Inter-government Monetary Cooperation, Centralization of Monetary Policies, and International Migration of Labor

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Abstract

Assuming a two-country economy with labor migration and efficiency wages, we investigate which of the two regimes—inter-government monetary cooperation between two independent monetary authorities or centralization of monetary policies by a single monetary authority under a monetary union—is advantageous under certainty and under supply or demand shocks. We show that the utility of the monetary authority does not differ across regimes under certainty, whereas centralization of the monetary policies under a monetary union tends to be advantageous to the monetary authority if a two-country economy is subject to supply or demand shocks. Further, we also show that the utility of workers does not differ across regimes under certainty and under supply or demand shocks. This suggests that in actual economies, which are interdependent on account of labor migration and are liable to be affected by shocks, centralization of the monetary policies under a monetary union appears to be preferable to inter-government monetary cooperation between the two independent monetary authorities.

JEL Classification: F42, E58, F22, J41, F41

Keywords: Inter-government monetary cooperation; Monetary union; Monetary policies; International migration of labor; Efficiency wages; Two-country economy

1. Introduction

This paper deals with monetary policy games in a two-country economy characterized by international migration of labor and efficiency wages. We compare the two regimes, i.e., inter-government monetary cooperation between the two independent monetary authorities and centralization of the monetary policies by a single monetary authority under a monetary union, and attempt to show that forming a monetary union and centralizing the monetary policies may prove to be advantageous if a two-country economy is subject to shocks. On the other hand, in the absence of shocks, even if the two countries do not form a monetary union, inter-government monetary cooperation gives the monetary authority and the workers the same utilities as those attainable under a monetary union.

Currently, it is impossible for many monetary authorities to ignore policy interdependence among countries. This is because countries have become increasingly interrelated not only on account of the growing volume of international trade of goods and flow of financial capital but also on account of the growing mobility of labor across borders.

Therefore, monetary policies are often decided upon cooperatively among countries without affecting the independence of the monetary authority of each country. In some cases, however, countries form a monetary union and centralize their monetary policies.

Needless to say, the question with regard to the optimal monetary regime in interdependent economies is not new. Studies pertaining to this question have produced a vast amount of literatures.[1] Hamada (1976), Oudiz and Sachs (1984), Canzoneri and Henderson (1988, 1991),

[1]See Persson and Tabelline (1995) and Daniels and VanHoose (1998) for an overview on this issue.

and Lewis (1989) are a few examples of the early contributors. Some argue that cooperation is preferable to non-cooperation, whereas others, such as Rogoff (1985), argue that non-cooperation is preferable to cooperation. Cooley and Quadrini (2003) studied the optimal monetary policies in a two-country economy under two regimes—multiple currencies controlled by independent monetary authorities and common currencies controlled by a centralized monetary authority. Pappa (2004) compared the three regimes, i.e., cooperation, non-cooperation, and monetary union in order to investigate the implications for macroeconomic stability and its welfare properties by assuming a two-country economy with monopolistic competition. Since the conclusions with regard to the optimal monetary regime depend on the type of economy that we aim to analyze, they are not uniform.

Although previous studies on the optimal monetary regimes assumed various types of open economies, they did not pay sufficient attention to the mobility of labor. Many of the open macroeconomic models used for the analyses of monetary policy games in interdependent economies overlook the possibility of international migration.

In contrast with the previous analyses, Agiomirgianakis (1998) assumed a symmetric two-country economy where the workers are assumed to migrate between the two countries due to the differences in real-consumption wages (nominal wages divided by the consumer price index).[2]

He showed that under the possibility of international migration of labor, inter-government

[2]See also Agiomirgianakis (1996, 1998, 1999, 2000); Agiomirgianakis and Zervoyianni (2001a, 2001b); and Shimada (2003, 2004, 2005a, 2005b) for the analyses of monetary policy games and international migration in open macroeconomic models.

monetary cooperation may prove to be advantageous. In particular, he revealed the fact that the utility of the monetary authority is likely to be higher when there is inter-government monetary cooperation rather than non-cooperation, whereas the utility of the workers does not differ across regimes.

In order to obtain this result, Agiomirgianakis modeled labor markets by assuming labor unions and determined nominal wages and employment in the same manner as that assumed in the monopoly union model.[3] He also modeled a symmetric two-country economy that is not subject to any shocks.

His result suggests that under the possibility of international migration of labor, it would be preferable for the monetary authorities of the two countries to cooperate with each other.[4] We may infer the following from his result. The monetary authority and the workers may be able to attain even higher utilities by centralizing the monetary polices under a monetary union since policy centralization under a monetary union is a more direct manner of cooperation.

However, we cannot immediately deduce the above implication from his result. This is because in his model, the monetary authority of each country does not lose its independence even under inter-government monetary cooperation and each country has its own currency and money market. Agiomirgianakis did not deal with the case where the two countries form a monetary union and one common monetary authority centralizes the monetary policies of the

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[3]See Dunlop (1944) and Oswald (1985) for the monopoly union model.

[4]Shimada (2005b) extended his analysis by assuming efficiency wages, i.e., the non-shirk model (Shapiro and Stiglitz 1984), and showed that inter-government monetary cooperation may prove to be advantageous not only to the monetary authority but also to the workers.

two countries.

Therefore, assuming a two-country economy with labor migration, this paper compares inter-government monetary cooperation between the two independent monetary authorities and centralization of the monetary policies by a single monetary authority under a monetary union, and attempts to ascertain which of the two regimes is advantageous to the monetary authority and the workers. Doing this will enable us to reveal the monetary regime that gives higher utilities to the monetary authority and the workers.

For this purpose, we assume efficiency wages, i.e., the non-shirk model, rather than labor unions, in order to model labor markets, since in reality, labor unions are not always influential in the determination of nominal wages and employment and are exogenous factors.[5] We also assume that a two-country economy may be affected by supply or demand shocks. Shocks are included in our model not only because actual economies are often subject to shocks but also because their existence is likely to change the ranking of alternative regimes.[6]

We demonstrate that if a two-country economy is not subject to any shocks, the utilities of the monetary authority and the workers are the same under both inter-government monetary cooperation and a monetary union. This can be explained as follows: In the absence of any shocks, the money market equilibrium conditions are virtually the same in the two regimes,

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[5]Efficiency wages in open economies with labor migration are, of course, not new. Assuming a dual labor market with efficiency wages, Carter (1999) analyzed the problem of illegal migration and Müller (2003) investigated the effects of migration on a small open economy.

[6]Agiomirgianakis and Zervoyianni (2001b) is one of the few studies that embrace shocks and examine their effects in an open economy with labor migration.

since the economic structures of the two countries are symmetric in both regimes. This suggests that the structural equations are virtually the same in the two regimes. Moreover, even if the two countries do not form a monetary union, under the possibility of international migration of labor, they can eliminate the negative effects arising from macroeconomic interdependence through migration flows by cooperating with each other. Therefore, if the two countries are not affected by shocks, cooperation between the two independent monetary authorities enables the monetary authority to attain the same utility as that under a monetary union. Moreover, the workers' utility does not differ across regimes, since their utility is dependent on the expectation of the consumer price index, which is the same under the two regimes.

We also demonstrate that if a two-country economy is subject to supply or demand shocks, centralization of the monetary policies by a single monetary authority under a monetary union may prove to be advantageous. This is can be explained as follows: Even if two countries are affected by shocks, cooperation between the two independent monetary authorities increases the utilities of the monetary authority and the workers. However, if two countries are subject to shocks, the economic structures of the two regimes are different. If two countries are affected by supply shocks, unemployment is more variable (has a larger variance) under a monetary union, whereas the consumer price index is more variable under inter-government monetary cooperation. If they are affected by demand shocks, both unemployment and the consumer price index are more variable under inter-government monetary cooperation. Therefore, under supply or demand shocks, if the monetary authority gives sufficient importance to the stability of the consumer price index, it can attain a higher utility by forming a monetary union and centralizing the monetary policies. Moreover, the utility of the workers does not differ across

regimes, since the expectation of the consumer price index is the same in both the regimes.

Our analysis has the following implications: If the two countries are not subject to any shocks and labor migrates between them, there is no need for them to form a monetary union. On the other hand, if they are affected by shocks and international migration of labor is possible, it would be preferable for both the countries to form a monetary union and centralize the monetary policies. Therefore, the question of whether the monetary authority of each country should retain its independence or whether the two countries should form a monetary union depends on the existence or non-existence of shocks.

The remainder of the paper is organized as follows: Section 2 presents a two-country macroeconomic model with labor migration and efficiency wages. The manner in which the workers migrate between the two countries will be assumed. Since a firm in each country cannot perfectly detect shirking by the workers, it sets nominal wages in a manner that would prevent shirking. Section 3 deals with a two-country economy under certainty, and we compare the utilities of the monetary authority and the workers under inter-government monetary cooperation between the two independent monetary authorities with those under a monetary union with a single monetary authority. A two-country economy is affected by supply shocks in Section 4 and demand shocks in Section 5, and the utilities of the monetary authority and the workers in the two regimes are compared. Section 6 presents the concluding comments.

2. The Model

We assume a two-country economy. The home and foreign countries are interdependent on account of international trade of goods and international migration of labor.

We assume two cases. In one case, each country has an independent monetary authority and both the countries have different currencies. In this case, each country has a money market and the monetary authority of each country can manipulate the stock of currency in each country. In another case, the two countries form a monetary union and they have a common monetary authority and a common currency. In this case, the two countries have a common money market and the common monetary authority manipulates the stock of the common currency.[7]

In either case, there are workers and a firm in each country. The workers are not organized into labor unions and are assumed to migrate between the two countries.

Each country's firm demands labor for producing a single type of product. Since the firm cannot perfectly detect shirking by workers, it sets nominal wages in a manner that would prevent shirking, treating the workers' effort and the money stock as given.

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[7]In this paper, we assume that the monetary policy decided by a common monetary authority affects the two countries through a common money market. However, this is not the only way to model a two-country economy and the monetary policy under a monetary union. By extending a two-country version of the Alesina and Tabellini (1987) model, van Aarle and Huart (1999) analyzed the interaction of monetary and fiscal policies under the Economic and Monetary Union (EMU). In their model, the European Central Bank (ECB) redistributes seignorage revenues (the increase of the European base money) between the two countries according to the percentage of shares they hold in the ECB. These redistributed revenues are included in the government budget constraints of the two countries. Accordingly, the monetary policy decided by the ECB is related to the two countries through the government budget constraint of each country.

The home (foreign) country's product is not only demanded in the home (foreign) country but also in the foreign (home) country, where it is exported. The products produced in the two countries are imperfect substitutes, and there are no financial capital movements between the two countries.

The structure of a two-country economy is summarized by Equations (1)–(7). These are similar to those employed by Jensen (1993), Zervoyianni (1997), Agiomirgianakis (1998), and Shimada (2004, 2005b). However, they did not deal with a case where the two countries form a monetary union. In contrast to these previous studies, this paper utilizes these equations to describe the two-abovementioned cases. Moreover, in this paper, a two-country economy may be affected by supply or demand shocks.[8] Variables are expressed in logs, unless specified otherwise. Variables without the asterisk represent the home country and those with the asterisk represent the foreign country.

$$y = al + u, \quad y^* = al^* + u^*, \quad 0 < a < 1. \tag{1}$$

$$l = -\frac{1}{1-a}(w-p) + \frac{1}{1-a}\ln a + \frac{1}{1-a}u, \quad l^* = -\frac{1}{1-a}(w^*-p^*) + \frac{1}{1-a}\ln a + u^*. \tag{2}$$

$$z \equiv ex + p^* - p. \tag{3}$$

$$y - y^* = bz, \quad b > 0. \tag{4}$$

$$q \equiv p + cz, \quad q^* \equiv p^* - cz, \quad 0 < c < 1/2. \tag{5}$$

$$w_c \equiv w - q, \quad w_c^* \equiv w^* - q^*. \tag{6}$$

$$m^d = p + y + v, \quad m^{*d} = p^* + y^* + v^*. \tag{7}$$

Equation (1) presents the production functions, where y represents output, l represents the employment level, and a is a constant not expressed in the log. Production may be

[8] Canzoneri and Henderson (1991) incorporated productivity disturbances into the production functions and demand disturbances into the demand for goods. As we will do in this paper, they assumed that disturbances are asymmetric in the two countries, although productivity disturbances were assumed to be symmetric in Canzoneri and Henderson (1988).

subject to supply shocks, which are represented by random variables u and u^* with zero mean and variance σ_u^2.[9] They are assumed to be independent of each other. All agents in a two-country economy have to make decisions with regard to migration, labor supply, labor demand, and the money stocks, prior to the realization of these shocks. They know only the means of these variables when they make their decisions.

Equation (2) presents the labor demand functions, where w represents nominal wages and p represents the product price. They are derived from profit maximization of each country's firm.

Equation (3) defines the real exchange rate z. In a case where each country has an independent monetary authority and its own currency, the nominal exchange rate, i.e., the home currency price of the foreign currency, ex changes in response to the changes in the trade balance. In another case where the two countries form a monetary union and have a common currency, exchange rate changes are ruled out by definition, i.e., $ex = 0$. In such a case, z can be interpreted as a relative price of the foreign country's product to the home country's product.

Equation (4) presents the equilibrium condition of the trade balances, where b is a constant not expressed in the log. The changes in the real exchange rates are assumed to have stronger effects on the trade balance than the changes in the difference between the two countries' national products, such that $b > 1$.[10] In a case where the two countries form a monetary union

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[9] Under certainty (Section 3) and under demand shocks (Section 5), u and u^* are assumed to be zero.

[10] See Shimada (2004), footnote 3, for the economic interpretation of b.

and have a common currency, Equation (4) can be considered as the demand functions for each country's product, according to which, the demand for the home (foreign) country's product increases with increases in the foreign (home) country's national product and the relative price of the foreign (home) country's product to the home (foreign) country's product.

Equation (5) defines the consumer price index q, where c is a constant not expressed in the log.[11] In the case of two independent monetary authorities, the home (foreign) country's consumer price index is a weighted average of the price of the home (foreign) country's product and the home (foreign) currency price of the foreign (home) country's product. In the case of a monetary union, it is a weighted average of the prices of the two countries' products.

Real-consumption wages w_c are defined by Equation (6).

Equation (7) presents the money demand functions. Money demand may be subject to demand shocks, which are represented by random variables v and v^* with zero mean and variance σ_v^2.[12] They are assumed to be independent of each other and also to be independent from u and u^*. All agents in a two-country economy know only the means of v and v^* when they make decisions about migration, labor supply, labor demand, and the money stocks.

Equation (7) enables us to define the money market equilibrium conditions as follows: In the case of two independent monetary authorities, the money markets are in equilibrium if each country's money demand is equal to the stock of each country's currency. On the other hand,

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[11]Residents of the home (foreign) country are assumed to have a preference for the goods produced in the home (foreign) country, such that $0 < c < 1/2$.

[12]Under certainty (Section 3) and under supply shocks (Section 4), v and v^* are assumed to be zero.

in the case of a monetary union, the money market is in equilibrium if the sum of two countries' money demand is equal to the stock of a common currency.

We assume that the workers migrate between the two countries due to the expected real-consumption wage differentials. Under uncertainty, real-consumption wages are affected by supply or demand shocks. In such a case, as mentioned before, the workers have to make their decisions with regard to migration prior to the realization of these shocks. For this reason, their decisions with regard to whether or not to migrate do not depend on the real-consumption wage differentials, but on their expectation with regards to the wages.

This assumption leads to the following definitions of the effective labor forces l^f :

$$l^f \equiv \bar{l} + d(Ew_c - Ew_c^*), \tag{8.1}$$

$$l^{*f} \equiv \bar{l}^* + d(Ew_c^* - Ew_c), \quad \bar{l} = \bar{l}^*, \tag{8.2}$$

where $\bar{l}$, which is a positive constant, denotes the domestic labor force in the absence of migration, i.e., the initial labor endowment, E denotes the expectation, and d, which is a positive constant not expressed in the log, measures the sensitivity of migration flows to changes in the expected real-consumption wage differentials. Equations (8.1) and (8.2) say that, for example, if the expected real-consumption wages in the home country are higher than those in the foreign country, then the native workers of the foreign country migrate to the home country by $d(Ew_c - Ew_c^*)$, and thereby the home country's effective labor force increases in comparison with its initial labor endowment.

The firm in each country sets nominal wages in a manner that would prevent shirking by the employed workers (Shapiro and Stiglitz, 1984) since, as mentioned before, each country's firm cannot perfectly detect whether or not the workers are shirking.

If a representative employed worker in each country does not shirk, his instantaneous utility

can be measured by the expected real-consumption wages minus effort. On the other hand, if he does shirk, his instantaneous utility is measured by the expected real-consumption wages. However, in such a case, he is detected and fired at the probability ρ, where $0 < \rho < 1$. This probability is assumed to be the same between the two countries. In addition, some of the employed workers in each country may separate from their jobs, even if they are not fired on the grounds of shirking. This separation rate, which is defined as the ratio of separations due to reasons other than shirking to the number of employed workers, is given by β, where $0 \leq \beta < 1$. The separation rate is assumed to be the same between the two countries.

The expected lifetime utility of a representative employed shirker in the home country V_E^S is,

$$rV_E^S = Ew_c + (\beta + \rho)(V_U - V_E^S), \tag{9}$$

where r is the discount rate, which is assumed to be the same between the two countries, and V_U is the expected lifetime utility of a representative unemployed worker in the home country. Equation (9) can be rewritten as,

$$V_E^S = \frac{Ew_c + (\beta + \rho)V_U}{r + \beta + \rho}. \tag{9'}$$

On the other hand, the expected lifetime utility of a representative employed non-shirker in the home country V_E^N is,

$$rV_E^N = Ew_c - \ln e + \beta(V_U - V_E^N), \tag{10}$$

where $e > 1$, and e, which is not expressed in the log, is effort exerted by a representative employed non-shirker in the home country. In this paper, the level of effort is given

exogenously and does not change throughout the analysis.[13] The level of effort exerted by a representative employed non-shirker is assumed to be the same between the two countries, i.e., $e = e^*$. Equation (10) can be rewritten as,

$$V_E^N = \frac{Ew_c - \ln e + \beta V_U}{r + \beta}. \tag{10'}$$

The employed workers in the home country may or may not shirk based on a comparison of V_E^N and V_E^S. In order to prevent them from shirking, the firm in the home country has to set nominal wages that are sufficiently high to ensure that $V_E^N \geq V_E^S$. However, because there is no reason for the firm in the home country to pay more than what is essential to eliminate shirking, it will set nominal wages such that $V_E^N = V_E^S (\equiv V_E)$. The following is obtained by substituting Equations (9') and (10') into this condition:

$$Ew_c = rV_U + (r + \beta + \rho)\frac{\ln e}{\rho}. \tag{11}$$

In turn, V_U is given by,

$$rV_U = E\ln\left(\frac{\overline{W}}{Q}\right) + \alpha(V_E - V_U), \tag{12}$$

where $\overline{W}$ is the unemployment benefit in the home country, which is a constant not expressed in the log, $Q \equiv \exp q$, and α, where $0 \leq \alpha < 1$, is the accession rate, which is defined as

[13]This is a simplifying assumption. However, the analysis will be more general if the employed workers determine the level of effort in such a way that their expected lifetime utility is maximized, given the nominal wages set by the firm. See Shimada (2005b) for the determination of the optimal level of effort.

the ratio of new hires in the home country to the number of workers unemployed in the home country. The accession rate is assumed to be the same between the two countries.

In order to simplify the analysis, we assume that there are no separations or accessions, i.e., $\beta = \alpha = 0$ and that $\overline{W} = \overline{W}^* = 1$.[14] Substituting these assumptions into Equations (11) and (12), nominal wages in the home country are derived as follows:

$$w = \left(1 + \frac{r}{\rho}\right) \ln e. \tag{13.1}$$

Equation (13.1) suggests that nominal wages in the home country increase with increases in the efforts of the employed workers in the home country and decrease with increases in the detection probability.[15]

The expected lifetime utility of a representative employed worker in the home country under the non-shirk condition takes the form of,

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[14]Carter (1998) made a similar assumption. He assumed that workers in the high-wage sector neither quit nor are separated from their jobs. This implies that there are no new hires in that sector, since, in steady state, the number of the workers separating from their jobs due to reasons other than shirking must be equal to the number of unemployed workers finding the jobs.

[15]Given the efforts of the employed workers in the home country, nominal wages in the home country do not change, which implies that migration has no effects on nominal wages. This comes from the assumption $\beta = \alpha = 0$. Without this assumption, in steady state α will be determined to satisfy $\beta L = \alpha(L^f - L)$, where $L \equiv \exp l$ and $L^f \equiv \exp l^f$. In this case, migration is likely to affect nominal wages, since α changes with migration.

$$V_E = -\frac{Eq}{r} + \frac{\ln e}{\rho}. \tag{14.1}$$

Equation (14.1) says that under the non-shirk condition, the expected lifetime utility of a representative employed worker in the home country decreases with increases in the home country's expected consumer price index.[16]

By a similar argument, nominal wages and the expected lifetime utility of a representative employed worker in the foreign country are obtained as follows:

$$w^* = \left(1 + \frac{r}{\rho}\right)\ln e^*, \tag{13.2}$$

$$V_E^* = -\frac{Eq^*}{r} + \frac{\ln e^*}{\rho}. \tag{14.2}$$

According to Equations (13.1), (13.2), (14.1), and (14.2), the nominal wages of the home and foreign countries are the same and the expected lifetime utility of a representative employed worker is symmetric between the two countries.[17]

We assume that each country wants to attain full employment and the consumer price index target. Accordingly, if the monetary authorities of the two countries are independent, they have the following utility functions:

$$V_{PA} = -E\{(l - l^f)^2\} - hE(q^2), \quad h > 0, \tag{15.1}$$

$$V_{PA}^* = -E\{(l^* - l^{*f})^2\} - hE(q^{*2}), \tag{15.2}$$

where h, which is a constant not expressed in the log, reflects the relative weight assigned by the monetary authorities to the consumer price index as against employment. Equations (15.1)

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[16]Under the non-shirk condition, the expected lifetime utility of a representative unemployed worker in the home country is $-Eq/r$.

[17]The expected lifetime utility of a representative unemployed worker is also symmetric between the home and foreign countries.

and (15.2) say that monetary authorities dislike deviations of the actual levels of employment from the effective labor forces, i.e., unemployment, and changes in the consumer price index.[18] The above-mentioned equations can be rewritten as the functions of means and variances of unemployment and the consumer price index.

$$V_{PA} = -\{E(l - l^f)\}^2 - h(Eq)^2 - Var(l - l^f) - hVar(q). \quad (15.1')$$

$$V_{PA}^* = -\{E(l^* - l^{*f})\}^2 - h(Eq^*)^2 - Var(l^* - l^{*f}) - hVar(q^*). \quad (15.2')$$

In the case of two independent monetary authorities, we focus our analysis on the inter-government monetary cooperation regime, where the monetary authorities of the home and foreign countries manipulate the stock of the two countries' currencies in such a manner that the sum of their utilities is maximized.[19]

On the other hand, if the two countries form a monetary union and have a single monetary authority, the monetary authority's utility function is $V_{PA} + V_{PA}^*$ and the monetary authority attempts to maximize it by controlling the stock of a common currency.

3. The Economy under Certainty

In this section, we assume a two-country economy without any shocks, i.e., u, u^*, v, and v^* are zero, and we compare the utilities of the monetary authority and the workers under inter-government monetary cooperation and a monetary union.

Since the two-country economy is not subject to any shocks, the utility functions of the monetary authorities (Equations 15.1 and 15.2) under inter-government monetary cooperation

[18] In order to simplify the analysis, the consumer price index target is assumed to be zero.

[19] Under inter-government monetary cooperation, independent monetary authorities might have an incentive to cheat. However, we do not assume such a possibility.

can be rewritten as,

$$V_{PA} = -(l - l^f)^2 - hq^2,$$
$$V^*_{PA} = -(l^* - l^{*f})^2 - hq^{*2}.$$

Under inter-government monetary cooperation, as mentioned before, since each country has a money market, the money markets in the home and foreign countries without demand shocks are in equilibrium if the following conditions are satisfied:

$$m = p + y, \quad m^* = p^* + y^*, \tag{16}$$

where m and m^* denote the home and foreign countries' money stocks under the two independent monetary authorities.

Structural equations under inter-government monetary cooperation, i.e., Equations (1)–(6) and (16), where $u, u^*, v, v^* = 0,$ can be solved for $l, l^*, y, y^*, p, p^*, z, q, q^*, w_c,$ and w^*_c as functions of $w, m,$ and m^*.[20]

$$l = m - w + \ln a. \tag{17.1}$$
$$l^* = m^* - w + \ln a. \tag{17.2}$$
$$y = a(m - w) + a \ln a. \tag{17.3}$$
$$y^* = a(m^* - w) + a \ln a. \tag{17.4}$$
$$p = (1 - a)m + aw - a \ln a. \tag{17.5}$$
$$p^* = (1 - a)m^* + aw - a \ln a. \tag{17.6}$$
$$z = \frac{a}{b}(m - m^*). \tag{17.7}$$
$$q = \left(1 - a + \frac{ac}{b}\right)m - \frac{ac}{b}m^* + aw - a \ln a. \tag{17.8}$$
$$q^* = \left(1 - a + \frac{ac}{b}\right)m^* - \frac{ac}{b}m + aw - a \ln a. \tag{17.9}$$
$$w_c = -\left(1 - a + \frac{ac}{b}\right)m + \frac{ac}{b}m^* + (1 - a)w + a \ln a. \tag{17.10}$$

[20] Structural equations are the same as those of Shimada (2005b). Henceforth, $w = w^*$ will be used for the derivation of the reduced form equations. The equality of nominal wages in the two countries comes from Equations (13.1) and (13.2).

$$w_c^* = -\left(1 - a + \frac{ac}{b}\right)m^* + \frac{ac}{b}m + (1-a)w + a\ln a. \tag{17.11}$$

Since the monetary authorities in the two countries cooperate with each other, they will set their money stocks such that the sum of their utilities is maximized, i.e., they will solve,

$\max_{m,m^*} V_{PA} + V_{PA}^*$ subject to (17.1), (8.1), (17.10), (17.11), (17.8), (17.2), (8.2), and (17.9).[21]

The first order conditions imply that $m = m^*$.[22] This gives us the following relation between the consumer price index and unemployment:

$$q = -\frac{1}{h(1-a)}(l - l^f). \tag{18}$$

Utilizing Equation (18), the money stocks under inter-government monetary cooperation without any shocks are derived as follows:

$$m = m^* = \frac{\{1 - ah(1-a)\}(1 + r/\rho)\ln e + h(1-a)a\ln a}{1 + h(1-a)^2} \ (\equiv m^{IGC}\big|_{u,u^*,v,v^*=0}). \tag{19}$$

Equation (19) shows that the money stocks do not depend on the sensitivity of migration flows to changes in the expected real-consumption wage differentials. This is because the monetary authorities are aware of the fact that the influence of a domestic monetary expansion for reducing unemployment through the induced fall in the effective labor force will be offset by an equal expansion abroad. Accordingly, the monetary authorities do not utilize monetary expansions to induce migration flows and thereby to reduce unemployment. Therefore, as suggested by Agiomirgianakis (1998), macroeconomic interdependence through migration flows is not operative.

Unemployment and the consumer price index are given as follows:

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[21] $\bar{l} = \bar{l}^* = \ln a$ is assumed throughout the paper.

[22] The same money stocks in the two countries suggest that $z = 0$, $y = y^*$, and $p = p^*$. Accordingly, even if the two countries have different currencies, under certainty, $ex = 0$.

$$l - l^f = l^* - l^{*f} = \frac{h(1-a)\{-(1+r/\rho)\ln e + a\ln a\}}{1+h(1-a)^2} \ (\equiv [l-l^f]^{IGC}\big|_{u,u^*,v,v^*=0}), \tag{20}$$

$$q = q^* = -\frac{-(1+r/\rho)\ln e + a\ln a}{1+h(1-a)^2} \ (\equiv q^{IGC}\big|_{u,u^*,v,v^*=0}). \tag{21}$$

The utilities of the monetary authority and the employed workers under inter-government monetary cooperation without any shocks can be calculated by substituting Equations (20) and (21) into Equations (14.1), (14.2), (15.1), and (15.2).[23]

Under a monetary union, as mentioned before, since the two countries have a common money market, the money market without demand shocks is in equilibrium if the following condition is satisfied:

$$m^{MU} = p + y + p^* + y^*, \tag{22}$$

where m^{MU} denotes the money stock under a monetary union.

Through appropriate substitutions, the model of Equations (1)–(6) and (22), where $ex = 0$ and $u,\ u^*,\ v,\ v^* = 0,$ can be solved for $l,\ l^*,\ y,\ y^*,\ p,\ p^*,\ z,\ q,\ q^*,\ w_c,$ and w_c^* as functions of w and m^{MU}.

$$l = l^* = \frac{m^{MU}}{2} - w + \ln a. \tag{23.1}$$

$$y = y^* = \frac{a}{2}m^{MU} - aw + a\ln a. \tag{23.2}$$

$$p = p^* = q = q^* = \frac{1-a}{2}m^{MU} + aw - a\ln a. \tag{23.3}$$

$$z = 0. \tag{23.4}$$

$$w_c = w_c^* = -\frac{1-a}{2}m^{MU} + (1-a)w + a\ln a. \tag{23.5}$$

If the two-country economy is not affected by any shocks, the difference in the two countries' national products depends only on the difference in the two countries' product prices, as suggested by Equations (1) and (2), since nominal wages are the same in the two countries.

[23]The expected lifetime utility of a representative unemployed worker in the home and foreign countries can be calculated by substituting Equation (21) into $-Eq/r$ and Eq^*/r.

This implies that even under a monetary union, the product prices and thereby the national products are the same in the two countries, since, in Equation (4) with $ex = 0$, both the difference in the two countries' national products (the left-hand side) and the real exchange rate (the right-hand side) depend only on the difference in the two countries' product prices. Consequently, the two countries have the same money demand, suggesting that the right-hand side of Equation (22) can be rewritten as $2(p + y)$. In addition, the money stock under a monetary union m^{MU} is equivalent to the sum of the two countries' money stocks under inter-government monetary cooperation, i.e., $m + m^*$ $(= 2m)$. As a result, the money market equilibrium condition under a monetary union can be rewritten as $2m = 2(p + y)$. This implies that the money market equilibrium condition under a monetary union is virtually the same as the one under inter-government monetary cooperation. Therefore, under certainty, we have virtually the same structural equations and thereby the same reduced form equations in the two regimes.[24]

The monetary authority, i.e., the common monetary authority of the two countries, manipulates the money stock in such a way as to maximize $V_{PA} + V_{PA}^*$, i.e., the countries will solve,

$$\max_{m^{MU}} V_{PA} + V_{PA}^* \quad \text{subject to (8.1), (8.2), (23.1), (23.3), and (23.5).}$$

The first order condition gives us the following relation between the consumer price index and unemployment:

$$q = -\frac{1}{h(1-a)}(l - l^f). \tag{24}$$

Equations (18) and (24) suggest that the consumer price index and unemployment are in the

[24] This can be understood by replacing $m^{MU}/2$ with m in Equations (23.1)–(23.5).

same relation under both inter-government monetary cooperation and a monetary union. This is because, as explained before, the structural equations and the utility function under a monetary union are virtually the same as those under two independent monetary authorities.

Utilizing Equation (24), the money stock under a monetary union without any shocks is derived as follows:

$$m^{MU} = \frac{2[\{1-ah(1-a)\}(1+r/\rho)\ln e + h(1-a)a\ln a]}{1+h(1-a)^2} (\equiv m^{MU}\big|_{u,u^*,v,v^*=0}). \qquad (25)^{25}$$

Equation (25) suggests that the money stock does not depend on d. This is because the monetary authority does not utilize monetary policies to induce migration flows and thereby to reduce unemployment. Therefore, macroeconomic interdependence through migration flows is not operative under a monetary union.

Unemployment and the consumer price index are given as follows:

$$l - l^f = l^* - l^{*f} = \frac{h(1-a)\{-(1+r/\rho)\ln e + a\ln a\}}{1+h(1-a)^2} \ (\equiv [l-l^f]^{MU}\big|_{u,u^*,v,v^*=0}), \qquad (26)$$

$$q = q^* = -\frac{-(1+r/\rho)\ln e + a\ln a}{1+h(1-a)^2} \ (\equiv q^{MU}\big|_{u,u^*,v,v^*=0}). \qquad (27)$$

Equations (20), (21), (26), and (27) suggest that, without any shocks, there is no difference between inter-government monetary cooperation and a monetary union with respect to unemployment and the consumer price index.

This implies that,

$$V_{PA}^{IGC}\big|_{u,u^*,v,v^*=0} = V_{PA}^{*IGC}\big|_{u,u^*,v,v^*=0} = V_{PA}^{MU}\big|_{u,u^*,v,v^*=0} = V_{PA}^{*MU}\big|_{u,u^*,v,v^*=0},$$

$$V_{E}^{IGC}\big|_{u,u^*,v,v^*=0} = V_{E}^{*IGC}\big|_{u,u^*,v,v^*=0} = V_{E}^{MU}\big|_{u,u^*,v,v^*=0} = V_{E}^{*MU}\big|_{u,u^*,v,v^*=0}.$$

Therefore, $V_{PA}+V_{PA}^*$ and the utilities of the employed and unemployed workers do not

[25] $m^{MU}\big|_{u,u^*,v,v^*=0} = 2m^{IGC}\big|_{u,u^*,v,v^*=0}$.

differ under inter-government monetary cooperation and a monetary union.[26] In other words, under certainty, the monetary authorities and all the workers can attain the same utility in either regime.

This result can be explained as follows: Since the economic structures of the two countries are symmetric in either regime, they have virtually the same economic structure in the two regimes under certainty, regardless of whether each country has a money market or the two countries have a common money market. Moreover, even if each country has an independent monetary authority, by cooperating with each other, the two countries can eliminate the negative effects on the utilities of the monetary authority and the workers arising from macroeconomic interdependence through migration flows, i.e., the higher consumer price index due to the monetary expansion to induce migration flows and thereby to reduce unemployment. This enables the monetary authority and the workers under inter-government monetary cooperation to achieve the same utilities as those achieved under a monetary union.

4. The Economy under Supply Shocks

In this section, the two-country economy is assumed to be subject to supply shocks, i.e., $u,\ u^* \neq 0,\ v, v^* = 0,$ and we compare the utilities of the monetary authority and the workers under inter-government monetary cooperation and a monetary union.

Structural equations in the inter-government monetary cooperation regime under supply

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[26] As done under the inter-government monetary cooperation regime, the expected lifetime utility of a representative unemployed worker in the home and foreign countries can be calculated by substituting Equation (27) into $-Eq/r$ and Eq^*/r.

shocks, i.e., Equations (1)–(6) and (16), where $u, u^* \neq 0$ and $v, v^* = 0,$ can be solved for $l, l^*, y, y^*, p, p^*, z, q, q^*, w_c,$ and w_c^* as functions of $w, m,$ and m^*.

$$l = m - w + \ln a. \tag{28.1}$$
$$l^* = m^* - w + \ln a. \tag{28.2}$$
$$y = a(m - w) + a \ln a + u. \tag{28.3}$$
$$y^* = a(m^* - w) + a \ln a + u^*. \tag{28.4}$$
$$p = (1 - a)m + aw - a \ln a - u. \tag{28.5}$$
$$p^* = (1 - a)m^* + aw - a \ln a - u^*. \tag{28.6}$$
$$z = \frac{a}{b}(m - m^*) + \frac{1}{b}(u - u^*). \tag{28.7}$$
$$q = \left(1 - a + \frac{ac}{b}\right)m - \frac{ac}{b}m^* + aw - a \ln a + \left(-1 + \frac{c}{b}\right)u - \frac{c}{b}u^*. \tag{28.8}$$
$$q^* = \left(1 - a + \frac{ac}{b}\right)m^* - \frac{ac}{b}m + aw - a \ln a + \left(-1 + \frac{c}{b}\right)u^* - \frac{c}{b}u. \tag{28.9}$$
$$w_c = -\left(1 - a + \frac{ac}{b}\right)m + \frac{ac}{b}m^* + (1 - a)w + a \ln a - \left(-1 + \frac{c}{b}\right)u + \frac{c}{b}u^*. \tag{28.10}$$
$$w_c^* = -\left(1 - a + \frac{ac}{b}\right)m^* + \frac{ac}{b}m + (1 - a)w + a \ln a - \left(-1 + \frac{c}{b}\right)u^* + \frac{c}{b}u. \tag{28.11}$$

Equations (28.1), (28.2), (28.10), and (28.11) as well as (17.1), (17.2), (17.10), and (17.11) suggest that the expectation of unemployment under supply shocks is equal to that of unemployment under certainty. Similarly, Equations (28.8) and (28.9) as well as (17.8) and (17.9) suggest that the expectation of the consumer price index under supply shocks is equal to that of the consumer price index under certainty. Moreover, the variances of unemployment and the consumer price index are independent of the money stocks. Therefore, Equations (15.1') and (15.2') suggest that utility maximization in the inter-government monetary cooperation regime under supply shocks gives us the same money stocks as those under certainty (Equation 19).

This implies that,

$$[-\{E(l - l^f)\}^2]^{IGC}\Big|_{u,u^* \neq 0,v,v^*=0} - [h(Eq)^2]^{IGC}\Big|_{u,u^* \neq 0,v,v^*=0} = V_{PA}^{IGC}\Big|_{u,u^*,v,v^*=0}, \tag{29}$$
$$[-\{E(l^* - l^{*f})\}^2]^{IGC}\Big|_{u,u^* \neq 0,v,v^*=0} - [h(Eq^*)^2]^{IGC}\Big|_{u,u^* \neq 0,v,v^*=0} = V_{PA}^{*IGC}\Big|_{u,u^*,v,v^*=0}. \tag{30}$$

On the other hand, the variances of unemployment and the consumer price index under supply shocks are as follows:

$$Var(l-l^f)^{IGC}\Big|_{u,u^*\neq 0,v,v^*=0} = Var(l^*-l^{*f})^{IGC}\Big|_{u,u^*\neq 0,v,v^*=0} = 0, \tag{31}$$

$$Var(q)^{IGC}\Big|_{u,u^*\neq 0,v,v^*=0} = Var(q^*)^{IGC}\Big|_{u,u^*\neq 0,v,v^*=0} = \left\{\left(-1+\frac{c}{b}\right)^2+\left(\frac{c}{b}\right)^2\right\}\sigma_u^2. \tag{32}$$

The utility of the monetary authority can be calculated by substituting Equations (29), (30), (31), and (32) into Equations (15.1') and (15.2'); the utility of the employed workers can be calculated by substituting Equations (28.8) and (28.9) into Equations (14.1) and (14.2).

Structural equations under a monetary union, i.e., Equations (1)–(6) and (22), where $ex = 0$, $u,\ u^* \neq 0$ and $v, v^* = 0$, can be solved for $l,\ l^*,\ y,\ y^*,\ p,\ p^*,\ z,\ q,\ q^*,\ w_c$, and w_c^* as functions of $w,\ m$, and m^*.

$$l = \frac{m^{MU}}{2} - w + \ln a + \frac{1}{2(1-a)}\left\{1-\frac{1}{a+b(1-a)}\right\}(u-u^*). \tag{33.1}$$

$$l^* = \frac{m^{MU}}{2} - w + \ln a + \frac{1}{2(1-a)}\left\{1-\frac{1}{a+b(1-a)}\right\}(u^*-u). \tag{33.2}$$

$$y = \frac{a}{2}m^{MU} - aw + a\ln a + \left\{-\frac{a}{2(1-a)}\frac{1}{a+b(1-a)}+\frac{1-1/a}{1-a}\right\}u - \frac{a}{2(1-a)}\left\{1-\frac{1}{a+b(1-a)}\right\}u^*. \tag{33.3}$$

$$y^* = \frac{a}{2}m^{MU} - aw + a\ln a + \left\{-\frac{a}{2(1-a)}\frac{1}{a+b(1-a)}+\frac{1-1/a}{1-a}\right\}u^* - \frac{a}{2(1-a)}\left\{1-\frac{1}{a+b(1-a)}\right\}u. \tag{33.4}$$

$$p = \frac{1-a}{2}m^{MU} + aw - a\ln a - \frac{1}{2}\left\{\frac{1}{a+b(1-a)}+1\right\}u - \frac{1}{2}\left\{-\frac{1}{a+b(1-a)}+1\right\}u^*. \tag{33.5}$$

$$p^* = \frac{1-a}{2}m^{MU} + aw - a\ln a - \frac{1}{2}\left\{\frac{1}{a+b(1-a)}+1\right\}u^* - \frac{1}{2}\left\{-\frac{1}{a+b(1-a)}+1\right\}u. \tag{33.6}$$

$$z = \frac{1}{a+b(1-a)}(u-u^*). \tag{33.7}$$

$$q=\frac{1-a}{2}m^{MU}+aw-a\ln a-\frac{1}{2}\left\{\frac{1-2c}{a+b(1-a)}+1\right\}u-\frac{1}{2}\left\{-\frac{1-2c}{a+b(1-a)}+1\right\}u^{*}. \quad (33.8)$$

$$q^{*}=\frac{1-a}{2}m^{MU}+aw-a\ln a-\frac{1}{2}\left\{\frac{1-2c}{a+b(1-a)}+1\right\}u^{*}-\frac{1}{2}\left\{-\frac{1-2c}{a+b(1-a)}+1\right\}u. \quad (33.9)$$

$$w_c=-\frac{1-a}{2}m^{MU}+(1-a)w+a\ln a+\frac{1}{2}\left\{\frac{1-2c}{a+b(1-a)}+1\right\}u+\frac{1}{2}\left\{-\frac{1-2c}{a+b(1-a)}+1\right\}u^{*}. \quad (33.10)$$

$$w_c^{*}=-\frac{1-a}{2}m^{MU}+(1-a)w+a\ln a+\frac{1}{2}\left\{\frac{1-2c}{a+b(1-a)}+1\right\}u^{*}+\frac{1}{2}\left\{-\frac{1-2c}{a+b(1-a)}+1\right\}u. \quad (33.11)$$

If a two-country economy is affected by supply shocks, reduced form equations under a monetary union are different from those under inter-government monetary cooperation. This is because the money market equilibrium conditions are not affected by supply shocks under inter-government monetary cooperation (Equations 28.3 and 28.5), whereas the money market equilibrium condition is affected by supply shocks under a monetary union (Equations 33.3 and 33.5). This implies that the money market equilibrium condition under a monetary union is different from the one under inter-government monetary cooperation, making the economic structures different in the two regimes.

However, Equations (33.1), (33.2), (33.8), (33.9), (33.10), and (33.11) imply that the expectations of unemployment and the consumer price index under supply shocks are equal to those of unemployment and the consumer price index under certainty. In addition, variances of unemployment and the consumer price index do not depend on the money stock. Accordingly, Equations (15.1') and (15.2') suggest that utility maximization by the monetary authority gives us the same money stock as that under certainty (Equation 25). Therefore, the sum of the first and second terms of Equation (15.1') (Equation 15.2') under supply shocks is equal to

$V_{PA}^{MU}\big|_{u,u^*,v,v^*=0}$ ($V_{PA}^{*MU}\big|_{u,u^*,v,v^*=0}$).[27]

On the other hand, the variances of unemployment and the consumer price index under supply shocks are as follows:

$$Var(l-l^f)^{MU}\big|_{u,u^*\neq 0,v,v^*=0} = Var(l^*-l^{*f})^{MU}\big|_{u,u^*\neq 0,v,v^*=0} = \frac{(1-b)^2}{2\{a+b(1-a)\}^2}\sigma_u^2, \tag{34}$$

$$Var(q)^{MU}\big|_{u,u^*\neq 0,v,v^*=0} = Var(q^*)^{MU}\big|_{u,u^*\neq 0,v,v^*=0} = \frac{1}{2}\left[\left\{\frac{1-2c}{a+b(1-a)}\right\}^2+1\right]\sigma_u^2. \tag{35}$$

The utility of the monetary authority can be calculated by utilizing $V_{PA}^{MU}\big|_{u,u^*,v,v^*=0}$, $V_{PA}^{*MU}\big|_{u,u^*,v,v^*=0}$, Equations (34), and (35); the utility of the employed workers can be calculated by substituting Equations (33.8) and (33.9) into Equations (14.1) and (14.2).

According to Equations (31) and (34),

$$Var(l-l^f)^{IGC}\big|_{u,u^*\neq 0,v,v^*=0} = Var(l^*-l^{*f})^{IGC}\big|_{u,u^*\neq 0,v,v^*=0}$$
$$< Var(l-l^f)^{MU}\big|_{u,u^*\neq 0,v,v^*=0} = Var(l^*-l^{*f})^{MU}\big|_{u,u^*\neq 0,v,v^*=0}.$$

We can explain this as follows: In either regime, the effective labor forces are not stochastic. Under inter-government monetary cooperation, the direct effects of supply shocks on labor demand and the indirect effects of the supply shocks on labor demand—which take place through the product price—offset each other, thereby making employment non-stochastic, as shown by Equations (28.1) and (28.2). On the other hand, under a monetary union, the domestic supply shocks directly affect the domestic labor demand. Moreover, as Equations (33.5) and (33.6) show, not only the domestic but also the foreign supply shocks indirectly affect the domestic labor demand through the product price. This is because the two countries have a

[27]This implies that the ranking of the utilities of the monetary authority under the two regimes is determined by the variances of unemployment and the consumer price index arising from supply shocks.

common money market. The direct and indirect effects of the supply shocks on the labor demand do not offset each other, thereby making employment stochastic under a monetary union (Equations 33.1 and 33.2).[28]

According to Equations (32) and (35),

$$Var(q)^{IGC}\Big|_{u,u^*\neq 0,v,v^*=0} = Var(q^*)^{IGC}\Big|_{u,u^*\neq 0,v,v^*=0}$$
$$> Var(q)^{MU}\Big|_{u,u^*\neq 0,v,v^*=0} = Var(q^*)^{MU}\Big|_{u,u^*\neq 0,v,v^*=0}.$$

The above equations can be explained as follows: Supply shocks affect the consumer price index through the product price and the real exchange rate. Equations (28.5) and (28.6) as well as Equations (33.5) and (33.6) show that the effects of supply shocks on the product price under inter-government monetary cooperation are stronger than those under a monetary union.[29] On the other hand, Equations (28.7) and (33.7) show that the effects of supply shocks on the real exchange rate under a monetary union are stronger than those under inter-government monetary cooperation.[30] Since the effects of the supply shocks on the consumer price index through the product price are stronger than those through the real exchange rate, the consumer price index

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[28] $Var(l)^{MU}\Big|_{u,u^*\neq 0,v,v^*=0} = Var(l^*)^{MU}\Big|_{u,u^*\neq 0,v,v^*=0} = [(1-b)^2/2\{a+b(1-a)\}^2]\sigma_u^2.$ This is equal to the variance of unemployment under a monetary union (Equation 34).

[29] $Var(p)^{IGC}\Big|_{u,u^*\neq 0,v,v^*=0} = Var(p^*)^{IGC}\Big|_{u,u^*\neq 0,v,v^*=0} = \sigma_u^2.$ $Var(p)^{MU}\Big|_{u,u^*\neq 0,v,v^*=0} = Var(p^*)^{MU}\Big|_{u,u^*\neq 0,v,v^*=0}$ $= (1/2)[1/\{a+b(1-a)\}^2 + 1]\sigma_u^2.$ Since $a+b(1-a)>1,$ the variance of the product price is larger under inter-government monetary cooperation than under a monetary union.

[30] $Var(z)^{IGC}\Big|_{u,u^*\neq 0,v,v^*=0} = Var(z^*)^{IGC}\Big|_{u,u^*\neq 0,v,v^*=0} = 2(1/b)^2\sigma_u^2.$ $Var(z)^{MU}\Big|_{u,u^*\neq 0,v,v^*=0}$ $= Var(z^*)^{MU}\Big|_{u,u^*\neq 0,v,v^*=0} = 2[1/\{a+b(1-a)\}^2]\sigma_u^2.$ Since $a+b(1-a)<b,$ the variance of the real exchange rate is larger under a monetary union than under inter-government monetary cooperation.

has a larger variance under inter-government monetary cooperation than under a monetary union.

Therefore, if h is large and the effects of the larger variance of the consumer price index under inter-government monetary cooperation dominate, $V_{PA} + V_{PA}^{*}$ may be larger under a monetary union than under inter-government monetary cooperation. However, if h is small and the effects of the larger variance of unemployment under a monetary union dominate, $V_{PA} + V_{PA}^{*}$ may be larger under inter-government monetary cooperation than under a monetary union.[31]

In other words, under supply shocks, a monetary union may prove to be advantageous to the monetary authority if it gives greater importance to the stability of the consumer price index, whereas inter-government monetary cooperation may prove to be advantageous to the monetary authority if it gives greater importance to the reduction of unemployment.

This result can be explained as follows: Even in the presence of supply shocks, cooperation between the two independent monetary authorities makes it possible for them to eliminate the negative effects arising from the possibility of labor migration between the two countries and macroeconomic interdependence. However, if the two countries are affected by supply shocks and greater importance is given to the stability of the consumer price index, negative effects on the inter-government monetary cooperation regime due to supply shocks will partly offset the positive effects due to cooperation. This will lead to a lower utility of the monetary authority under inter-government monetary cooperation.

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[31] If h is sufficiently large, then $V_{PA}^{MU} + V_{PA}^{*MU} > V_{PA}^{IGC} + V_{PA}^{*IGC}$. On the contrary, if h 0, then $V_{PA}^{MU} + V_{PA}^{*MU} < V_{PA}^{IGC} + V_{PA}^{*IGC}$.

Since the expectations of the consumer price index under supply shocks do not differ across regimes, the utilities of the employed and unemployed workers take the same values under both inter-government monetary cooperation and a monetary union.

These results have the following implications: In the presence of supply shocks, whether the two countries should form a monetary union or should remain independent and cooperate in the conduct of the monetary policy depends on how much importance is given to the stability of the consumer price index. If the two countries give substantial importance to the stability of the consumer price index, it would be preferable for them to form a monetary union.

5. The Economy under Demand Shocks

In this section, the two-country economy is assumed to be subject to demand shocks, i.e., $u,\ u^* = 0,\ v, v^* \neq 0,$ and we compare the utilities of the monetary authority and the workers under inter-government monetary cooperation and a monetary union.

Structural equations in the inter-government monetary cooperation regime under demand shocks, i.e., Equations (1)–(6), and the money market equilibrium conditions $m = p + y + v$ and $m^* = p^* + y^* + v^*,$ where $u,\ u^* = 0$ and $v, v^* \neq 0,$ can be solved for $l,\ l^*,\ y,\ y^*,\ p,\ p^*,\ z,$ $q,\ q^*,\ w_c,$ and w_c^* as functions of $w,\ m,$ and m^*.

$$l = m - w + \ln a - v. \tag{36.1}$$
$$l^* = m^* - w + \ln a - v^*. \tag{36.2}$$
$$y = a(m - w) + a \ln a - av. \tag{36.3}$$
$$y^* = a(m^* - w) + a \ln a - av^*. \tag{36.4}$$
$$p = (1 - a)m + aw - a \ln a - (1 - a)v. \tag{36.5}$$
$$p^* = (1 - a)m^* + aw - a \ln a - (1 - a)v^*. \tag{36.6}$$
$$z = \frac{a}{b}(m - m^*) - \frac{a}{b}(v - v^*). \tag{36.7}$$
$$q = \left(1 - a + \frac{ac}{b}\right)m - \frac{ac}{b}m^* + aw - a \ln a - \left(1 - a + \frac{c}{b}\right)v + \frac{ac}{b}v^*. \tag{36.8}$$

$$q^* = \left(1 - a + \frac{ac}{b}\right)m^* - \frac{ac}{b}m + aw - a\ln a - \left(1 - a + \frac{c}{b}\right)v^* + \frac{ac}{b}v. \tag{36.9}$$

$$w_c = -\left(1 - a + \frac{ac}{b}\right)m + \frac{ac}{b}m^* + (1-a)w + a\ln a + \left(1 - a + \frac{c}{b}\right)v - \frac{ac}{b}v^*. \tag{36.10}$$

$$w_c^* = -\left(1 - a + \frac{ac}{b}\right)m^* + \frac{ac}{b}m + (1-a)w + a\ln a + \left(1 - a + \frac{c}{b}\right)v^* - \frac{ac}{b}v. \tag{36.11}$$

According to Equations (36.1), (36.2), (36.10), and (36.11) as well as Equations (17.1), (17.2), (17.10), and (17.11), the expectation of unemployment under demand shocks is equal to that of unemployment under certainty. Similarly, according to Equations (36.8) and (36.9) as well as (17.8) and (17.9), the expectation of the consumer price index under demand shocks is equal to that of the consumer price index under certainty. Moreover, the variances of unemployment and the consumer price index are independent of the money stocks. Therefore, as under supply shocks, Equations (15.1') and (15.2') suggest that utility maximization in the inter-government monetary cooperation regime under demand shocks gives us the same money stocks as those under certainty (Equation 19).

This implies that,

$$[-\{E(l - l^f)\}^2]^{IGC}\Big|_{u,u^*=0,v,v^*\neq 0} - [h(Eq)^2]^{IGC}\Big|_{u,u^*=0,v,v^*\neq 0} = V_{PA}^{IGC}\Big|_{u,u^*,v,v^*=0}, \tag{37}$$

$$[-\{E(l^* - l^{*f})\}^2]^{IGC}\Big|_{u,u^*=0,v,v^*\neq 0} - [h(Eq^*)^2]^{IGC}\Big|_{u,u^*=0,v,v^*\neq 0} = V_{PA}^{*IGC}\Big|_{u,u^*,v,v^*=0}. \tag{38}$$

On the other hand, the variances of unemployment and the consumer price index under demand shocks are as follows:

$$Var(l - l^f)^{IGC}\Big|_{u,u^*=0,v,v^*\neq 0} = Var(l^* - l^{*f})^{IGC}\Big|_{u,u^*=0,v,v^*\neq 0} = \sigma_v^2, \tag{39}$$

$$Var(q)^{IGC}\Big|_{u,u^*=0,v,v^*\neq 0} = Var(q^*)^{IGC}\Big|_{u,u^*=0,v,v^*\neq 0} = \left\{\left(1 - a + \frac{ac}{b}\right)^2 + \left(\frac{ac}{b}\right)^2\right\}\sigma_v^2. \tag{40}$$

The utility of the monetary authority can be calculated by substituting Equations (37), (38), (39), and (40) into Equations (15.1') and (15.2'); the utility of the employed workers can be calculated by substituting Equations (36.8) and (36.9) into Equations (14.1) and (14.2).

Structural equations under a monetary union, i.e., (1)–(6), and the money market equilibrium condition $m^{MU} = p + y + v + p^* + y^* + v^*$, where $ex = 0$, u, $u^* = 0$ and $v, v^* \neq 0$, can be solved for l, l^*, y, y^*, p, p^*, z, q, q^*, w_c, and w_c^* as functions of w, m, and m^*.

$$l = l^* = \frac{m^{MU}}{2} - w + \ln a - \frac{v + v^*}{2}. \tag{41.1}$$

$$y = y^* = \frac{a}{2} m^{MU} - aw + a \ln a - \frac{a}{2}(v + v^*). \tag{41.2}$$

$$p = p^* = q = q^* = \frac{1-a}{2} m^{MU} + aw - a \ln a - \frac{1-a}{2}(v + v^*). \tag{41.3}$$

$$z = 0. \tag{41.4}$$

$$w_c = w_c^* = -\frac{1-a}{2} m^{MU} + (1-a)w + a \ln a + \frac{1-a}{2}(v + v^*). \tag{41.5}$$

If the two-country economy is affected by demand shocks, the reduced form equations under a monetary union are different from those under inter-government monetary cooperation. This is because the product prices and the national products in the two countries are the same under a monetary union (Equations 41.3 and 41.2), whereas they are different in the two countries under inter-government monetary cooperation (Equations 36.5, 36.6, 36.3, and 36.4). As a result, the money market equilibrium conditions are different in the two regimes, making the structural equations and thereby the reduced form equations different under the two regimes.

However, Equations (41.1), (41.3), and (41.5) imply that the expectations of unemployment and the consumer price index under supply shocks are equal to those of unemployment and the consumer price index under certainty. In addition, the variances of unemployment and the consumer price index do not depend on the money stock. Accordingly, as under supply shocks, Equations (15.1') and (15.2') suggest that utility maximization by the monetary authority gives us the same money stock as that under certainty (Equation 25). Therefore, the sum of the first and second terms of Equation (15.1') (Equation 15.2') under demand shocks is equal to

$V_{PA}^{MU}\big|_{u,u^*,v,v^*=0}$ ($V_{PA}^{*MU}\big|_{u,u^*,v,v^*=0}$).[32]

On the other hand, the variances of unemployment and the consumer price index under demand shocks are as follows:

$$Var(l-l^f)^{MU}\big|_{u,u^*=0,v,v^*\neq 0} = Var(l^*-l^{*f})^{MU}\big|_{u,u^*=0,v,v^*\neq 0} = \frac{\sigma_v^2}{2}, \tag{42}$$

$$Var(q)^{MU}\big|_{u,u^*=0,v,v^*\neq 0} = Var(q^*)^{MU}\big|_{u,u^*=0,v,v^*\neq 0} = \frac{(1-a)^2}{2}\sigma_v^2. \tag{43}$$

According to Equations (39) and (42),

$$Var(l-l^f)^{IGC}\big|_{u,u^*=0,v,v^*\neq 0} = Var(l^*-l^{*f})^{IGC}\big|_{u,u^*=0,v,v^*\neq 0}$$
$$> Var(l-l^f)^{MU}\big|_{u,u^*=0,v,v^*\neq 0} = Var(l^*-l^{*f})^{MU}\big|_{u,u^*=0,v,v^*\neq 0}.$$

We can explain this as follows: Under inter-government monetary cooperation, since each country has its own money market and demand shocks affect employment indirectly through the product price, only domestic demand shocks affect the product price and thereby employment. On the other hand, under a monetary union, since the two countries have a common money market, not only domestic but also foreign demand shocks affect the product price, making employment subject to domestic and foreign demand shocks. However, the effects of demand shocks on employment are weaker under a monetary union than under inter-government monetary cooperation. Moreover, as mentioned before, the effective labor forces are not stochastic in either regime. This implies that the variance of unemployment is larger under inter-government monetary cooperation than under a monetary union.

According to Equations (40) and (43),

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[32] As in a case where the two-country economy is affected by supply shocks, this implies that the ranking of the utilities of the monetary authority under the two regimes is determined by the variances of unemployment and the consumer price index arising from demand shocks.

$$Var(q)^{IGC}\Big|_{u,u^*=0,v,v^*\neq 0} = Var(q^*)^{IGC}\Big|_{u,u^*=0,v,v^*\neq 0}$$
$$> Var(q)^{MU}\Big|_{u,u^*=0,v,v^*\neq 0} = Var(q^*)^{MU}\Big|_{u,u^*=0,v,v^*\neq 0}.$$

The above equations can be explained as follows: Under inter-government monetary cooperation, demand shocks affect the consumer price index through the product price and the real exchange rate, as can be seen by Equations (36.5), (36.6), and (36.7). On the other hand, as Equations (41.3) and (41.4) show, under a monetary union, demand shocks affect the consumer price index only through the product price. Since the effects of demand shocks on the consumer price index are stronger under inter-government monetary cooperation, the variance of the consumer price index is larger under this regime.

Therefore, $V_{PA} + V_{PA}^*$ is larger under a monetary union than under inter-government monetary cooperation. In other words, when the two-country economy is subject to demand shocks, a monetary union is always advantageous to the monetary authority.

This can be explained as follows: As explained in the cases of certainty and supply shocks, even if the monetary authorities are independent, cooperation between them increases their utilities. However, under demand shocks, these positive effects are always partly offset by the negative effects arising from demand shocks, i.e., the larger variances of unemployment and the consumer price index. This implies that a monetary union is advantageous to the monetary authority.

Since the expectations of the consumer price index under the demand shocks are the same in both the regimes, despite being affected by demand shocks, the utilities of the employed and unemployed workers are the same under both inter-government monetary cooperation and a monetary union.

The result in this section suggests that it would be preferable for the two countries to form a

monetary union if they are affected by demand shocks.

6. Conclusions

Using a two-country macroeconomic model with international migration of labor and efficiency wages, we compared the utilities of the monetary authority and the workers under the regimes of inter-government monetary cooperation and a monetary union, assuming that the two countries may be affected by supply or demand shocks.

We showed that under certainty, there is no difference in the utility of the monetary authority between both regimes; whereas, under supply or demand shocks, centralization of the monetary policies by a single monetary authority under a monetary union may prove to be advantageous to the monetary authority. We also showed that the utility of the workers is the same in both the regimes not only under certainty but also under supply or demand shocks.

Our results imply that the question of whether or not countries should form a monetary union is dependent on the existence or non-existence of shocks, and that if the countries are subject to supply or demand shocks, which is very likely in actual economies, it would be preferable for them to form a monetary union and centralize their monetary policies.

Acknowledgements

I am deeply indebted to George M. Agiomirgianakis and Dipak R. Basu for providing many encouraging comments and helpful suggestions. This paper was presented at the 5th annual meeting of the European Economics and Finance Society. I am grateful to the participants at the conference for helpful comments and valuable suggestions. Of course, any shortcomings of the paper are my responsibility.

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