$, to improve upon the gap between the marginal utility of consumption and marginal disutility of labor effort, Home

[11] Optimal wage setting implies $\mathrm{E}L^{\nu} = \mathrm{E}C^{(1-\rho)}$. As this has to hold for each instance under flexible wages, we get $L^{\nu} = C^{(1-\rho)}$. Hence, the implied intra-temporal elasticity of labor with respect to consumption is $\frac{(1-\rho)}{\nu}$.

[12] This follows as an immediate implication of (i) marginal utilities of any shared consumption good must equal relative prices and (ii) in case of tradable goods PPP of tradable goods imply that marginal utilities of tradable consumption goods must be identical across countries. Hence, $\frac{U_{C_T}}{U_{C^*_T}} = 1$ under complete financial markets and initially identical countries (compare Backus and Smith (1993)).

national authority has to counter-cyclically decrease consumption by either increasing consumption taxes or reducing money supply. Foreign national authority counter-cyclically increases consumption to oppose the negative foreign productivity shock.[13] Thereby, the nominal exchange rate appreciates but by less than necessary to offset the direct effect of the productivity shock on the terms of trade. As a consequence, the terms of trade and the real exchange rate still deteriorate even when national authorities target the flexible wage allocation. The immediate implication for Home and Foreign marginal utilities of consumption is that Home marginal utility is lower than Foreign. To see this, note that in the equilibrium without international asset markets, the ratio of marginal utilities of tradable goods consumption reads

$$\frac{U_{C_T}}{U_{C_T^*}} = ToT^{-(1-\rho)(1-\gamma)}.$$

Thus, Home households consume too much tradable goods whereas Foreign households consume to few tradable goods as efficient risk sharing would require. If households were able to perfectly contract state contingent payments in international financial markets, Home households would have to make a transfer to Foreign households to equate marginal utilities of tradable goods consumption. However, by the lack of international financial markets, consumption risk sharing can only be achieved by nominal exchange rate management. In fact, an implicit Home transfer to Foreign can be attained by a depreciation of Home currency: the Home tradable good becomes cheaper for Foreign residents whereas the Foreign tradable good becomes dearer for Home residents. Therefore, Home residents pay more in exchange for Foreign goods which indeed comes along with a reproduction of a transfer. As a result, from a global perspective it is not optimal to nationally target the flexible wage equilibrium. As the story goes exactly the symmetric way for $\rho < 1$, it turns out that the optimal market interventions to asymmetric productivity shocks are less responsive than simply targeting the flexible wage allocation. Hence, in general, optimal policy responses to asymmetric shocks face the trade-off between dispelling domestic inefficiencies caused by wage rigidity and the inefficiency caused by the lack of international risk sharing. Note that it is this trade-off only that renders the optimal policy conduct to be second-best.[14]

4.2 Non-Cooperative Public Policy: Nash

Next, I consider what public policies look like when the single Home and Foreign national policymakers conduct public policy independently. Recall the discussion of the respective welfare functions that policymakers seek to maximize. The only difference between Home and Foreign residents' wefare stems from the terms of trade. Hence, national policymakers deviate from the optimal policy only on the grounds of manipulating the terms of trade to their own national benefits.

4.2.1 Ex Ante Intervention to Wage Setting

Proposition 3. *The (unique) Nash equilibrium of non-cooperatively set public policy interventions to the wage setting yields*

$$\mathrm{I}_W^{Nash} = \frac{\theta - 1}{\theta}\left(1 + \frac{\gamma\mathcal{X}}{\mathcal{Y} + (1-\gamma)\mathcal{X}}\right),$$

[13] In fact, one can easily show that $\mathrm{i}_{C_{a_d}}^{flex} = \frac{(1-\rho)(1-\gamma)}{\mathcal{Y}}$ indeed replicates the flexible wage allocation in case of asymmetric shocks and one finds that $-1 < \mathrm{i}_{C_{a_d}}^{flex}$. Moreover, the terms of trade than still changes by $\widehat{tot} = -\frac{\nu}{\mathcal{Y}}\hat{a}_d$.

[14] Compare also the discussion in Obstfeld and Rogoff (2002) and Evers (2007) on this trade-off.

and $\mathrm{I}_W^{*\,Nash} = \mathrm{I}_W^{Nash}$ *by symmetry. Furthermore,*

$$\mathrm{I}_W^{Nash} > \mathrm{I}_W^{Opt} \quad \textit{if} \quad \gamma \neq 0 \quad \textit{and} \quad \mathrm{I}_W^{Nash} = \mathrm{I}_W^{Opt} \quad \textit{if} \quad \gamma = 0.$$

Proof. See Appendix. □

From this proposition follows that non-cooperatively set policy interventions to workers' wage setting will be strictly larger than the optimal one unless the two countries are in autarky, ie. $\gamma = 0$. By the discussion of the equilibrium wages, higher nominal interest rates or labor income taxes entail higher wage claims ex ante. Why, then, has the national policymaker the incentive to induce wage claims to be inefficiently higher than the optimal level? The answer is to improve upon the consumption-labor trade-off. Given the other country's wage level, an increase in domestic wages implies an increase in labor income and consequently in expected consumption the next period. However, in equilibrium, higher relative wages imply higher terms of trade and a reduction in domestic goods demand. Furthermore, higher relative wages also induce a direct fall in labor demand. Hence, aggregate labor demand and labor income falls. The net effect on the consumption-labor ratio and thus on welfare, however, is positive because households substitute to the relatively cheaper foreign goods. Thus, domestic policymakers "beggar-thy-neighbor" by exporting labor effort and importing more consumption goods at relatively higher domestic wages. As a result, as both Home and Foreign national authorities behave symmetrically in equilibrium, higher Home and Foreign inflation and labor income tax induce inefficiently high nominal wage claims that reduce in turn aggregate world output and world consumption. Only in case of no trade, ie. when the two countries are closed economies ($\gamma = 0$), does the positive net substitution effect vanish and the optimal policy intervention to wage setting indeed constitutes a Nash equilibrium.

Ex Post Intervention to Consumption Spending

Proposition 4. *The (unique) Nash equilibrium of non-cooperatively set public policy interventions to consumption spending yields*

$$\mathrm{i}_{C_{a_w}}^{Nash} = \frac{(1-\rho)}{\mathcal{X}} \quad \textit{and} \quad \mathrm{i}_{C_{a_d}}^{Nash} = (1-\rho)(1-\gamma)\left(\frac{\mathcal{X} + (1-\gamma)\mathcal{Y}}{\mathcal{Z}\mathcal{Y} + (1-\gamma)\mathcal{X}^2}\right),$$

where $\mathrm{i}^{*\,Nash}_{C_{a_w}} = \mathrm{i}^{Nash}_{C_{a_w}}$ *and* $\mathrm{i}^{*\,Nash}_{C_{a_d}} = \mathrm{i}^{Nash}_{C_{a_d}}$ *by symmetry. Furthermore,*

$$\mathrm{i}_{C_{a_w}}^{Nash} = \mathrm{i}_{C_{a_w}}^{Opt} \quad \textit{and} \quad \mathrm{i}_{a_d}^{Nash} \begin{cases} < \mathrm{i}_{a_d}^{Opt} & \textit{if } \rho > 1 \textit{ and } 0 < \gamma < 1. \\ > \mathrm{i}_{a_d}^{Opt} & \textit{if } \rho < 1 \textit{ and } 0 < \gamma < 1. \\ = \mathrm{i}_{a_d}^{Opt} & \textit{if } \rho = 1 \textit{ or } \gamma \in \{0, 1\}\ . \end{cases}$$

Proof. See Appendix. □

Indeed, when the two countries are hit by a common aggregate productivity shock, it is not surprising that the Nash solution does coincide with the optimal response: The only source of frictions are preset wages. Hence, as the impact of the shock is identical, the policy targets coincide.

In contrast, when the two countries are hit by idiosyncratic shocks, the optimal response does not constitute a Nash equilibrium of the policy rule setting game in general. If national policymakers decide on their respective policy interventions non-cooperatively, Proposition 4 implies that as long as the lack of complete international financial markets matters, ie. as long as $\rho \neq 1$ or $0 < \gamma < 1$, both single national authorities face the incentive to unilaterally react more actively to idiosyncratic shocks than it is globally efficient. *Why?* The answer is again to improve upon the domestic labor-leisure trade-off. Put differently, national policymakers regard it beneficial to close the domestic gap between marginal utility of consumption and marginal disutility of labor at the cost of increasing the international gap between Home and Foreign marginal utilities of consumption. By the discussion above, optimal public policy responses to idiosyncratic productivity shocks trade off gains from replicating the flexible wage allocation and the gains from international consumption risk sharing. In particular, the optimal policy rule moves away from replicating the flexible wage equilibrium because the efficient consumption risk sharing requires a less active response to shocks in order to implicitly compensate for the lack of state-contingent transfers within complete international financial market. For instance, when $\rho > 1$ and an asymmetric shock increases Home productivity and reduces Foreign productivity, the optimal policy rule induces the nominal exchange rate to fall by less than under replicating the flexible wage equilibrium in order to lessen the appreciation of the terms of trade. That is, the Home tradable good must be cheaper for Foreign residents and Foreign tradable good must be dearer for Home residents than under replicating the flexible wage equilibrium. The consequence is an implicit transfer of tradable goods from Home to Foreign that increases demand for Home labor and reduces demand for Foreign labor. From a national perspective, however, it pays to deviate from the optimal policy response since given the other national policymaker sticks to the optimal rule, the gains from reducing the domestic marginal utility gap by altering the terms of trade outweighs the loss implied by the widening of the international gap between marginal consumption utility. Specifically, Home reduces labor effort by cutting consumption spending in order to further bridge the domestic gap by either expanding money supply or lowering consumption taxes. For $\rho > 1$, the consumption level itself falls by less than the labor effort (compare the discussion of Proposition 2). The reason is that a cut in Home consumption spending appreciates Home currency and improves the terms of trade. Hence, Home residents' substitute for the then cheaper Foreign good. The Home currency appreciation in turn inflicts a beggar-thy-neighbor effect on Foreign because it directly reduces Foreign consumption and increases Foreign labor effort. The analog story holds true for $\rho < 1$.

As a consequence, deviations from the optimal policy responses to idiosyncratic productivity shocks result in an amplification of the response of the nominal exchange rate and thereby of the terms of trade. From a global perspective, this amplification of the terms of trade fluctuations harms both Home and Foreign residents since this leads to higher consumption fluctuations. The result is that international risk sharing and thus international consumption smoothing has worsened.

5 Monetary Cooperation and Fiscal Independence

Next, the analysis of decentralized public policies follows. In this case, national policymaking is separated between two distinct authorities: a monetary policy authority that decides on the nominal interest rate and the money supply rule and a fiscal policy authority that decides on consumption and labor income taxes. I focus on the case when

monetary authorities coordinate their respective policy instruments in order to maximize the sum of Home and Foreign residents welfare whereas the fiscal authorities implement their respective policies independently of each other so as to maximize the domestic residents' welfare only.

In this section, it is shown that for all instances when there is an incentive for self-oriented national authorities to deviate from both the optimal ex ante intervention to the wage setting (compare Proposition 3) and the optimal ex post market intervention rules (compare Proposition 4), monetary policy coordination inevitably leaves room for independently operating national fiscal authorities to exploit their power on the terms of trade. In particular, by the two lemmata in Section 3, monetary and fiscal policy instruments are perfect substitutes with regard to the respective interventions. Only the compound action of domestic monetary and fiscal policy accounts for the effect on private households behavior. Hence, coordinating monetary authorities seek to implement the optimal levels of public policy interventions. Independently acting fiscal authorities, however, undermine monetary authorities endeavor by enforcing a deviation of the optimal public policy intervention levels by the motives as discussed in the foregoing section.

Ex Ante Wage Setting Intervention

The following proposition states that in case of ex ante intervention to the wage setting gains from monetary policy coordination are fully carried off by the fiscal sides:

Proposition 5. *The (unique) Nash Equilibrium between the cooperating monetary authorities and the two symmetric independent fiscal authorities entails fiscal dominance, ie. the net nominal interest rates are tied down to zero whereas the wage taxes are set to the non-cooperative level.*

Proof. See Appendix. □

Since the net nominal interest rates cannot become negative, the two fiscal authorities will force the cooperating monetary authorities to implement zero net nominal interest rates as then fiscal authorities exerts full control over Home and Foreign wage setting. As a result, in the Nash equilibrium with symmetric fiscal actions, Home and Foreign fiscal authorities will implement the non-cooperative levels of public policy intervention ${I^*_W}^{Nash} = I^{Nash}_W$. The importance of this result cannot be overemphasized: As argued above, the magnitude of welfare implications of ex ante intervention to the wage setting is of first-order. Therefore, gains from policy coordination are of first-order. As a consequence, by Proposition 5, potentially large gains from policy coordination can only be realized if the fiscal policy is included in the international policy cooperation.

Ex Post Market Intervention

In case of common productivity shocks, the only distortion that matters ex post are preset wages. Hence, there is no basis on which the cooperating monetary authorities and the two self-oriented fiscal policymakers might dispute. As a consequence, we find the following result.

Proposition 6. *The (continuum of) Nash Equilibria between the cooperating monetary authorities and the two symmetric independent fiscal authorities entails the optimal national compound policy responses to aggregate shocks.*

Proof. See Appendix. □

In fact, since both domestic monetary and fiscal authority want to implement the optimal feedback rule of ex post public intervention $i^{*Opt}_{C_{a_w}} = i^{Opt}_{C_{a_w}}$, all combinations of monetary and fiscal coefficients that lead to the optimal feedback rule are equilibria. Hence, all what domestic public policymakers face is a coordination problem of which combination to choose.

In case of idiosyncratic shocks, however, national fiscal authorities face an incentive to enforce a deviation from optimal policy responses on the grounds that they want to improve upon the domestic gap between the marginal consumption utility and the marginal disutility of labor effort at the cost of worsening international consumption risk sharing. The next proposition shows that as long as the need for a risk sharing arrangement matters, self-oriented national fiscal authorities will indeed effectively deteriorate optimal public policy responses to idiosyncratic shocks.

Proposition 7. *Only if $\rho = 1$ or $\gamma \in \{0, 1\}$, the (continuum of) Nash equilibria between the cooperating monetary authorities and the two symmetric independent fiscal authorities in pure strategies entail optimal national compound policy responses to idiosyncratic shocks. Otherwise, if $\rho \neq 1$ and $0 > \gamma > 1$, the (unique) Nash equilibrium exhibits mixed strategies which inevitably lead to welfare losses as compared to the optimal response to asymmetric shocks.*

Proof. See Appendix. □

Obviously, when the goals of cooperating monetary authorities and the two distinct national fiscal authorities coincide and all policymakers seek to close the domestic gaps induced by the wage rigidity, the Nash equilibria must consist of optimal responses to asymmetric shock. This is the case either if the countries are closed ($\gamma = 0$) or if international financial markets are redundant ($\rho = 1$ or $\gamma = 1$). Again, as in case of aggregate productivity shocks, policymakers still face a coordination problem that implies the Nash solution to be non-unique. On the other hand, if the goals do not coincide, cooperating monetary policymakers want to implement the optimal policy responses $i^{Opt}_{C_{a_d}} and i^{*Opt}_{C_{a_d}}$. Given the action taken by the monetary authorities, the equilibrium best responses of national fiscal authorities are to choose consumption taxes so as to implement the Nash intervention rules $i^{Nash}_{C_{a_d}}$ and $i^{*Nash}_{C_{a_d}}$. Hence, it follows from the perfect substitutability of national policy instruments (Lemma 1) that there cannot exist a Nash equilibrium in pure strategies. Nevertheless, there exists a Nash equilibrium in mixed strategies. As a result, the mixed strategies equilibrium must entail welfare losses as compared to the globally optimal response to asymmetric productivity shocks because on average the national responses are more active as it is optimal. To evaluate the relevance of these theoretical results, I consider a numerical exercise in the next subsection.

6 Gains and losses from Policy Cooperation with and without Fiscal Independence

The losses that fiscal independence implies for international monetary policy coordination are assessed on the basis of a numerical simulation of the model. To alleviate comparisons and since the model is similar in structure to theirs, I adopt the parameters chosen by Obstfeld and Rogoff (2002). To be specific, I assume that $\sigma_{a_w} = \sigma_{a_d} = 0.01$ and that

Table 2

	Low-trade scenario ($\gamma = 0.2$)					High-trade scenario ($\gamma = 0.6$)				
	Different values for ρ					Different values for ρ				
	$\rho = .5$	$\rho = 1$	$\rho = 2$	$\rho = 4$	$\rho = 8$	$\rho = .5$	$\rho = 1$	$\rho = 2$	$\rho = 4$	$\rho = 8$
Welfare Measure (compensating % change in consumption)										
ξ^{I_W}	0	0	0	0	0	0	0	0	0	0
ξ^{I_C}	-0.13	0	-0.061	-0.157	-0.228	0.004	0	0.004	-0.005	-0.028
ξ	-0.13	0	-0.061	-0.157	-0.228	0.004	0	0.004	-0.005	-0.028

Gains from monetary policy coordination when fiscal authorities operate independently as compared to the case when both national monetary and fiscal policy are conducted non-cooperatively.

$\nu = 1$. The value for θ is chosen to be $\theta = 7.66$. This implies a monopolistic markup over marginal costs of 15%. Two possible scenarios are considered: a low-trade scenario ($\gamma = 0.2$) which corresponds to an import over GDP ratio of 10% and high-trade scenario ($\gamma = 0.6$) which corresponds to an import over GDP ratio of 30%. The impacts of different public policy arrangements are measured by their % change in consumption that is required to compensate the representative household to be indifferent between either two policy environments. ξ denotes the percentage compensation of consumption so that $U((1+\xi)C^A, L^A) = U(C^B, L^B)$, where A and B are two different policies. Moreover, the structure of the model allows an easy decomposition of this measure into the two relevant components: effects of the ex ante policy interventions to the wage setting (ξ^{I_W}) and effects of the ex post policy interventions to the consumption spending (ξ^{I_C}).

Table 2 reports the gains from international monetary policy coordination when national fiscal authorities act independently. There are no gains from coordinating monetary policy interventions to households' optimal wage setting as Proposition 5 shows: The Fiscal authorities dominate the cooperating monetary authorities by tying the nominal interest rate to zero and implementing the competitive level of public policy interventions. In case of ex post interventions, only asymmetric shocks lead to a divergence of policy goals. As shown in Proposition 7, as long as risk-sharing matters, the unique Nash equilibrium is in mixed strategies. Surprisingly, in the low-trade scenario, coordinating monetary policy actually leads to welfare losses. For independently acting fiscal authorities forces policymakers to mix their responses to asymmetric shocks, circumstances arise where the compound ex post policy interventions are either less responsive than optimal or more responsive than it would be nationally desirable. Welfare losses in expected utility by having both these circumstances outweigh the gains from reacting at least sometimes optimally to asymmetric shocks. Furthermore, these losses are increasing in the absolute deviation of ρ from unity because thereby the consequences of policy disturbances on expected utility become more pronounced. The same effect persists in the high-trade scenario. The welfare implications are, however, smaller because the inefficiency arising from consumption risk sharing plays a less important role in case of higher trade integra-

Table 3

	Low-trade scenario ($\gamma = 0.2$)					High-trade scenario ($\gamma = 0.6$)				
	Different values for ρ					Different values for ρ				
	$\rho = .5$	$\rho = 1$	$\rho = 2$	$\rho = 4$	$\rho = 8$	$\rho = .5$	$\rho = 1$	$\rho = 2$	$\rho = 4$	$\rho = 8$
Welfare Measure (compensating % change in consumption)										
ξ^{I_W}	1.674	0.537	0.155	0.042	0.011	11.566	5.831	2.378	0.811	0.243
ξ^{I_W}	0.151	0	0.062	0.158	0.229	0.007	0	0.006	0.019	0.037
ξ	1.827	0.537	0.217	0.200	0.240	11.574	5.831	2.384	0.830	0.280

Gains from fiscal policy coordination when monetary authorities already cooperate as compared to the case when monetary policy coordinate but fiscal authorities operate independently.

tion. Recall that the elasticity of substituting the Home tradable good for the Foreign tradable good is always one. Hence, relative price movements can be better dealt with by households substituting for the relatively cheaper tradable good the larger the share of tradable consumption goods in the overall consumption basket is.

Welfare gains from fiscal policy coordination when monetary authorities already cooperate are presented in Table 3. In contrast to the first exercise, there are gains from choosing the ex ante intervention to households' wage setting cooperatively. The figures in the first row show that these gains from fiscal cooperation are substantial. They are decreasing in ρ even though the inter-temporal inefficiency caused by the non-optimal policy intervention is increasing simply because the inter-temporal elasticity of substitution is decreasing in ρ, too. Thus, consumption patterns are less sensible to disturbances to the optimal wage-setting. The gains are, however, increasing in the degree of openness because the national policymakers are more prone to manipulate the terms of trade ex ante as the relative importance of the terms of trade is naturally increasing in Home as well as Foreign shares of tradable goods in overall consumption. Corresponding to the results in the first exercise, the gains from cooperation of the fiscal authorities' ex post markets interventions is increasing in ρ but decreasing for higher trade integration as consumption risk sharing occurs stronger through trade itself.

In this numerical exercise, two result are worth being emphasized: First, the results show that monetary policy cooperation may lead to welfare losses when independent fiscal policymakers follow national interests only. Second, welfare gains from international public policy coordination - and in particular fiscal policy coordination when monetary authorities already cooperate - are quite large. Both points are in sharp contrast to the existing literature on international monetary policy coordination: First gains from cooperation are fairly small as they solely stem from ex post market interventions and exchange rate responses to shocks (with the exception of Cooley and Quadrini (2003), Arseneau (2007) and Evers (2007)). Second, the crucial role of fiscal policy responses to monetary cooperation is fully neglected.

7 Conclusion

The goal of this paper has been to analyze the interplay of monetary and fiscal policy domains in a world where countries are linked through trade. In particular, it is questioned that one can analyze the gains and losses of international arrangements that promote the coordination of either monetary or fiscal policy without taking into account the response of the remaining independent and non-cooperatively conducted public policy to this arrangement. This claim is addressed in a simple stochastic two-country sticky-wage model with a cash-in-advance restriction. In this environment, monetary authorities can affect the terms of trade by conducting a general short-run monetary policy using both the nominal interest rate and the money supply. Fiscal authorities can also affect the terms of trade by using distortionary taxes on labor income and consumption. It turns out that labor income taxes and nominal interest rates are perfectly substitutable national policy instruments when policymakers affect workers' optimal wage setting ex ante. The consumption tax and the money supply are perfectly substitutable national policy instruments when policymakers alter the consumption spending ex post. As a consequence, I find that international monetary policy coordination requires fiscal policy coordination, too, in order to fully skim off the gains from international policy coordination. Moreover, the numerical exercise suggests that letting the fiscal authorities act independently when monetary authorities cooperate might even lead to welfare losses.

Against this background, I adopt a critical stance on considering monetary policy coordination without taking into account the implications for fiscal policy conduct. The main argument is that as long as national monetary and fiscal authorities share the same objectives - in our case the respective residents' welfare - they do also share the same incentives to manipulate the terms of trade in their country's favor. Hence, as both national authorities do dispose of policy instruments to effectively alter the terms of trade, coordination of monetary policy in order to overcome strategic incentives of self-oriented national monetary policymakers - as it is argued in the literature - still leaves playground for fiscal policymakers to exploit their own monopoly power. The numerical example demonstrates that gains from monetary policy coordination are negligibly small or even negative (Table 2) even though gains from policy coordination in general might be large (Table 2 + Table 3). Therefore, the conclusion is that if one takes the game-theoretic arguments seriously - as one definitely should - the optimum policy domain where international coordination takes place must span the monetary policy as well as the fiscal policy.

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