Effects of Monetary Policy Coordination on Small Open Economies

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ABSTRACT

This paper proposes an innovative approach for analyzing the influence of external shocks on small open economies. This approach has two new features: First, it incorporates the role of large-country monetary policy coordination in influencing shocks. Second, it categorizes types of external effects into two. The direct effects are propagated by international market surprises. The indirect effects are the shocks which pass through another country before reaching the small open economy. Simulation results show that indirect effects are significantly large and their size depends on where the shock originated from and on the policy coordination regime followed by large countries.

Key Words: External shocks, small open economy, monetary policy coordination, efficient monetary policy frontier.

JEL Classifications: E52, E58, F41, F36

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1. Introduction

This paper analyzes the impact of external shocks on small open economies. The effects of these shocks have been discussed in the literature by authors such as Dornbusch (1985), Calvo, Leiderman and Reinhart (1993) and Reinhart and Reinhart (2001). There's a common element among the analyses offered by all of these authors: they have all treated external shocks as independent, without regard to the markets and policies that generate and moderate these shocks before they reach a small open economy. This paper improves upon this literature by recognizing and incorporating the role of large-country markets and policy in the shocks transmitted to the small open economies.

External shocks may affect a small open economy either directly or indirectly. In this paper, "direct shocks" refer to those that are propagated by surprises that drive the world markets. "Indirect shocks" are those that pass through another country before reaching the small open economy. In the case of indirect shocks, surprises that drive international markets affect large-country behavior. The spillovers from the decisions of that country's policymakers and the response of the market in that country are then transmitted to the small open economy. As the transmission takes place, the shock comes to reflect the policy stance of the country through which it passes. The interaction of the large country with the rest of the world also plays a role, with the shock reaching to the small open economy taking a different shape when there is policy coordination among these countries. The existing literature limits itself to direct shocks -indirect shocks are ignored. In this paper, I demonstrate that the indirect effects are both different than and are as important as direct effects.

We can see an illustration of direct and indirect shocks in the case of Mexico and the oil price hikes of the 1970s. World oil markets experienced two price hikes in the 1970s: an increase from 2.80 dollars to 12 dollars per barrel between 1973 and 1974 and from 15 dollars to 40 dollars per barrel in 1979. The direct effect on government revenues and inflation rate was felt immediately in Mexico. The indirect effect was determined by the industrial countries' response to the shock. The timing of the first oil price hike coincided with the breakdown of the Bretton Woods system. The response of industrial countries to this shock was rather limited and to a certain extent still coordinated (Meyer et al 2002). The world economies did not experience dramatic exchange rates fluctuations in that period. As a result, the indirect effect was not severe either. Export revenues increased, the Mexican economy had improved access to external borrowing, and Mexico became one of the most active borrowers of that time (Yergin 1993).

The second oil price hike illustrates how changed responses of the large countries affected the intensity of the indirect shock. The Fed, which did not respond strongly to high and rising inflation rates before 1979, began to follow a radically different policy with the appointment of Paul Volcker as the new chairman. The nominal three-month U.S. Treasury bill rate increased to 20 percent in 1980 and stayed high until 1982. Other industrialized countries such as Germany, Japan and the U.K. who had started to follow contractionary policies in the mid 1970s, tightened their policies further after the second hike. That is to say, each country tightened its monetary policy without coordinating its policy with other large countries.[1] These contractionary policies, while decreasing inflation in these countries, also transmitted a series of interest rate and demand reduction shocks to small open economies such as Mexico. The cost of loans taken by Mexico rose due to the link to the U.S. interest rate or LIBOR. Interest payments on accumulated debt increased sharply. Schaffer (2005) indicates that Mexico's interest bill tripled from 2.3 billion dollars in 1979 to 6.1 billion dollars in 1982. The increased interest rates in the developed countries led investors to lose confidence in countries like Mexico. As a result, the Mexican economy suffered a severe recession. By the end of the 1982, inflation was in the three-digit range. This crisis was so harmful that the 1980s has been called a "lost decade" for Mexico. Although there were other factors contributing to the debt crisis, overall the indirect effects of the oil price hikes through world financial and product markets played a significant role in the Mexican crisis.

The approach introduced in this article offers three advantages over the current literature. First, the example above shows that the small open economy is actually hit by two sets of shocks at the same time: the market-based shock and the impact of policy reactions of large economies to the original shock. This indirect effect can be even larger than the direct effect. Therefore, ignoring the indirect effect can lead to deceptive results in measuring impact. Second, the current literature does not take into account the initial shock and starts with the

[1] According to Meyer et al (2002) "The elections of Margaret Thatcher and Ronald Reagan led to a cessation of serious attempts at policy coordination in the early 1980s, as these leaders tended to favor unilateral action and were generally suspicious of international coordination in all spheres."

policy shock right away. Since the size of the policy responses depends on the scale of the initial shock, ignoring this initial size effect makes evaluations of the policy shocks less precise. In addition to this, in real life policy makers are not able to stabilize their economies completely. Residuals of initial shocks will be transmitted to the small open economies together with the policy spillover. The approach introduced in this article corrects for the size effect, allows for the residuals of the initial shocks and a larger variety of policy shocks to influence the small open economy at the same time.

The third and most important advantage of this approach is that it takes the interactions between large economies into account. Due to the web of relationships among world economies, the externalities created by the policy actions of a country give rise to policy conflicts with other countries and therefore policy responses. When these responses are determined in an uncoordinated way, i.e. based on individual country self interest, reactions can be "too much" or "not enough" as each country tries to gain an advantage at the expense of the others. On the other hand, when the countries engage in joint welfare maximization, they internalize the costs or benefits of the spillovers. The degree of coordination between large countries is important for small open economies, since the indirect effects will be shaped by the degree of policy coordination among large countries. In the 1979 oil price shock example above, monetary policy decisions among industrial countries taken in an uncoordinated way intensified the interest-rate shock to the Mexican economy.

In analyzing the influence of external shocks on small open economies, this last effect cannot be captured by simply changing the size of the initial shock, or by increasing the variety of shocks. To take this impact into account, the interactions between large countries should be modeled in detail. For this purpose, in the theoretical section of the analysis, a small open economy model and a two-large-country model are brought together. The impact of external shocks on the small open economy is then examined through[2] volatility tables and efficient policy frontiers.

[2] Impulse response functions are available upon request.

2. Literature Review

While the small open economy literature has not studied indirect effects in detail before, we see that it recognizes the importance of coordination between large countries on small open economies. In a discussion on the U.S.-Europe competition to appreciate their currencies in 1980s in the aftermath of oil price shocks, McKibbin and Sachs (1991) and Frankel and Roubini (2001) both note the potential impact that coordination would have on small open economies. According to Frankel and Roubini (2001) "…the outcome of this ultimately futile race was high world real interest rates. The developing countries, though innocent bystanders, were said to be the victims hardest-hit". McKibbin and Sachs (1991) suggest that the G7 countries should have entered a cooperative agreement to refrain from attempts to appreciate their currencies, and thereby lower world real interest rates. They see this as the biggest possible contribution of the large countries in helping solve the international debt problem. Reinhart and Reinhart (2001) investigate the impact of a possible target zone arrangement among G3 countries on developing countries. While they do not perform a thorough analysis of monetary policy coordination, they recognize the fact that G3 countries can contribute to small open economies by decreasing their exchange rate volatilities. The common suggestion of these papers is that coordination among large countries could create positive externalities for small open economies.

While there's been some recognition that indirect effects may be important, their role has not been examined by the empirical literature. Canova (2005) analyzes the effect of foreign monetary policy shocks on small open economies. Dornbusch (1985) and Izquierdo et al (2007) analyze the influence of large country business cycles on small open economies. Calvo, Leiderman and Reinhart (1993) and Fernandez-Arias (1996) analyze the influence of rates of return in developed countries in explaining capital flows to developing countries. All of these articles analyze the direct effects of the external shocks, ignoring the indirect effects.

As in the case of empirical works, theoretical articles analyzing the small open economies focus on direct effects of external shocks. Articles such as Clarida, Gali and Gertler (2002), McCallum and Nelson (2001) and Gali and Monacelli (2005) treat foreign shocks including policy shocks as exogenous processes. Svensson (2000) does go further and introduces a central bank reaction function for the foreign country which reacts to exogenous shocks to inflation and output gap. Svensson treats large country policy shocks as responses to exogenous supply and demand shocks. Therefore, he considers the indirect effect only for policy shocks, but as with the other articles in this literature, he models the rest of the world as consisting of one large country. This approach misses the influence of coordination on the policy shocks.

Support for the approach proposed in this article can be found in the large-open-economy literature. This literature recognizes the fact that foreign country policy shocks are actually reactions to supply and demand shocks. They analyze policy alternatives to see if large countries can improve their welfare by coordinating their policies. Early articles in this literature such as Canzoneri and Gray (1985), Canzoneri and Henderson (1991) and Oudiz and Sachs (1985) analyze this issue by using the old Keynesian multiplier setup for both static and dynamic games and find that gains are possible for coordination regimes. Recent articles such as Obstfeld and Rogoff (2002), Corsetti and Pesenti (2001) and Liu and Pappa (2008) use New-Keynesian models which incorporate optimizing households, monopolistic competition, and some form of nominal inertia. Among these articles, those that incorporate more macroeconomic interdependence and those that introduce asymmetries between countries have a tendency to find more gains from coordination between large countries. In this article, I take a similar approach but analyze the effect of coordination between large countries on small open economies.

In the next section, I will introduce the small-open-economy model developed by Svensson (2000). I will then extend Svensson's model by combining it with Clarida, Gali, Gertler (2002)'s large country model to capture the indirect effects. After the introduction of the theoretical model, the simulation results will be presented.

3. Theoretical Model

3.1. A Small Open Economy Model

Svensson (2000) introduces a small open economy model that is well-suited to analyze the influence of external shocks on a typical emerging market economy. The representative agent in this model consumes both domestic and foreign goods. In addition to being used as a consumption good, the foreign good is also used in production. In line with empirical evidence for small countries, the imported good is priced in the currency of the producer. While financial markets have not been explicitly modeled, the assumption of unitary elasticity of substitution between domestic and foreign goods provides complete market results in this model[3].

In addition to these, Svensson (2000) has two other features which are useful in analyzing the influence of external shocks. First, it carefully models the exchange rate channel, which is very important in evaluating external shocks. Second, Svensson introduces a lag structure which provides a realistic lag length for the transmission of monetary policy. He recognizes the fact that it takes time for monetary policy to influence the real economy. He assumes that it takes a longer time for monetary policy to influence domestic inflation than for aggregate demand and the CPI.

The foreign world is assumed to consist of one country in Svensson (2000) as customary in this literature. The response of the foreign central bank to exogenous shocks is endogenized to a certain extent with the introduction of a Taylor rule for the foreign monetary authority. With the introduction of a three-country model, I will take this approach a step further and completely endogenize the large-country policy choices.

Below I introduce the basic equations of Svensson (2000). In this section, the variable $z_{t+\tau|t}$ denotes the rational expectation of $z_{t+\tau}$ at time t.

Phillips Curve:

In modeling domestic inflation, the model combines the Calvo-type Phillips curve and the Fuhrer and Moore (1995) Phillips curve. Therefore, domestic inflation Π_t depends on lagged and future inflation, together with previous expectations of the output gap, x_t. The real exchange rate term in the Phillips curve, q_t, is associated with the existence of imported raw materials. u_t in this equation represents the cost-push shock hitting the small open economy.

$$\Pi_t = \alpha_\pi \Pi_{t-1} + \left(1-\alpha_\pi\right)\Pi_{t+1|t-2} + \alpha_y\left(x_{t|t-2} + \beta_y\left(x_{t-1} - x_{t-1|t-2}\right)\right) + \alpha_q q_{t|t-2} + u_t \qquad (1)$$

[3] See David and Doyle (2003) for details.

CPI Equation:

Because of the existence of foreign goods in the consumption basket, the CPI depends on the real exchange rate directly.

$$\Pi_t^c = \Pi_t + \omega\left(q_t - q_{t-1}\right) \tag{2}$$

where Π_t^c is CPI inflation and ω is the share of imported goods in CPI.

IS Equation:

The IS equation in Svensson (2000) has an unusual functional form. While in a typical IS curve in this literature today's output gap is associated with expected output gap in the next period, in Svensson (2000) output gap today is also influenced by the previous period's output gap. The reason for this is that he assumes that aggregate demand adjusts only partially. In accordance with this assumption, aggregate demand is taken to be a convex combination of lagged aggregate demand and today's expectations of future output demand.

$$x_t = \beta_y x_{t-1} - \beta_\rho \rho_{t|t-1} + \beta_{y*} y^*_{t|t-1} + \beta_q q_{t|t-1} - \left(\gamma_y^n - \beta_y\right) y_{t-1}^n + v_t - \eta_t^n \tag{3}$$

Current real interest rates:

$$r_t \equiv i_t - \Pi_{t+1|t} \tag{4}$$

Sum of the current and expected future real interest rates:

$$\rho_t \equiv \sum_{\tau=0}^{\infty} r_{t+\tau|t} \tag{5}$$

The UIP condition:

$$i_t - i_t^* = e_{t+1|t} - e_t + \varphi_t \tag{6}$$

The real interest parity condition:

$$q_{t+1|t} = q_t + i_t - \Pi_{t+1|t} - i_t^* + \Pi_{t+1|t}^* - \varphi_t \qquad (7)$$

The definition of real exchange rate:

$$q_t = e_t + p_t^* - p_t \qquad (8)$$

UIP Shock:

$$\varphi_t = \gamma_\varphi \varphi_{t-1} + \zeta_{\varphi,t} \qquad (9)$$

Policy Rule:

Svensson (2000) compares the performance of different policy rules. In the first part of the simulations, one of those policy rules, which is given below, will be used. In the second part, the optimal policy response is going to be derived.

$$i_t = 1.5\Pi_t + 0.5x_t \qquad (10)$$

3.2. A Two-Large-Country Model

The two-country model that will be combined with the Svensson (2000) needs to be compatible with this model in terms of main assumptions. Moreover, it needs to be in a general equilibrium framework to be able to reflect different aspects of the interaction between large countries. The model developed by Clarida, Gali and Gertler (2002) satisfies these properties. As in Svensson (2000), this model also assumes nominal price stickiness. Nominal prices are set on a staggered basis as in Calvo (1983). Both models assume perfect exchange rate pass-through. In modeling the financial markets, Clarida, Gali and Gertler (2002) make complete financial markets assumption, which is in line with Svensson (2000)'s unitary elasticity of substitution assumption. Additionally, the two-country model of Clarida, Gali and Gertler (2002) analyzes the gains from coordination for the large countries and this model provides a convenient setup for tracing the path shocks follow before reaching the small country.

3.2.A. Details of the Two-Country Model

This is a two-country general equilibrium model in which markets are complete and countries are symmetric in every aspect. Since workers are assumed to have market power, exogenous variation in this market power generates cost push pressure on inflation. The model has a producer currency pricing scheme and the foreign country's output has a place in the consumption basket of the representative agent.

Foreign output is one of the determinants of the domestic marginal cost of production. It has "terms of trade" and "wealth" impacts on marginal cost. The first impact is related to the influence of foreign output on the relative prices. The second impact is related to the influence of foreign output on domestic consumption. The total effect of foreign output on marginal cost is summarized by the parameter $\kappa_0 = \gamma(\sigma - 1)$ below. The value of this parameter depends on country size and the value of the inverse intertemporal elasticity of substitution. By following the literature, the inverse intertemporal elasticity of substitution, σ , is going to be taken to be equal to 2 in the following section. Therefore, the wealth effect outweighs the terms of trade effect. When the output in one country increases, foreign workers' desire to work increases and the other country's marginal cost of production goes up.

The main characteristics of the model described above result in the following equations. Below, the subscripts A and B represent the nationality of the variables in the large countries. In this section, I will present equations that belong to A. Symmetric equations will apply to B as well.

IS Equation:

$$x_{A,t} = x_{A,t+1|t} - \sigma_0^{-1}\left(i_{A,t} - \Pi_{A,t+1|t} - r\overline{r}_{A,t}\right) + v_{A,t} \qquad (11)$$

where $x_{A,t}$ is Country A's output gap which is defined as the difference between output and the natural output level, $x_{A,t} = y_{A,t} - \overline{y}_{A,t}$. $i_{A,t}$ is the nominal interest rate, $\Pi_{A,t+1|t}$ is expected domestic inflation rate, $r\overline{r}_{A,t}$ is the natural interest rate in A and $v_{A,t}$ is the demand shock.

Phillips Curve:

$$\Pi_{A,t} = \beta \Pi_{A,t+1|t} + \lambda x_{A,t} + u_{A,t} \qquad (12)$$

This is a typical new Keynesian Phillips curve where domestic inflation depends on expected inflation and the output gap. Exogenous variation in the market power of the labor force generates cost push pressure on inflation.

Flexible Price Output:

$$\overline{y}_{A,t} = \kappa^{-1}\left[\left(1+\phi\right)a_{A,t} - \kappa_0 y_{B,t}\right] \qquad (13)$$

The natural output depends on an exogenous technology parameter $a_{A,t}$ and foreign country output. The reason why foreign output is seen in this equation is related to the impact of foreign output on marginal cost of production. Since in the flexible price equilibrium real marginal cost of production is constant and κ_0 is taken to be greater than zero, an increase in foreign output pushes natural output down.

Natural Interest Rate:

$$r\overline{r}_{A,t} = \sigma_0\left(\overline{y}_{A,t+1|t} - \overline{y}_{A,t}\right) + \kappa_0\left(y_{B,t+1|t} - y_{B,t}\right) \qquad (14)$$

The natural interest rate depends not only on domestic productivity, but also on the expected growth in the world output.

Cost Push Shock:

$$u_{A,t} = \rho u_{A,t-1} + \varepsilon_{A,t}\ . \qquad (15)$$

The cost-push shock follows an AR (1) process and $\varepsilon_{A,t}$ is the random component of this shock.

The model is closed with an optimal monetary policy rule. Two cases have been considered here. In the non-cooperative Nash case, each central bank follows an independent monetary policy. In the coordination case, policy makers of A and B determine their policies together.

Non-cooperative Nash Solution:

In the non-cooperative Nash case, the central banks have concern only for the domestic output gap and domestic inflation. The optimal monetary policy requires the central bank to respond only to a change in the domestic inflation expectations. The optimal interest rate rule in the Nash case is

$$i_{A,t} = r\overline{r}_{A,t} + \vartheta \Pi_{A,t+1|t} \text{ where } \vartheta = 1 + \frac{\xi \sigma_0 (1-\rho)}{\rho} > 1 \tag{16}$$

Cooperative Solution:

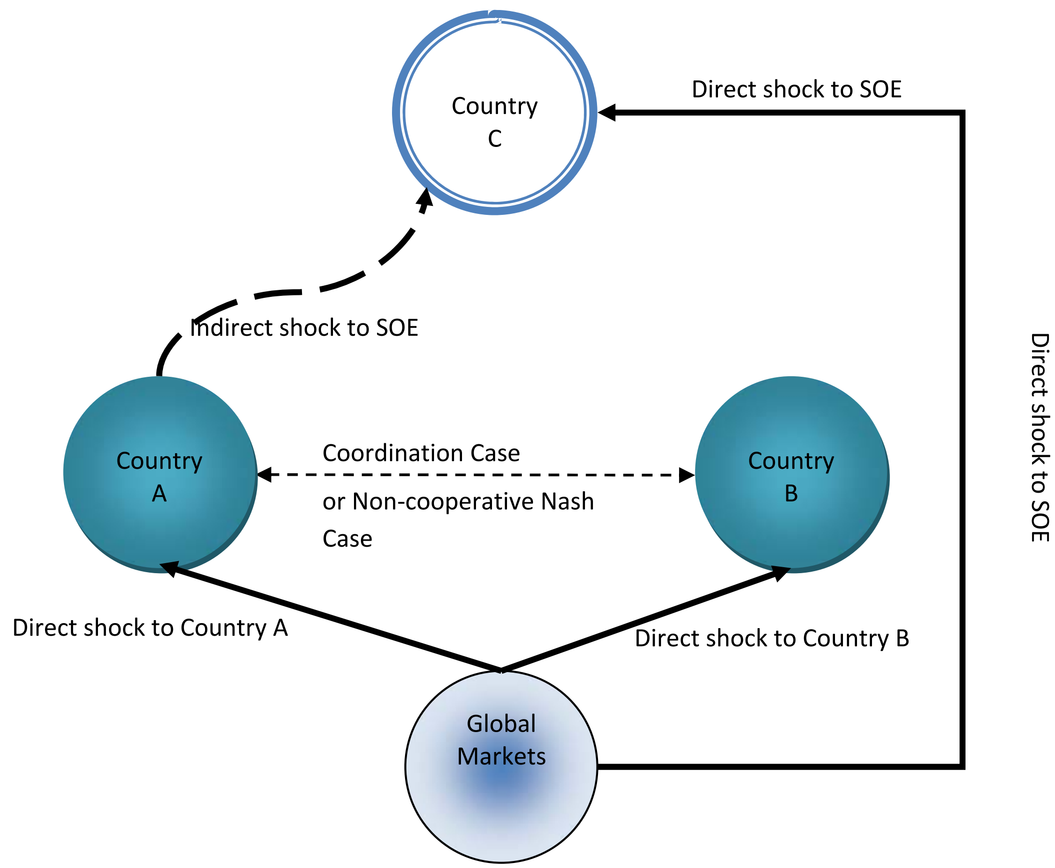
In the cooperative case a common objective function has been optimized by A's and B's policymakers. The solution to this optimization problem gives the following optimal interest rate rule

$$i_{A,t} = r\overline{r}_{A,t} + \vartheta \Pi_{A,t+1|t} + \frac{\kappa_0}{\kappa}(\vartheta - 1)\Pi_{B,t+1|t} \tag{17}$$

Therefore, depending on the monetary policy regime followed by A and B, monetary authorities respond only to domestic or to domestic and foreign inflation expectations.

$y_t^* = x_{A,t}$

Figure 1: Illustration of Simplified Version of Direct and Indirect Shocks



3.3. Connections between the Small Open Economy and the Rest of the World:

To simplify the analysis, the small country is assumed to have trade and financial connections with only one of the large countries, Country A. Therefore, foreign country variables in the small open economy model will be the variables that belong to Country A.

$$i_t^* = i_{A,t} \tag{18}$$

$$\Pi_t^* = \Pi_{A,t} \tag{19}$$

$$y_t^* = x_{A,t} \tag{20}$$

Figure 1 above illustrates a global cost-push shock influencing A, B and C. In this figure, the size of an indirect shock is going to be determined by both A and B. Even if C does not have direct connections with B, B will influence the value of the shock and additionally will transmit the shocks influencing its economy to C through A.

4. Simulation Results

In this section, simulation results of direct and indirect effects of external cost-push shocks on the small open economy are presented. For this purpose, indirect effects of shocks influencing only A, only B and both A and B will be examined below.

The three-country-model is going to be modified as needed in the simulations. First of all, instead of using coefficients of equation (10), the coefficients of the Taylor rule are going to be derived optimally in section 4.3.B. Secondly, in addition to the changes in the coefficients of the model and characteristics of shocks, new features such as debt stock will be introduced into the model in the sensitivity analysis[4] in order to replicate common characteristics of emerging market economies.

4.1. Analysis of the Indirect Effects under Different Policy Regimes

In this section, the influence of cost push shocks on A and B will be presented. As it can be seen from equation (12), cost-push shocks increase inflation expectations in the country they hit. Therefore, this country will tighten its policy under both coordinated and non-coordinated regimes.

Table 1 below presents the standard deviations computed from the simulation of a one-standard-deviation shock to $\varepsilon_{A,t}$, and to $\varepsilon_{A,t}$ and $\varepsilon_{B,t}$ at the same time. In the third and fourth column, volatilities under non-coordinated and coordinated regime are presented respectively. These shocks are assumed to be persistent with a 0.9 autocorrelation coefficient.

[4] The sensitivity analysis is presented in Appendix 2.

Table 1: The Volatility of Macroeconomic Variables of Large Countries*

		Non-coordinated Regime	Coordinated Regime
Cost-Push Shock to A	$\Pi_{A,t}$	1.062	1.148
	$x_{A,t}$	10.701	10.639
	$r_{A,t}$	1.585	1.577
	$\Pi_{B,t}$	0.000	0.315
	$x_{B,t}$	0.000	0.228
	$r_{B,t}$	0.069	0.102
Cost-Push Shock to A and B	$\Pi_{A,t}$	1.062	0.833
	$x_{A,t}$	10.701	10.867
	$r_{A,t}$	1.654	1.679
	$\Pi_{B,t}$	1.062	0.833
	$x_{B,t}$	10.701	10.867
	$r_{B,t}$	1.654	1.679

**Source: Author's calculations.*

Case 1: Shock Influences only Country A

When the monetary authority in A tightens its policy in response to a cost-push shock, the decline in A's output increases workers' desire to work in B. Therefore A's response to a cost-push shock decreases marginal cost of production and increases natural output in B. Under the non-cooperative case, the monetary authority in B stabilizes only its domestic output gap and moves nominal rates in order to stabilize the change in its natural output. As it can be seen from Table 1, there are no inflation spillovers to B under this regime.

Under the cooperative regime, B's policy makers respond not only to a change in its domestic inflation expectations, but also to a change in inflation expectations in A. The more B tightens, the more A's marginal cost will go down and the more A will benefit from that. Therefore, B's monetary policy is tightened more than needed to stabilize its domestic output under the coordinated regime. As a result there will be a negative inflation spillover to B. On the other hand, with the help of B's response, A stabilizes its economy by increasing its real interest rates less than how much they would increase in the non-coordinated regime. B's benefit from the coordination is limited to the decline in the marginal cost spillover from A to B in this regime.

Case 2: Perfectly Correlated Shocks to A and B

When perfectly correlated supply shocks influence both A and B at the same time, monetary policy in A and B will be tightened under both the coordinated and the non-coordinated regimes. Each policy maker will respond to this shock by focusing only on its domestic shock under the non-coordinated regime. They will respond to the indirect effect of the other country's shock only to the extent that it influences their natural output. However, under the coordinated regime the optimal policy response to the indirect effect of the other country's shock will be more than stabilizing the influence on the natural output. Therefore, the real interest rates in A and B would increase more under the coordinated regime than the uncoordinated regime.

4.2. Volatility of Macroeconomic Variables of Country C

In this section, the influence of external shocks on C will be analyzed. External shocks here will include the direct shock, which is the one-standard-deviation cost-push shock to C, and indirect shock which are the shocks that are transmitted to C through A.

Although the magnitude of shocks changes depending on which country is originally influenced and which policy regime is followed by A and B, the real interest rate of A increases and output gap declines when cost-push shocks influences A and/or B. That is to say, A transmits a positive real interest shock and a negative output gap shock to C.

The first impact of these shocks on the small economy is going to be felt on the real exchange rate, which will depreciate in line with real exchange rate parity condition. The influence of the depreciation will be seen immediately on the CPI. Because of the lag structure of the model, it will take one period for the output gap to be influenced. The depreciation and A's output gap shock will influence the A's demand for C's output next period. Therefore, it takes one period for the monetary authority of C to respond to this shock. In two periods, depreciations' influence on the supply side will be felt as a result of changes in foreign input costs. When depreciation increases the domestic inflation with a two-period lag, monetary authority in C increases its policy rates even more in line with equation (10). As a result, the output gap in C declines before it is stabilized in the following periods.

Table 2 presents the standard deviations computed from the simulation of the stochastic model. The volatility columns in these tables refer to the different approaches used in analyzing these shocks. The first column considers only the direct shocks. The second and third columns show the total effect which includes both direct and indirect shocks under Nash and coordination regimes.

The first block of Table 2 presents the standard deviations of various macroeconomic variables that belong to C in response to a cost-push shock influencing *only A*. Since A has to adjust its interest rates less under the coordinated regime, lower volatility is transmitted to C in this case. Therefore, when shocks influence C's trade partner, C will benefit from coordinated policies.

Table 2: The Volatility of Macroeconomic Variables of the Small Open Economy*

		Direct Effect	Total Effect Under Non-coordinated Regime	Total Effect Under Coordinated Regime
Cost-Push Shock to A	Π_t^c	0	2.129	2.119
	Π_t	0	1.207	1.201
	x_t	0	0.956	0.951
	q_t	0	13.648	13.577
Cost-Push Shock to B	Π_t^c	0	0.082	0.126
	Π_t	0	0.057	0.083
	x_t	0	0.026	0.045
	q_t	0	0.428	0.716
Cost-Push Shock to A and B	Π_t^c	0	2.210	2.244
	Π_t	0	1.264	1.284
	x_t	0	0.980	0.995
	q_t	0	14.074	14.292
Cost-Push Shock to A, B and C	Π_t^c	19.412	20.217	20.232
	Π_t	18.810	20.064	20.083
	x_t	15.223	16.200	16.215
	q_t	33.579	20.751	20.566

**Source: Author's calculations.*

On the remaining blocks of Table 2, shocks influence either only B or both A and B at the same time. First of all, when B is influenced by a shock, the coordinated regime does not generate a better result for C. As it can be seen from Table 1, A's policy makers tighten their policy more under the coordinated regime than non-coordinated regime. As a result, coordinated regime transmits higher volatility to C when B is involved. Secondly, since B does not have trade and financial connections with C, B is expected to be less influential on C. The second block of Table 2 shows that indirect effects of B's shocks are smaller than A's shocks.

Overall, these results provide evidence to the fact that the literature misses a significant amount of volatility by following the direct shock approach. The results also illustrate that coordinated monetary policies will provide better results for small countries when small country's trade partners are the only countries influenced by the shock.

4.3. The Tradeoff between Output and Inflation Variability under Optimal Monetary Policy

In the previous section, volatility of basic macroeconomic variables is analyzed under the assumption that the monetary authority follows the nominal interest rule given by equation (10). In this section, the influence of external shocks on the small country is going to be analyzed with efficient policy frontiers. The tradeoff between output and inflation volatility is compared under different policy coordination regimes followed by large countries with the help of these frontiers.

4.3. A. Efficient Monetary Policy Frontiers

Equation (21) below represents a standard loss function that has been commonly used by the literature in analyzing optimal monetary policy[5].

$$E\left(L_t\right)=Var\left(\Pi_t\right)+\mu Var\left(x_t\right) \tag{21}$$

where μ is the preference parameter which indicates the relative weight that the policymaker attaches to the variance of the output gap and $Var\left(\Pi_t\right)$ and $Var\left(x_t\right)$ are the variances of inflation and output gap. A smaller value of μ means that the central bank accepts high output variability in order to keep inflation as close as

5 See Froyen and Guander (2007) for details of loss functions.

possible to the target and vice versa. Central banks' optimal response to shocks depends on the value of μ and different μ values result in a different combination of inflation and output variability.

Efficiency frontiers are developed by changing the value of μ with a numerical grid search. For each value in the grid, corresponding optimal policy responses and variances of output gap and inflation are calculated. Therefore, frontiers show the best available combinations of variability in output and inflation for each of these different weights. Along this frontier it is not possible to attain lower inflation variability without increasing variability in output. Any policy rule that results in an inflation-output variability outcome above the frontier is not "efficient" in the sense that better outcomes are possible with a different rule.

4.3.B. Efficient Monetary Policy Frontiers of Country C

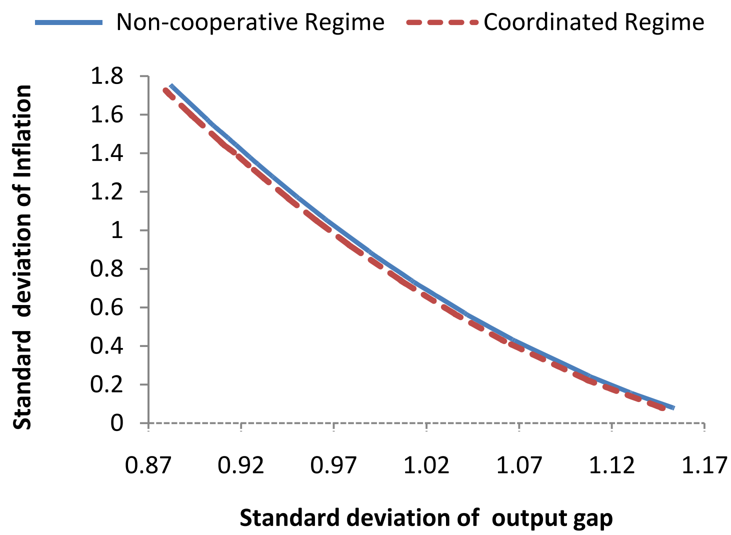
The monetary authority of C is still assumed to follow a Taylor rule. Instead of using the parameters given in equation (10), this time the parameters of the Taylor rule are determined optimally in such a way to minimize the central bank's loss function. They depend on the shocks that are influencing C and relative weights of inflation and output gap in the loss function.

In this section, efficient frontiers are derived for the cases that are covered in Table 2 above. In this calculation, the value of the relative weight is changed over $0 < \mu < 20$ interval with increments equal to 0.1. As discussed above, the shocks influencing C differ depending on the policy regime followed by A and B. Figures below will include two frontiers-one for coordinated, one for non-coordinated regime- to compare output inflation trade-offs under different coordination regimes.

Case 1: Cost Push Shock to A

In the first block of Table 2, it is shown that when a cost-push shock influences C's trade partner, the partner country transmits a smaller shock to C when it coordinates its policy with other large country. Figure 2 displays output-inflation trade-off of C in response to this indirect shock. Under the coordinated regime, the efficient frontier is found to be on the left, indicating more favorable results for C.

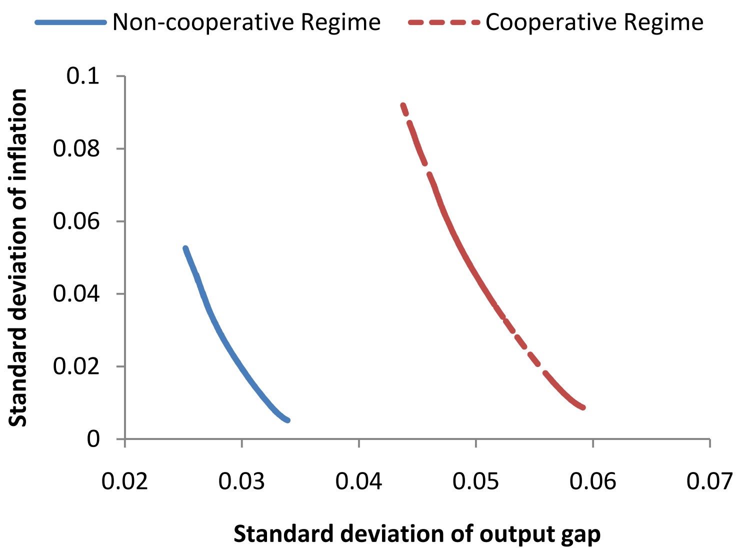
Figure 2: Efficient Monetary Policy Frontier of C When Cost-Push Shock Hits A



Case 2: Cost Push Shock to B

Figure 3 represents the output-inflation variability in C in response to indirect effect from B. In the second block of Table 2, it is shown that the indirect effect transmitted to C becomes smaller when non-partner country B is the only country influenced by a shock. In line with this finding, the scale of the Figure 3 is found to be smaller below. Moreover, when A coordinates its policy with B, it is found that A transmits a bigger shock to C. Therefore, the efficient frontier is on the right when A and B coordinates in Figure 3.

Figure 3: Efficient Monetary Policy Frontier of C When Cost-Push Shock Hits B



Case 3: Cost Push Shock to A and B

In the third block of Table 2, it is shown that when a cost-push shock influences both partner and non-partner country, the shock transmitted to C is smaller under non-coordinated regime. Figure 4 supports this result and reveals that the efficient frontier is on the right when A and B coordinates.

Case 4: Cost Push Shock to A, B and C

Finally when A, B and C are all influenced by external shocks, the variability is shown to jump in the last block of Table 2. Supporting this, the scale of the frontiers Figure 5 is found to be larger than other frontiers presented before. Moreover, in line with the findings of Table 2, when a cost-push shock influences three countries at the same time, the shock transmitted to C is smaller under non-coordinated regime. Figure 5 supports this result and shows that the efficient frontier is to be slightly on the right when A and B coordinates.

Figure 4: Efficient Monetary Policy Frontier of C When Cost-Push Shock Hits A and B

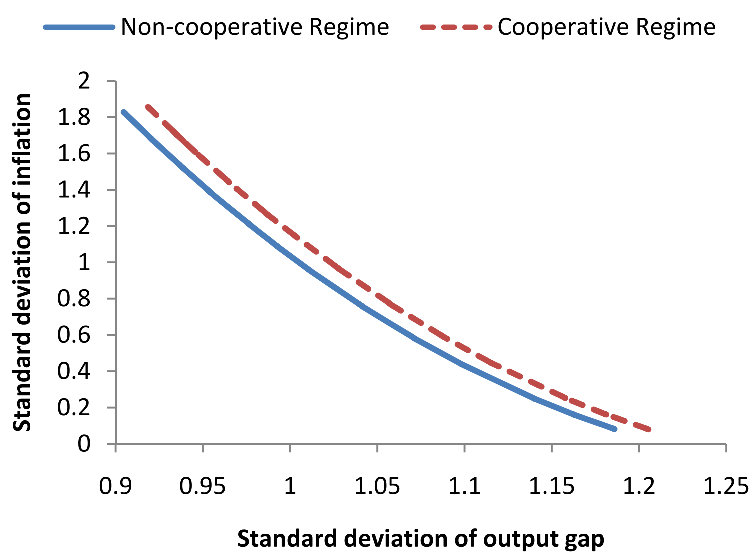
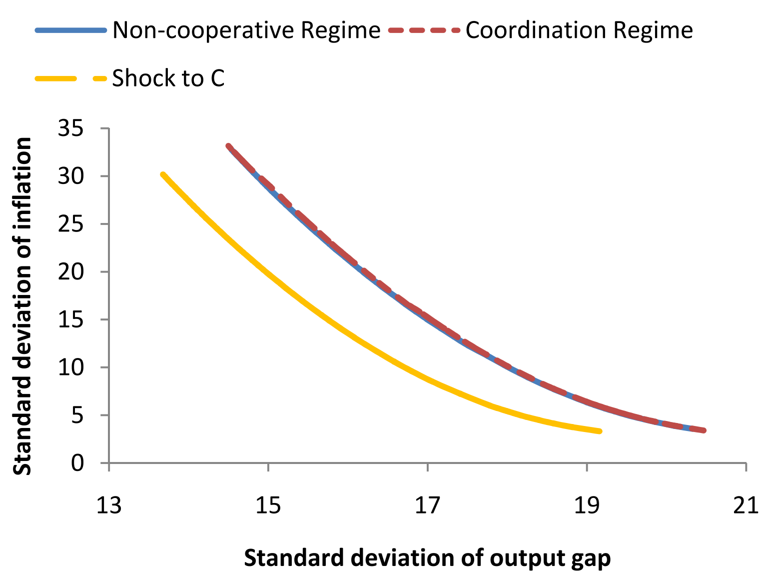


Figure 5: Efficient Monetary Policy Frontier of C When Cost-Push Shock Hits A, B and C



5. Conclusions and Policy Implications

Current small open economy literature takes outside world as given and ignores interactions among world economies. This paper examined the appropriateness of this assumption by developing and simulating a three-country model. The simulation results show that by excluding indirect effect a significant amount of volatility is ignored. Moreover, indirect effects do not consist solely of the size effect. They are also shaped by the interactions among large countries. Therefore, absence of indirect effects can't be compensated by changing the size of the initial shock, or by increasing the variety of shocks. They can only be captured by a three-country model which allows us to track the path external shocks follow before reaching the small open economy.

The intensity of indirect shocks is found to be dependent upon whether the shock initially influences small country's trade partners and whether large countries choose to coordinate their policies or not. It is found that when the small country's trade partners are the only countries influenced by the shock, the coordinated regime will provide better results for the small country. However, under the coordinated regime when a shock hits both partner and non-partner countries, the trade partners' interest rate will be adjusted more in order to help non-partner countries out. As a result, the size of interest rate shocks transmitted to the small country will be magnified under the coordinated regime.

Alternative scenarios analyzed in the sensitivity analysis show that the results of this article can be applied to a wide range of countries. When the size of large countries is not taken to be identical, only the size of shocks transmitted to the small country changes. Additionally, results are found to be robust when the identical shock assumption is changed. The sensitivity analysis also shows that the influence of shocks will be felt deeper in some countries more than others as expected. For instance, when the small country is more open, the shocks are found to be more influential. When the small economy has a foreign debt stock, the influence of external shocks will be magnified since in this case the interest rate shock will be felt more strongly.

Findings of this article shed lights on puzzles that can't be explained with the current small open economy models. Continuing with the Mexico example provided at the beginning of the article, this article suggests a possible explanation for the difference between the influence of first and second oil price shocks of 1970s on Mexican economy. The reason why the first shock did not have as unfavorable effects as the second shock can be explained by the change in the characteristics of Mexico and the world economies in 1970s. While Mexico had a relatively mild debt to GDP ratio at the beginning of the 1970s, the heavy borrowing from international financial markets increased this ratio almost three times until the end of 1970s. This, in turn, increased the sensitivity of Mexico to foreign interest rate shocks. Additionally, in the second oil price shock, the policy preferences of large countries also changed. Large countries, most of which were Mexico's trade partners, responded to the second shock by tightening their policy without cooperating. Therefore, interest rate shock itself was larger in the second oil price shock than the first shock.

The results of this article improve monetary policy framework of small open economies. First it provides better measurement of shocks, which is essential for an optimal policy response. Second, it analyzes the policy trade off policymakers face under alternative policy regimes followed by the large countries through efficient policy frontier analysis. The results illustrate how the policy trade-off is shaped by outside world. Third, the framework provided by this article has implications on the selection of exchange rate regimes of the small countries. When large countries follow non-cooperative regimes, exchange rate volatilities will be exacerbated in the outside world. Therefore, policymakers considering fixed exchange rate regime need to take into account the policy regime followed by its large-country trade partners and this article provides an appropriate framework for this analysis.

Additionally, the results offer insights for the international community by illustrating that decisions taken by large countries would have externalities on small open economies. While it is not possible to impose certain policies to be followed on large countries for the sake of helping small countries, this article shows how the decisions taken by large countries have implications on the world welfare. It suggests that international institutions such as the World Bank and the IMF may contribute to the world welfare by encouraging coordinated policies among countries which have extensive trade relations with small open economies.

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Appendix 1. Parameter Values Used in the Simulations

While Svensson (2000) reports the parameter values that he used in the simulations, Clarida, Gali and Gertler (2002) does not simulate the model. Therefore, I used Svensson (2000)'s parameter values in the simulations when it is appropriate. For the parameters that do not take place in Svensson (2000), the values that have been commonly used by the literature are used.

Table 1.1 Parameter Values Used in the Simulations:

$\beta = 0.95$	$\sigma = 2$	$\sigma_0 = 1.5$	$\kappa_0 = 0.5$	$\kappa = 1.9$	$\lambda = 0.20$	$\phi = 0.2$	$\gamma = 0.5$
$\beta_y = 0.8$	$\beta_\rho = 0.05$	$\beta_{y*} = 0.09$	$\beta_q = 0.055$	$\alpha_\pi = 0.6$	$\alpha_y = 0.08$	$\alpha_q = 0.01$	$\omega = 0.5$

where $\sigma_0 = \sigma - \kappa_0$, $\kappa_0 = \gamma(\sigma - 1)$, $\kappa = \sigma + \phi - \gamma(\sigma - 1)$, $\lambda = \delta\kappa$

In Table 1.1, β is the discount factor, σ is the inverse of intertemporal elasticity of substitution, κ_0 is the elasticity of marginal cost with respect to foreign output, κ is the elasticity of marginal cost with respect to domestic output, ϕ is the inverse elasticity of labor supply. Variables in the second row of Table 1.1 are the coefficients of equations (1) and (3).

Appendix 2. Sensitivity Analysis

In this section, sensitivity analysis results are presented. In each sub-section below, one parameter of interest is changed while the rest of the parameters are kept the same as in the previous section. Volatility tables are replicated for different set of parameter values.

2A.1. Change in the Degree of the Small Country's Openness

The share of imported goods in the CPI, ω, is in a sense measures the openness of the small open economy to the outside world. In the previous section, this variable is taken to be equal to 0.3 by following Svensson (2000). In this section, larger values of ω is used and the influence of this change is analyzed. As we move to the right on the Table 2.1, the share of imported goods in consumption basket increases. The table reveals that volatility of the small open economy variables increases as the value of this parameter increases. This increase is found to be especially noticeable when shocks influence A. Since the indirect effects of shocks influencing B are smaller, the increase is found to be relatively smaller in the second block of the table.

Table 2.1: Volatility of Macroeconomic Variables of the Small Open Economy for Different Values of ω *

		$\omega = 0.4$		$\omega = 0.5$		$\omega = 0.6$		$\omega = 0.7$	
		NCR	**CR**	**NCR**	**CR**	**NCR**	**CR**	**NCR**	**CR**
Cost-Push Shock to A	Π_t^c	2.74	2.72	3.44	3.42	4.24	4.22	5.18	5.15
	x_t	0.99	0.98	1.04	1.04	1.12	1.12	1.24	1.23
Cost-Push Shock to B	Π_t^c	0.10	0.15	0.11	0.18	0.12	0.21	0.13	0.23
	x_t	0.02	0.04	0.02	0.04	0.02	0.04	0.02	0.04
Cost-Push Shock to A and B	Π_t^c	2.83	2.88	3.54	3.60	4.35	4.42	5.30	5.38
	x_t	1.01	1.02	1.06	1.07	1.13	1.15	1.24	1.26

**Source: Author's calculations. NCR = Non-coordinated regime, CR = Coordinated regime*

2A.2. Introduction of Initial Foreign Debt Stock

In the previous sections, the small open economy is assumed to have zero initial debt stock. In this section, this assumption is going to be changed in order to examine the influence of the debt stock on the scale of direct and indirect shocks.

The first column of Table 2.2 below replicates the bottom of Table 2, which presents the direct effect of a cost-push shock that hits A, B and C at the same time. In the remaining columns, the total effects of the external shock for coordinated cases are given for different foreign debt/GDP ratios. Table shows that as the initial debt stock increases, the influence of foreign interest shocks become more significant. Therefore, indirect effects are magnified. When debt stock is equal to 20 percent, the total effect of the shock on x_t is doubled- indirect effect becomes as large as the direct effect itself. When debt stock is equal to 50 percent, the indirect effect of the shock on Π_t^c becomes as large as the direct effect.

Table 2.2: Volatility of Macroeconomic Variables of the Small Open Economy When Initial Debt Stock is Introduced*

			d=0	d=20	d=30	d=40	d=50	d=60
		Direct Effect	Total Effect	Total Effect	Total Effect	Total Effect	Total Effect	Total Effect
Cost-Push Shock to A, B and C	Π_t^c	19.412	20.232	25.102	30.102	35.951	42.300	48.953
	Π_t	18.810	20.083	21.314	22.758	24.639	26.864	29.355
	x_t	15.223	16.215	30.686	42.308	54.567	67.116	79.818
	q_t	33.579	20.566	57.077	82.470	108.454	134.687	161.047

**Source: Author's calculations.*

2A.3. Change in the Correlation Coefficient

Large countries A and B are assumed to be identical in every aspect in most of the simulations. Moreover, when shocks are allowed to influence both A and B at the same time, it is assumed that shocks are identical as well. In this section, the identical shock assumption is changed. Shocks will be assumed to follow processes given by equation (2.1) and (2.2) below.

$$\varepsilon_{A,t} = c + c1 \tag{2.1}$$

$$\varepsilon_{B,t} = \theta c + c2 \tag{2.2}$$

where c represents the common shock and $c1$ and $c2$ characterize country specific components of these shocks. The correlation coefficient of the shock influencing A and B is θ, which has been taken to be equal to 1 so far, is going to be changed and as the degree of correlation decreases, the country specific component of the shocks becomes larger.

To analyze the influence of this change, the third block of the Table 2 is replicated for values of θ between 1 and -1. The differences in the volatility of C's macroeconomic variables between different regimes are examined. In Figures 2.1.A and 2.1.B, percentage differences in the volatilities between coordinated and non-coordinated regime are presented. Positive values in these figures indicate that non-coordinated regime increases the volatility of the small open economy variables. Negative values indicate that the coordinated regime generates higher volatilities.

These figures show that when the country specific components of the shocks are small, policy coordination between A and B generates larger volatility. Policy makers in A tighten their policy more under coordination than non-coordination in order to contribute B's disinflation efforts.

On the other hand, when the correlation coefficient is negative the results changes. When for instance $\theta = -1$, A will be influenced by a positive cost-push shock, while B will have the opposite. Therefore, inflation expectations in A increases, while they decline in B. A's policy rates are increased less than the case in which B also had a positive shock according to equation (17). Therefore, a smaller shock will be transmitted to C and the standard deviations of output gap and CPI will be smaller under the coordinated regime.

Figure 2.1.A. Percentage Changes in the Volatility of Output Gap

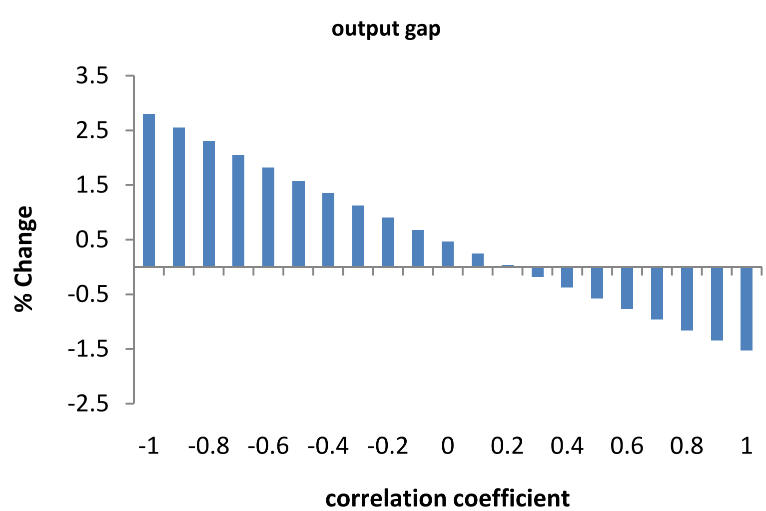
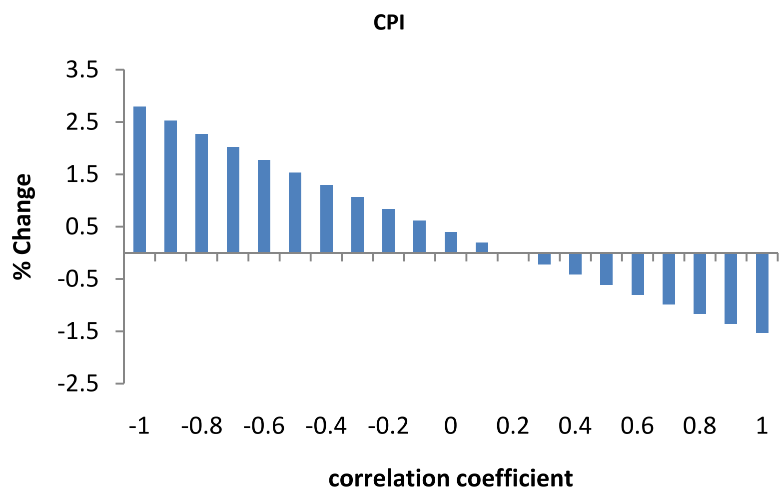


Figure 2.1.B. Percentage Changes in the Volatility of CPI



2A.4. Change in the Size of Large Countries

In the previous sections, A and B are assumed to have equal sizes. In this section, Table 2 is going to be replicated under the assumption that the trade partner has a smaller size than the non-partner country, which could be thought as the rest of the world.

As it can be seen from Table 2.4, as a result of the decline in the size of Country A, it transmits smaller shocks to Country C. Additionally, the results on Table 2. 4 are found to be in line with the findings of Table 2 in terms of the advantages and disadvantages of the coordinated regimes.

Table 2.4: The Volatility of Macroeconomic Variables of the Small Open Economy When A and B have Different Sizes*

		Direct Effect	Total Effect Under Non-coordinated Regime	Total Effect Under Coordinated Regime
Cost-Push Shock to A	Π_t^c	0	0.600	0.552
	Π_t	0	0.358	0.329
	x_t	0	0.251	0.231
	q_t	0	3.703	3.410
Cost-Push Shock to B	Π_t^c	0	0.018	0.088
	Π_t	0	0.013	0.051
	x_t	0	0.006	0.039
	q_t	0	0.095	0.557
Cost-Push Shock to A and B	Π_t^c	0	0.582	0.640
	Π_t	0	0.345	0.380
	x_t	0	0.245	0.270
	q_t	0	3.608	3.967
Cost-Push Shock to A, B and C	Π_t^c	19.412	19.618	19.639
	Π_t	18.810	19.152	19.187
	x_t	15.223	15.467	15.491
	q_t	33.579	30.199	29.866

**Source: Author's calculations.*