ISSN 1791-3144

DEPARTMENT OF ECONOMICS
DISCUSSION PAPER SERIES

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WP 2008 - 16

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Exchange Rate Volatility and Output Volatility: a Theoretical Approach*

Maria Grydaki and Stilianos Fountas

Abstract

This paper makes an attempt to determine the factors influencing exchange rate and exchange rate uncertainty, as well as, output and output variability. In the context of a small open economy under flexible exchange rates regime it is found that the level both of exchange rate and output is affected by monetary and inflationary shocks, as well as shocks in government spending, output and trade balance. Further, the uncertainty of exchange rate and output is associated positively with the uncertainty of all shocks while the contemporaneous occurrence of selected shocks imposes either a positive or negative impact on exchange rate and output volatility. Finally, it is shown that the effect of the determinants either of exchange rate volatility or output volatility is very sensitive to the parameter values.

Keywords: exchange rate volatility, output volatility, open-economy models

JEL: E32, F31, F41

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1. Introduction

A central issue in the theoretical and empirical macro literature concerns the relationship between macroeconomic uncertainty, which results from unanticipated changes of important macro variables, and macroeconomic performance measured by indicators such as the output growth rate. Lately, there has been an increasing focus on the analysis of volatility of macro variables, in particular volatility of output growth (Stock and Watson, 2002). This interest is motivated by the phenomenon of the Great Moderation in which output growth volatility has declined in the G7 countries.

Following the collapse of Bretton Woods system of fixed exchange rates (in the late 1960s), the main country participants in global trade (USA, Japan, European countries) adopted a floating exchange rates regime early in 1973 based on the forces of supply and demand in each economy. Many economists argued that a floating exchange rates regime would be beneficial for the world economy mainly due to the following reasons: (a) monetary policy autonomy is retained, (b) symmetry, and, (c) exchange rates as automatic stabilizers. What should be taken into consideration is the impact of this new regime on economies' welfare.

However, a much discussed consequence of the flexible exchange rate regime is the resulting exchange rate uncertainty. Exchange rate uncertainty can have negative effects on both domestic and foreign decisions. It causes reallocation of resources among sectors and countries, between exporters and importers. In other words, if there is no growth in trade volumes, then there will be welfare failure globally. Although, a priori, there is a negative impact of exchange rate uncertainty on growth and welfare, there is some empirical evidence of positive effects of exchange rate uncertainty on trade and growth.

So far, the literature on macro uncertainty focuses on the impact of the uncertainty on macroeconomics variables, such as output growth, inflation, trade volumes and investment. However, there seems to be a lack of studies examining the determinants of macro uncertainty from both a theoretical and an empirical point of view. The present paper departs from past, related studies by investigating the causes of exchange rate volatility and output volatility in a small open economy. Our methodological framework builds on the work of Driskill and McCafferty (1980), which develops a

model of a small, open economy under floating exchange rates regime that incorporates uncertainty and explores the determinants of exchange rate volatility. We extend their work by incorporating into the model an output equation which accommodates fiscal and foreign sector aspects. Our model reveals that the determinants of exchange rate volatility and output volatility are: the volatility of money supply shocks, price volatility, government spending volatility, output shock volatility, trade balance volatility and the existence of contemporaneous selected shocks. Some of the findings of exchange rate uncertainty are in line with Obstfeld and Rogoff (1995, 1996).

The remainder of the paper proceeds as follows: In section 2 we appose the relevant studies to exchange rate volatility and in section 3 we state the theoretical open-economy macro model for the analysis of exchange rate volatility. In section 4 we solve the model for the exchange rate process under rational expectations and compute the exchange rate variance. Also, we set out the comparative-statics results between exchange rate variance and the variance of its determinants. In section 5 we review the empirical literature on the relationship between output volatility and other macro variables such as inflation and growth. In section 6 we solve the model for output volatility process and we compute the comparative-statics between output volatility and the variance of its determinants. Section 7 reports the main findings.

2. A Brief Literature Review

Exchange Rate Volatility

In their seminal work Driskill and McCafferty (1980) examine the exchange rate model in terms of uncertainty in a small open economy under a flexible exchange rate regime. Under rational expectations they shed light on the capital mobility role. They claim that high capital mobility: a) increases the portfolio variability when changes in anticipated assets relative returns take place; b) decreases the exchange rate volatility which is caused by real shocks; c) increases the exchange rate volatility when unanticipated shocks occur within the economy. Turnovsky and Bhandari (1982) extend the Driskill-McCafferty analysis focusing not only on the short-run effects of structural shocks of domestic and foreign variables on domestic economy, but also examining the impact of the degree of

capital mobility on the determinants' variance. Regarding exchange rate volatility, the existence of a shock in the foreign price level and the foreign nominal interest rate in combination with the increasing capital mobility leads to an increase in the variance of exchange rate while the variance of foreign prices causes a decrease in the variance of exchange rate. Furthermore, the occurrence of a supply disturbance affects negatively the variance of exchange rate.

Driskill and McCafferty (1987) extend their previous work (Driskill and McCafferty, 1980) by: (i) including the assumption of risk-aversion and the analysis of the good-market and (ii) adding in the model the asset demand equation derived from optimizing behaviour rather than ad hoc theory. They conclude that exchange rate volatility is affected positively by the variance of money supply shocks and that it is possible the existence of multiple equilibria if changes in preferences and technology take place. Moreover, Manuelli and Peck (1990) consider an overlapping generation model with stochastic endowments providing evidence that exchange rate volatility is not dependent on the fundamentals of the economy. On the other hand, shocks to these fundamentals affect significantly exchange rate volatility. Furthermore, Betts and Devereux (1996) implement a pricing-to-market model adopting some of the assumptions of Obstfeld and Rogoff (1995) model and their findings reveal that the greater the portion of goods under pricing-to-market regime the higher the relative exchange rate variance. In other words, the model of pricing-to-market imposes a great impact on the uncertainty of exchange rate.

Empirically, Bayoumi and Eichengreen (1998) review the effect of Optimum Currency Areas (OCA)¹ variables on nominal exchange rate volatility finding that the terms of trade, capital controls and money supply impose a negative impact on exchange rate volatility. Later, Canales-Kriljenko and Habermeier (2004) show that the volatility of exchange rate is determined by inflation, GDP growth, fiscal deficit and trade openness. They conclude that the volatility in terms of trade does not affect significantly the exchange rate volatility. Karras (2006) computes the standard deviation of exchange rate and infers that openness imposes a positive but of ambiguous significance impact on exchange rate

¹ OCA variables include: a) output volatility (in terms of standard deviation); b) export heterogeneity; c) terms of trade; d) size of economy; e) capital control; f) money supply; g) interest rate volatility.

variability. Additionally, his findings show that exchange rate variability is inversely related to trade openness and economic size according to methods that are implemented in the selected sample.

Output Volatility

Recently, an increasing number of empirical studies focus on output growth volatility and our purpose is to appose the studies that present the determinants of output volatility. Theoretically, Turnovsky and Bhandari (1982) argue that the existence of a shock in the foreign price level and the foreign nominal interest rate in combination with the increasing capital mobility, as well as the occurrence of a supply disturbance, leads to an increase in the variance of domestic real output.

Caporale and McKiernan (1996) estimate a GARCH–M model and infer that there is a significant and affirmative relationship between volatility and growth for UK. The same result is also obtained by Grier and Perry (2000), differing the sample and the time span that are used. They conclude that the link between volatility and growth is positive but it is not significant across all subsamples. Furthermore, Fountas, Karanasos and Kim (2002) investigate the link between average inflation and real growth as well as the nominal and real uncertainty focusing on the Japanese economy. Estimating a GARCH model, their findings support that a high rate of inflation (output growth) leads to high inflation (output growth) uncertainty.

Fatas and Mihov (2002), using data on 51 countries provide evidence of positive relationship between output volatility and discretionary fiscal policy volatility. Their findings are supportive of the negative conjunction between output volatility and economic growth². Additionally, Fiaschi and Lavezzi (2003) draw the conclusion that growth volatility is associated negatively with total GDP, per capita GDP and trade openness, while there is a positive link with the share of agricultural sector.

Moreover, Fatas and Mihov (2006), working with annual data of 48 US states over the period 1963-2000, infer that policy volatility and Gross Domestic Product exert a strong affirmative impact on output volatility while government size is found to affect output volatility negatively³. Furthermore,

² The same conclusion is drawn in Fatas and Mihov (2005) in a cross-section of 91 countries. The only difference lies to the significance of this effect.

³ If elasticity of spending is added to the model then the impact on output volatility is not significant and the government size impinges a positive impact on output volatility.

Karras (2006) investigates the association between trade openness and economic growth in terms of GDP, aggregate consumption and aggregate investment. In the case of GDP, trade openness is positively related to output volatility but this relationship is not statistically significant in both samples that he uses. The same result holds in the case of investment meaning that trade openness has a positive but insignificant impact on investment variability in both samples while consumption volatility seems to be affected positively and significantly only in the first sample. The preceding inferences change when the economic size is included in the model.

More recently, Furceri (2007) makes the inference that the effect of government expenditure volatility and output volatility is stronger (and negative) on output growth for developing countries rather than developed (OECD), while Imbs (2007) provides evidence of negative correlation between growth and volatility across countries but positive across sectors. The significant negative relationship between volatility and growth is also confirmed by Ramey and Ramey (1995). In the OECD sample they also find: (i) strong link between government spending volatility and output volatility, and, (ii) strong negative and significant relationship with growth even after including time and country fixed effects.

Contrary to other relevant studies for the relationship between output variability and growth, Fountas et al (2004) find no evidence of association between output variability and output growth. They draw such inference having based their research on quarterly data over the period 1961-2000 for the Japanese economy and having employed three different specifications of GARCH models. A previous study of Speight (1999) makes the inference that shocks to output growth affect significantly the output volatility.

3. Theoretical Model

A small, open economy with a perfectly elastic supply of imports at a fixed world price is considered in this paper as in Driskill and McCafferty (1980). Contrary to Driskill and McCafferty (1980) the domestic output is not exogenous in our model. We propose an aggregate demand specification depending on the level of real exchange rate (relative prices) and the government

spending volume. Domestic residents can hold either bonds (domestic or foreign) or domestic money. Foreigners are assumed to hold bonds and foreign money.

The building blocks in the model are: (i) a standard money market equilibrium condition, (ii) the goods market where the output is demand determined, and, (iii) the foreign exchange market represented by the Balance of Payments (BOP) equilibrium condition. Furthermore, we assume rational expectations regarding the exchange rate. All equations are presented in their log-linear form.

The Money Market

Money demand is assumed to be:

$$m_t^d = p_t - \lambda r_t, \lambda > 0 \quad (1)$$

where m_t is the log of domestic money demand, p_t , r_t reflect the domestic price level and the domestic interest rate, respectively and λ is a positive coefficient indicating that money demand is a decreasing function of interest rate. Money supply is assumed to have the form:

$$m_t^s = \bar{m} + \varepsilon_t = \varepsilon_t \quad (2)$$

where ε_t is a random variable with zero mean and known constant variance σ_ε^2 . In other words the shock is an i.i.d. random variable. The domestic price level is given by:

$$p_t = \bar{p} + z_t = z_t \quad (3)$$

where z_t is a shock in prices (inflationary shock) that determines the price level. z_t is also an i.i.d. random variable. Solving equations (1)-(3) we get the money market equilibrium condition which can be written as:

$$r_t = -\left(\frac{1}{\lambda}\right)\varepsilon_t + \left(\frac{1}{\lambda}\right)z_t. \quad (4)$$

Demand for Domestic Output

The output volume is assumed to be a decreasing function of domestic interest rate and an increasing function of relative prices and the domestic government expenditure:

$$y_t = \phi_1 r_t + \phi_2 (e_t + p_t^f - p_t) + \gamma g_t + v_t, \phi_1 < 0, \phi_2 > 0, \gamma > 0 \quad (5)$$

where e_t is the exchange rate between domestic and foreign economy defined as units of domestic currency per units of foreign currency, p^f is the exogenous foreign price level and is set at zero (for simplicity), g_t represents the domestic government spending factor and v_t is assumed to reflect unanticipated shocks in the output process and it is an i.i.d. random variable. The assumption $\phi_1 < 0$ holds because of the inverse relationship between output and interest rate; $\phi_2 > 0$ reflects the exchange rate specification and $\gamma > 0$ indicates the positive relationship between government expenditure and output. Moreover, the government spending volume is defined as:

$$g_t = \bar{g} + \omega_t = \omega_t \quad (6)$$

where ω_t is an unexpected shock in the government spending volume⁴ and an i.i.d. random variable.

The Foreign Exchange Market

The supply of foreign exchange comes from the transactions on the trade account. Therefore, the net supply of foreign exchange is supposed to be an increasing function of the log of relative prices and a decreasing function of the log of domestic output volume.

$$T_t = \alpha(e_t + p_t^f - p_t) + \beta y_t + u_t, \quad a > 0, \quad \beta < 0 \quad (7)$$

where T_t reflects the trade balance in foreign currency units, e_t is the exchange rate in logarithmic form, p_t^f and p_t are the logs of foreign and domestic price level, respectively, y_t presents the domestic product and u_t is an i.i.d. random variable. The assumption that $a > 0$ ⁵ means that the sum of price elasticity of imports and exports (in absolute value) is greater than 1. Moreover, the restriction that $\beta < 0$ denotes the negative relationship between output and trade balance. For simplicity, p^f is set at zero.

The net demand for foreign assets B_t is indicated by the capital flows function which is assumed to be:

⁴ The value of parameters $\bar{m}$, $\bar{p}$, $\bar{g}$ is set at zero for simplicity in equations (2), (3), (6), respectively.

⁵ This assumption is known as Marshall-Lerner condition where $|Ex| + |Em| \geq 1$ and Ex, Em corresponds to export elasticity and import elasticity, respectively.

$$B_t = \eta \left[E_t e_{t+1} - e_t + r_t^f - r_t \right], \quad \eta > 0 \quad (8)$$

where $E_t e_{t+1}$ is the expected value of exchange rate at $t+1$ given the available information at time t , r^f reflects the foreign interest rate which is set equal to zero and η measures the degree of capital mobility⁶ which is considered as given.

The foreign exchange market clearing condition is:

$$\Delta B_t = T_t \quad (9)$$

which implies that the exchange rate at time t adjusts until the change in the domestic demand for foreign assets equals the supply of foreign exchange from the trade balance.

4. Exchange Rate Volatility

Exchange Rate Determination and Exchange Rate Variance

Equations (1)-(9) constitute a system of equations that can be solved for e_t under rational expectations:

$$\begin{aligned} e_t = & A_1 \left[\eta(1 - \pi_0) + \beta\phi_1 \right] \varepsilon_t + A_1 \left[-\eta(\pi_0 - 1)^2 + \beta\phi_1\pi_0 \right] \left\{ \varepsilon_{t-1} + \pi_0 \varepsilon_{t-2} + \pi_0^2 \varepsilon_{t-3} + \dots \right\} + A_1 \left[\eta(\pi_0 - 1) + \right. \\ & \left. + \lambda(\alpha + \beta\phi_2) - \beta\phi_1 \right] z_t + A_1 \left[\eta(\pi_0 - 1)^2 + \lambda\pi_0(\alpha + \beta\phi_2) - \beta\phi_1\pi_0 \right] \left\{ z_{t-1} + \pi_0 z_{t-2} + \pi_0^2 z_{t-3} + \dots \right\} - \\ & - \beta\gamma\lambda A_1 \left\{ \omega_t + \pi_0 \omega_{t-1} + \pi_0^2 \omega_{t-2} + \dots \right\} - \beta\lambda A_1 \left\{ v_t + \pi_0 v_{t-1} + \pi_0^2 v_{t-2} + \dots \right\} - \lambda A_1 \left\{ u_t + \pi_0 u_{t-1} + \pi_0^2 u_{t-2} + \dots \right\} \quad (10) \end{aligned}$$

where $A_1 = \pi_0 / \lambda \eta (1 - \pi_0)$

Equation (10) indicates that the exchange rate is determined by contemporaneous unanticipated shocks in money supply, price level, government spending, output and the trade balance account, as well as by the past values of these shocks.

In order to examine the determinants of exchange rate uncertainty, we compute the unconditional variance of equation (10). It is implied that the unconditional mean of e_t is $E(e_t) = 0$ for all t and it is assumed that the various shocks are pairwise correlated. Under these assumptions, the exchange rate variance is formed by the following equation:

⁶ In our model it can be proved that the degree of capital mobility does not affect the final results.

$$\begin{aligned}
\sigma_e^2 = & A_2 \left\{ \left[\eta(1-\pi_0) + \beta\phi_1 \right]^2 (1-\pi_0^2) + \left[-\eta(\pi_0-1)^2 + \beta\phi_1\pi_0 \right]^2 \right\} \sigma_\varepsilon^2 + A_2 \left\{ \left[\eta(\pi_0-1) + \lambda(\alpha + \beta\phi_2) - \beta\phi_1 \right]^2 \right. \\
& \left. (1-\pi_0^2) + \left[\eta(\pi_0-1)^2 + \lambda\pi_0(\alpha + \beta\phi_2) - \beta\phi_1\pi_0 \right]^2 \right\} \sigma_z^2 + \beta^2 \gamma^2 \lambda^2 A_2 \sigma_\omega^2 + \beta^2 \lambda^2 A_2 \sigma_v^2 + \lambda^2 A_2 \sigma_u^2 - 2A_2 \\
& \left\{ -\lambda(\alpha + \beta\phi_2) \left[\beta\phi_1 + \eta(1-\pi_0)^2 \right] + 2\eta(1-\pi_0)^2 \left[\beta\phi_1 + \eta(1-\pi_0) \right] + \beta^2 \phi_1^2 \right\} \text{Cov}(\varepsilon_t, z_t) - 2\beta\gamma\lambda A_2 \\
& \left[\eta(1-\pi_0)^2 + \beta\phi_1 \right] \text{Cov}(\varepsilon_t, \omega_t) - 2\beta\lambda A_2 \left[\lambda(\alpha + \beta\phi_2) - \beta\phi_1 - \eta(1-\pi_0)^2 \right] \text{Cov}(z_t, v_t) - 2\lambda A_2 \\
& \left[\lambda(\alpha + \beta\phi_2) - \beta\phi_1 - \eta(1-\pi_0)^2 \right] \text{Cov}(z_t, u_t) + 2\beta\gamma\lambda^2 A_2 \text{Cov}(\omega_t, u_t) + 2\beta\lambda^2 A_2 \text{Cov}(v_t, u_t) \quad (11)
\end{aligned}$$

where $A_2 = \pi_0^2 / \lambda^2 \eta^2 (1-\pi_0)^2 (1-\pi_0^2)$

Having specified the equation of exchange rate we compute the comparative-statics results in order to investigate the conjunction between the level of exchange rate and its determinants.

Comparative Statics of Exchange Rate and its Variance

We provide evidence that money supply and government shocks and unanticipated changes in output are associated positively with exchange rate level, as given below:

$$\frac{\partial e_t}{\partial \varepsilon_t} = A_1 \left[\eta(1-\pi_0) + \beta\phi_1 \right] > 0, \quad \frac{\partial e_t}{\partial \omega_t} = -\beta\gamma\lambda A_1 > 0, \quad \frac{\partial e_t}{\partial v_t} = -\beta\lambda A_1 > 0 \quad (12)$$

On the other hand, trade balance shocks affect negatively the level of the exchange rate while inflationary shocks are found to have an ambiguous effect on the exchange rate, as expressed in the following equations, respectively:

$$\frac{\partial e_t}{\partial u_t} = -\lambda A_1 < 0, \quad \frac{\partial e_t}{\partial z_t} = A_1 \left[\eta(\pi_0-1) + \lambda(\alpha + \beta\phi_2) - \beta\phi_1 \right] \quad (13)$$

Having derived the equation for the exchange rate variance, we can compute the comparative statics results in order to determine the relationship between the exchange rate variance and its various determinants.

First, we consider the effect of changes of money supply uncertainty:

$$\frac{\partial \sigma_e^2}{\partial \sigma_\varepsilon^2} = A_2 \left\{ \left[\eta(1-\pi_0) + \beta\phi_1 \right]^2 (1-\pi_0^2) + \left[-\eta(\pi_0-1)^2 + \beta\phi_1\pi_0 \right]^2 \right\} > 0 \quad (14)$$

An increase in the money supply uncertainty increases the exchange rate variance, depicted in Figure 1. Using a variant of the Mundell-Fleming model under flexible exchange rates we develop the IS, LM and BP curves in the (r, e) space. The LM curve appears to be horizontal because Central Bank targets the interest rate level. In order to justify the slope of the BP curve we consider that a depreciation of the exchange rate is associated with a fall in the interest rate for the maintenance of equilibrium in foreign exchange market, implying that BP curve is downward-sloping. Moreover, as the domestic interest rate rises, investment volume falls and so does output. Furthermore, a depreciation of exchange rate (e increases) leads to an increase in output. Thus the IS curve is upward-sloping, but flatter than the BP under the assumption that a change in domestic interest rate imposes a greater effect on domestic demand than on foreign demand. The initial equilibrium point is A. We assume that a small increase in money supply occurs. Such an increase causes a fall to interest rates leading to a downward shift of LM and the economy moves from point A to point B. Point B reflects a deficit in the Balance of Payments because a fall in interest rates causes an increase in output through the increase of capital outflows leading to a CA deficit. In order to restore the equilibrium, IS shifts to the right and BP to the left and the new equilibrium is reached at point C, where the economy exhibits an increase in exchange rate (depreciation of exchange rate) from e_0 to e_1 . If money supply increases more, then interest rates will fall more and the exchange rate will depreciate more (point C')⁷. A similar analysis holds for negative supply shocks.

Following the previous result, the variance of price shocks, government spending shocks, output demand shocks and trade balance shocks is linked positively⁸ with exchange rate variance:

$$\frac{\partial \sigma_e^2}{\partial \sigma_z^2} = A_2 \left\{ \left[\eta(\pi_0 - 1) + \lambda(\alpha + \beta\phi_2) - \beta\phi_1 \right]^2 (1 - \pi_0^2) + \left[\eta(\pi_0 - 1)^2 + \lambda\pi_0(\alpha + \beta\phi_2) - \beta\phi_1\pi_0 \right]^2 \right\} > 0 \quad (15)$$

$$\frac{\partial \sigma_e^2}{\partial \sigma_\omega^2} = \beta^2 \gamma^2 \lambda^2 A_2 > 0, \quad \frac{\partial \sigma_e^2}{\partial \sigma_v^2} = \beta^2 \lambda^2 A_2 > 0, \quad \frac{\partial \sigma_e^2}{\partial \sigma_u^2} = \lambda^2 A_2 > 0 \quad (16)$$

⁷ We focus on the effect of uncertainty round a money supply shock and thus we refer to small and large fluctuations of such shock.

⁸ The diagrammatic analysis of these comparative-statics is not reported because of its simplicity.

Figure 1: The positive effect of the variance of a money supply shock on
exchange rate variance

An interesting aspect of exchange rate volatility is how it is affected by the covariance of various shocks. For instance, if the government decides to increase the money supply in order to finance the volume of expenditures, the impact on exchange rate volatility will be positive as shown in the following expression:

$$\frac{\partial \sigma_e^2}{\partial \text{Cov}(\varepsilon_t, \omega_t)} = -2\beta\gamma\lambda A_2 \left[\eta(1-\pi_0)^2 + \beta\phi_1 \right] > 0 \quad (17)$$

Furthermore, if we take into consideration that there are contemporaneous shocks in money supply and prices, then the effect on exchange rate volatility is given by:

$$\frac{\partial \sigma_e^2}{\partial \text{Cov}(\varepsilon_t, z_t)} = -2A_2 \left\{ -\lambda(\alpha + \beta\phi_2) \left[\beta\phi_1 + \eta(1-\pi_0)^2 \right] + 2\eta(1-\pi_0)^2 \left[\beta\phi_1 + \eta(1-\pi_0) \right] + \beta^2\phi_1^2 \right\} \quad (18)$$

The sign of equation (18) is ambiguous meaning that when a price shock and a money supply shock coexist⁹ then the impact on the variance of exchange rate is either positive or negative. Moreover, the

⁹ For instance, if an increase in interest rates occurs then deposits will rise and thus the money supply increases.

impact of the coexistence of shocks (i) in prices and output as well as (ii) in prices and trade balance on the variance of exchange rate is given by the following equations:

$$\frac{\partial \sigma_e^2}{\partial \text{Cov}(z_t, v_t)} = -2\beta\lambda A_2 \left[\lambda(\alpha + \beta\phi_2) - \beta\phi_1 - \eta(1 - \pi_0)^2 \right] \quad (19)$$

$$\frac{\partial \sigma_e^2}{\partial \text{Cov}(z_t, u_t)} = -2\lambda A_2 \left[\lambda(\alpha + \beta\phi_2) - \beta\phi_1 - \eta(1 - \pi_0)^2 \right] \quad (20)$$

Just as in the previous case the sign of (19) and (20) can be either positive or negative. Contrary to the already reported findings, the covariance of government spending shocks and trade balance shocks as well as the covariance of output and trade balance unanticipated changes, impose a negative impact on exchange rate volatility given by the following equations, respectively:

$$\frac{\partial \sigma_e^2}{\partial \text{Cov}(\omega_t, u_t)} = 2\beta\gamma\lambda^2 A_2 < 0, \quad \frac{\partial \sigma_e^2}{\partial \text{Cov}(v_t, u_t)} = 2\beta\lambda^2 A_2 < 0 \quad (21)$$

In an attempt to clarify which variance or covariance impinges greater impact on the exchange rate variance, we compute the pairwise relative effect of selected variances and covariances. More specifically, we make several comparisons between variances and covariances.

We find that either the one impact or the other affects more the variance of exchange rate according to the restrictions that are imposed for each parameter. For instance, the variance of a government spending shock has a greater impact on exchange rate variance than the variance of a shock in output, $(\partial \sigma_e^2 / \partial \sigma_\omega^2) > (\partial \sigma_e^2 / \partial \sigma_v^2)$, under the condition $\gamma > 1$ ¹⁰. A plausible explanation for this result is that a large increase in government spending (and its variance) affects the output more than an output shock (and its variance). Therefore, the variance of a government spending shock impinges greater impact on the variance of exchange rate via the channel of output variance. If $0 < \gamma < 1$, then the inverse result holds. Moreover, the impact of the variance of an output shock on the exchange rate variance is greater than that of the variance of a trade balance shock, $(\partial \sigma_e^2 / \partial \sigma_v^2) > (\partial \sigma_e^2 / \partial \sigma_u^2)$, under the constraint $\beta < -1$. In this case a large increase in output will affect more the trade balance

¹⁰ We find that under this condition the covariance of a government spending shock and a trade balance shock imposes a greater impact on exchange rate variance than the coexistence of an output and a trade balance shock, $\partial \sigma_e^2 / \partial \text{Cov}(\omega_t, u_t) > \partial \sigma_e^2 / \partial \text{Cov}(v_t, u_t)$. The inverse inference is drawn if $0 < \gamma < 1$ holds.

(negatively) rather than a shock in trade balance. In terms of volatility, the variance of an output shock affects the variance of exchange rate more than the variance of a trade balance shock via the variance of trade balance. If $-1 < \beta < 0$, then the inverse result holds. The same inference is drawn for the rest relative effects but for their computation more than one restriction for each parameter should be satisfied.

Just in the case of the covariance effects, we find that $(\partial \sigma_e^2 / \partial \text{Cov}(\varepsilon_t, \omega_t)) < (\partial \sigma_e^2 / \partial \text{Cov}(\omega_t, u_t))$, meaning that the effect of the coexistence of policy shocks (monetary and fiscal) on the exchange rate variance is weaker than the contemporaneous shocks in government spending and trade balance.

At this point we can try a comparison of exchange rate volatility and its determinants, which are also expressed in terms of volatility, of our model with the optimizing behaviour model of Obstfeld and Rogoff (1995, 1996).

Obstfeld and Rogoff (1995, 1996) assume that: a) there is a continuum of individual monopolistic producers indexed by $z \in [0,1]$, each of whom produces a single differentiated good z ; b) All producers reside in two countries, Home and Foreign. Home producers produce goods indexed by $z \in [0, \eta]$ whereas Foreign producers produce goods indicated by $z \in (\eta, 1]$; c) There is no capital or investment and the economy exhibits elastic labor supply; d) the production of good z depends on the marginal revenue of higher production, the disutility of effort and the marginal utility of consumption; e) all agents within a country have symmetric preferences and constraints; f) PPP holds. The utility function of a typical Home agent j is given by:

$$U_t^j = \sum_{s=t}^{\infty} \beta^{s-t} \left[\log C_s^j + \chi \log \frac{M_s^j}{P_s} - \frac{\kappa}{2} y_s(j)^2 \right] \quad (22)$$

Where C is a real consumption index and P is the Home money price level indexed respectively by:

$$C^j = \left[\int_0^1 c^j(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}}, \quad P = \left[\int_0^1 p(z)^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \quad (23)$$

and $\frac{\kappa}{2} y_s(j)^2$, θ^{11} reflect the disutility of individual to produce more output and price elasticity of demand faced by each monopolist, respectively. The law of one price holds so $P = \varepsilon P^*$, where P^* denotes the foreign money price level. The individual budget constraint and the government budget constraint are:

$$P_t B_{t+1}^j + M_t^j = P_t (1 + r_t) B_t^j + M_{t-1}^j + p_t(j) y_t(j) - P_t C_t^j - P_t \tau_t \quad (24)$$

where r_t reflects the interest rate on bonds between $t-1$ and t , $y_t(j)$ is output of good j , $p_t(j)$ is the domestic currency price for good j which need not be the same for all j because of product differentiation. The variable M_{t-1}^j indicates agents' holdings of nominal money balances entering period t and τ_t denotes lump-sum taxes.

$$G_t = \tau_t + \frac{M_t - M_{t-1}}{P_t} \quad (25)$$

Where G is government's real consumption index being formed as:

$$G = \left[\int_0^1 g(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} \quad (26)$$

Governments act as price takers and their demand functions are:

$$g(z) = \left[\frac{p(z)}{P} \right]^{-\theta} G \quad (27)$$

Therefore the demand function for representative agents is given by:

$$y^d = \left[\frac{p(z)}{P} \right]^{-\theta} (C^w + G^w) \quad (28)$$

where $C^w = \eta C + (1-\eta)C^*$ and $G^w = \eta G + (1-\eta)G^*$ and a $*$ denotes the magnitudes of foreign country.

Obstfeld and Rogoff maximizing (22) subject to budget constraints find that the level of exchange rate is a function of money supply and government spending differentials. The mathematical form of this expression is:

¹¹ $\theta > 1$ because $MR < 0$ when the demand elasticity is less than 1 (CES).

$$e = \frac{2\theta + \delta(1+\theta)}{2\theta + \theta\delta(\theta+1)}(m - m^*) + \frac{\delta(\theta^2 - 1)}{2\theta + \theta\delta(\theta+1)}(g - g^*), \quad \theta > 1, \delta > 0 \quad (29)$$

where δ is rate of time preference. The variables m , m^* reflect the money supply of domestic and foreign country, respectively and g , g^* indicate the government spending volume in domestic and foreign country, respectively.

We compute the variance of equation (29) under the assumptions that monetary and government spending shocks in both countries are correlated and that changes in money supply and government spending occur contemporaneously in home and foreign country, respectively:

$$\begin{aligned} \sigma_e^2 = & \left(\frac{2\theta + \delta(1+\theta)}{2\theta + \theta\delta(\theta+1)} \right)^2 \sigma_m^2 + \left(-\frac{2\theta + \delta(1+\theta)}{2\theta + \theta\delta(\theta+1)} \right)^2 \sigma_{m^*}^2 + \left(\frac{\delta(\theta^2 - 1)}{2\theta + \theta\delta(\theta+1)} \right)^2 \sigma_g^2 + \\ & + \left(-\frac{\delta(\theta^2 - 1)}{2\theta + \theta\delta(\theta+1)} \right)^2 \sigma_{g^*}^2 - \frac{2(\delta + (2+\delta)\theta)^2}{\theta^2(2+\delta+\delta\theta)^2} \text{Cov}(m, m^*) - \frac{2\delta(\theta^2 - 1)^2}{\theta^2(2+\delta+\delta\theta)^2} \text{Cov}(g, g^*) + \\ & + \frac{2\delta(\delta + (2+\delta)\theta)(\theta^2 - 1)}{\theta^2(2+\delta+\delta\theta)^2} \text{Cov}(m, g) + \frac{2\delta(\delta + (2+\delta)\theta)(\theta^2 - 1)}{\theta^2(2+\delta+\delta\theta)^2} \text{Cov}(m^*, g^*). \end{aligned} \quad (30)$$

Computing the comparative statics of equation (30) we get:

$$\frac{\partial \sigma_e^2}{\partial \sigma_m^2} = \left(\frac{2\theta + \delta(1+\theta)}{2\theta + \theta\delta(\theta+1)} \right)^2 > 0 \quad (31)$$

$$\frac{\partial \sigma_e^2}{\partial \sigma_{m^*}^2} = \left(-\frac{2\theta + \delta(1+\theta)}{2\theta + \theta\delta(\theta+1)} \right)^2 > 0 \quad (32)$$

$$\frac{\partial \sigma_e^2}{\partial \sigma_g^2} = \left(\frac{\delta(\theta^2 - 1)}{2\theta + \theta\delta(\theta+1)} \right)^2 > 0 \quad (33)$$

$$\frac{\partial \sigma_e^2}{\partial \sigma_{g^*}^2} = \left(-\frac{\delta(\theta^2 - 1)}{2\theta + \theta\delta(\theta+1)} \right)^2 > 0 \quad (34)$$

$$\frac{\partial \sigma_e^2}{\partial \text{Cov}(m, m^*)} = -\frac{2(\delta + (2+\delta)\theta)^2}{\theta^2(2+\delta+\delta\theta)^2} < 0 \quad (35)$$

$$\frac{\partial \sigma_e^2}{\partial \text{Cov}(g, g^*)} = -\frac{2\delta(\theta^2 - 1)^2}{\theta^2(2 + \delta + \delta\theta)^2} < 0 \quad (36)$$

$$\frac{\partial \sigma_e^2}{\partial \text{Cov}(m, g)} = \frac{\partial \sigma_e^2}{\partial \text{Cov}(m^*, g^*)} = \frac{2\delta(\delta + (2 + \delta)\theta)(\theta^2 - 1)}{\theta^2(2 + \delta + \delta\theta)^2} > 0 \quad (37)$$

Equations (31) through (37) show that an increase in the variance of money supply and government spending, as well as the coexistence of money supply and government spending affect exchange rate volatility positively. This result is also inferred from the ad hoc model. Equations (35) and (36) are indicative of the negative relationship between the covariance of selected variables and exchange rate volatility.

5. Output Volatility

Output Determination and Output Variance

Having determined the level of exchange rate from equation (10) we can model the output level by substituting equations (3), (4), (6) and (10) into (5) yielding:

$$\begin{aligned} y_t = & B_1 \left[\eta(1 - \pi_0)(\pi_0\phi_2 - \phi_1) + \beta\phi_1\pi_0\phi_2 \right] \varepsilon_t + \pi_0\phi_2 B_1 \left[-\eta(\pi_0 - 1)^2 + \beta\phi_1\pi_0 \right] \{ \varepsilon_{t-1} + \pi_0\varepsilon_{t-2} + \pi_0^2\varepsilon_{t-3} + \dots \} + \\ & + B_1 \left\{ \phi_2 \left[\eta(\pi_0 - 1)(\pi_0 + \lambda) + \lambda(\alpha + \beta\phi_2)\pi_0 \right] + \phi_1 \left[\eta(1 - \pi_0) - \beta\phi_2\pi_0 \right] \right\} z_t + \pi_0\phi_2 B_1 \left[\eta(\pi_0 - 1)^2 + \right. \\ & + \lambda(\alpha + \beta\phi_2)\pi_0 - \beta\phi_1\pi_0 \left. \right] \{ z_{t-1} + \pi_0 z_{t-2} + \pi_0^2 z_{t-3} + \dots \} - \gamma\lambda B_1 \left[\beta\pi_0\phi_2 - \eta(1 - \pi_0) \right] \omega_t - \beta\gamma\pi_0^2\phi_2\lambda B_1 \{ \omega_{t-1} + \\ & + \pi_0\omega_{t-2} + \dots \} - \lambda B_1 \left(\beta\pi_0\phi_2 - \eta(1 - \pi_0) \right) v_t - \beta\pi_0^2\phi_2\lambda B_1 \{ v_{t-1} + \pi_0 v_{t-2} + \dots \} - \pi_0\phi_2\lambda B_1 \\ & \{ u_t + \pi_0 u_{t-1} + \pi_0^2 u_{t-2} + \dots \} \end{aligned} \quad (38)$$

where $B_1 = 1/\lambda\eta(1 - \pi_0)$

Equation (38) indicates that the level of output is defined by the same factors as the exchange rate level which seems to be reasonable since we have substituted the equation of exchange rate into the output equation. Thus, money supply shocks, inflationary shocks, unanticipated changes in government spending as well as in output process and trade balance affect the level of output.

Furthermore, we compute the variance of equation (38) in order to make inference about the determinants of output uncertainty. It is implied that the unconditional mean of y_t is found to be $E(y_t)=0$ for all t and the various shocks that affect output are pairwise correlated. Under these assumptions, the output variance is formed by the following equation:

$$\begin{aligned}
\sigma_y^2 = & \frac{B_2}{\lambda^2} \left\{ \left[\eta(1-\pi_0)(\pi_0\phi_2 - \phi_1) + \beta\phi_1\phi_2\pi_0 \right]^2 (1-\pi_0^2) + (\pi_0^2\phi_2^2) \left[-\eta(\pi_0-1)^2 + \beta\phi_1\pi_0 \right]^2 \right\} \sigma_\varepsilon^2 + \\
& + \frac{B_2}{\lambda^2} \left\{ \left[\phi_2 \left[\eta(\pi_0-1)(\pi_0 + \lambda) + \lambda(\alpha + \beta\phi_2\pi_0) \right] + \phi_1 \left[\eta(1-\pi_0) - \beta\phi_2\pi_0 \right] \right]^2 (1-\pi_0^2) + (\pi_0^2\phi_2^2) \right. \\
& \left. \left[\eta(\pi_0-1)^2 + \lambda\pi_0(\alpha + \beta\phi_2) - \beta\phi_1\pi_0 \right]^2 \right\} \sigma_z^2 + \gamma^2 B_2 \left\{ \left[\beta\pi_0\phi_2 - \eta(1-\pi_0) \right]^2 (1-\pi_0^2) + \beta^2\pi_0^4\phi_2^2 \right\} \sigma_w^2 + \\
& + B_2 \left\{ \left[\beta\pi_0\phi_2 - \eta(1-\pi_0) \right]^2 (1-\pi_0^2) + \beta^2\pi_0^4\phi_2^2 \right\} \sigma_v^2 + \pi_0^2\phi_2^2 B_2 \sigma_u^2 - \frac{B_2}{\lambda^2} \left\{ 2 \left[\phi_2^2\pi_0^2 (\eta(1-\pi_0)^2 - \beta\phi_1\pi_0) \right. \right. \\
& \left. \left. (\eta(1-\pi_0)^2 - (\beta\phi_1 - \alpha\lambda - \beta\phi_2\lambda)\pi_0) \right] - \left[\phi_2\eta(\pi_0-1)\pi_0 + \phi_1(\eta - (\beta\phi_2 + \eta)\pi_0 + \phi_2((\alpha + \beta\phi_2)\lambda\pi_0 + \right. \right. \\
& \left. \left. + (\pi_0-1)(\lambda + \pi_0)) \right] (1-\pi_0^2) \right\} \left\{ Cov(\varepsilon_t, z_t) - \frac{2\gamma B_2}{\lambda} \left[\phi_1 \left(\beta^2\phi_2^2\pi_0^2 + \frac{1}{B_2} - 2\beta\phi_2\pi_0 B_3 \right) + \phi_2\eta(1-\pi_0)^2\pi_0 \right. \right. \\
& \left. \left. (\beta\phi_2\pi_0 - \eta(1-\pi_0^2)) \right] Cov(\varepsilon_t, \omega_t) - \frac{2B_2}{\lambda} \left\{ \phi_1 \left[-\beta^2\phi_2^2\pi_0^2 + \frac{1}{B_2} \right] + \phi_2 \left[\lambda + (\beta\phi_2(\alpha + \beta\phi_2)\pi_0^2 - \frac{1}{B_2} + \alpha\pi_0 B_3) \right. \right. \right. \\
& \left. \left. + \eta(1-\pi_0)^2\pi_0(-\beta\phi_2\pi_0 - \eta(1-\pi_0^2)) \right] \right\} Cov(z_t, v_t) - \frac{2B_4}{\lambda} \left\{ \phi_1 \left[-\beta\phi_2\pi_0 + B_3 \right] + \phi_2 \left[-\eta((1-\pi_0)^2\pi_0 + \right. \right. \\
& \left. \left. + \lambda(\alpha + \beta\phi_2)\pi_0 - B_3) \right] \right\} Cov(z_t, u_t) + 2\gamma B_4 \left[\beta\phi_2\pi_0 - B_3 \right] Cov(\omega_t, u_t) - 2B_4 \left[\beta\phi_2\pi_0 - B_3 \right] Cov(v_t, u_t) \quad (39)
\end{aligned}$$

where $B_2 = 1/\eta^2(1-\pi_0)^2(1-\pi_0^2)$, $B_3 = \eta(1-\pi_0)^2(1+\pi_0)$, $B_4 = \phi_2\pi_0 B_2$

In order to define the relationship between the output level and the various shocks that are found to affect it as well as the relationship between output volatility and the volatility of various shocks, we compute the comparative-statics analysis as follows.

Comparative Statics of Output and its Variance

Shocks in money supply, government spending and output impose a positive effect on the level of output, as shown below:

$$\frac{\partial y_t}{\partial \varepsilon_t} = B_1 \left[\phi_2 \eta (\pi_0 - 1) \pi_0 + \phi_1 (\eta - (\beta \phi_2 + \eta) \pi_0) \right] > 0 \quad (40)$$

$$\frac{\partial y_t}{\partial \omega_t} = \gamma \lambda B_1 (\eta (\pi_0 - 1) + \beta \phi_2 \pi_0) > 0 \quad (41)$$

Contrary to these results, unanticipated changes in trade balance cause a negative effect on output level while shocks in prices and output are found to impose an ambiguous impact given by the following equations, respectively:

$$\frac{\partial y_t}{\partial u_t} = \phi_2 \pi_0 \lambda B_1 < 0 \quad (42)$$

$$\frac{\partial y_t}{\partial z_t} = -B_1 \left[\phi_1 (\eta - (\beta \phi_2 + \eta) \pi_0) + \phi_2 ((\alpha + \beta \phi_2) \lambda \pi_0 + \eta (\pi_0 - 1) (\lambda + \pi_0)) \right] \quad (43)$$

$$\frac{\partial y_t}{\partial v_t} = \lambda B_1 [\eta (1 - \pi_0) + \beta \phi_2 \pi_0] \quad (44)$$

Given the variance of output we may compute the comparative-statics in order to provide evidence for the relationship between output variability and its determinants. We find that changes in the variance of money supply shock affects output volatility positively as expressed in the following equation:

$$\frac{\partial \sigma_y^2}{\partial \sigma_\varepsilon^2} = \frac{B_2}{\lambda^2} \left\{ [\eta (1 - \pi_0) (\pi_0 \phi_2 - \phi_1) + \beta \phi_1 \phi_2 \pi_0]^2 (1 - \pi_0^2) + (\pi_0^2 \phi_2^2) [-\eta (\pi_0 - 1)^2 + \beta \phi_1 \pi_0]^2 \right\} > 0 \quad (45)$$

The effect of the variance of a money supply shock is illustrated in Figure 2. An increase (small) in money supply shifts the LM curve downwards and the economy goes from point A to point B. At B, there is an incipient deficit in the Balance of Payments because due to the lower interest rate the level of capital inflows is insufficient to offset the deficit in the CA. The deficit in the Balance of Payments means that the exchange rate has to depreciate. As the exchange rate depreciates (e increases), Net Exports increase because the relative price of domestic goods on international markets has fallen. The rise of NX has two effects: a) Total Expenditures increase therefore the IS curve moves right, and, b) the Current Account improves so the BP curve moves to the right. The new equilibrium occurs at C, where the economy has had an increase in y from y_0 to y_1 . Following the same analysis for the case

of a greater increase in the money supply, we find that the economy has had a greater increase in the output, y (from y_0 to y_2). A similar analysis holds for negative shocks to money supply. Thus, an increase in the variance of a monetary supply shock affects positively the output variance.

Figure 2: The positive effect of a change in the variance of a money supply shock on output variance

In addition, the variance of the price level, government spending, output and trade balance impose a positive impact on output volatility as shown in equations (46) through (49), respectively.

$$\frac{\partial \sigma_y^2}{\partial \sigma_z^2} = \frac{B_2}{\lambda^2} \left\{ \left[\phi_2 \left[\eta(\pi_0 - 1)(\pi_0 + \lambda) + \lambda(\alpha + \beta\phi_2\pi_0) \right] + \phi_1 \left[\eta(1 - \pi_0) - \beta\phi_2\pi_0 \right] \right]^2 (1 - \pi_0^2) + \right. \\ \left. + (\pi_0^2 \phi_2^2) \left[\eta(\pi_0 - 1)^2 + \lambda\pi_0(\alpha + \beta\phi_2) - \beta\phi_1\pi_0 \right]^2 \right\} > 0 \quad (46)$$

$$\frac{\partial \sigma_y^2}{\partial \sigma_\omega^2} = \gamma^2 B_2 \left\{ \left[\beta\pi_0\phi_2 - \eta(1 - \pi_0) \right]^2 (1 - \pi_0^2) + \beta^2 \pi_0^4 \phi_2^2 \right\} > 0 \quad (47)$$

$$\frac{\partial \sigma_y^2}{\partial \sigma_v^2} = B_2 \left\{ \left[\beta\pi_0\phi_2 - \eta(1 - \pi_0) \right]^2 (1 - \pi_0^2) + \beta^2 \pi_0^4 \phi_2^2 \right\} > 0 \quad (48)$$

$$\frac{\partial \sigma_y^2}{\partial \sigma_u^2} = \pi_0^2 \phi_2^2 B_2 > 0 \quad (49)$$

Furthermore, we provide evidence that the coexistence of money supply shocks and government spending shocks imposes a positive impact on output volatility, given by the following equation:

$$\begin{aligned} \frac{\partial \sigma_y^2}{\partial \text{Cov}(\varepsilon_t, \omega_t)} = & -\frac{2\gamma B_2}{\lambda} \left[\phi_1 \left(\beta^2 \phi_2^2 \pi_0^2 + \frac{1}{B_2} - 2\beta \phi_2 \pi_0 B_3 \right) + \right. \\ & \left. + \phi_2 \eta (1 - \pi_0)^2 \pi_0 \left(\beta \phi_2 \pi_0 - \eta (1 - \pi_0^2) \right) \right] > 0 \end{aligned} \quad (50)$$

Contrary to the positive effect of the variance of various shocks on output volatility, the occurrence of contemporaneous shocks (i) in money supply and prices, (ii) in prices and output, as well as, (iii) in prices and trade balance, and, (iv) the covariance of output shocks and trade balance shocks, affects either positively or negatively the variance of output as expressed in equations (51) – (54), respectively:

$$\begin{aligned} \frac{\partial \sigma_y^2}{\partial \text{Cov}(\varepsilon_t, z_t)} = & -\frac{B_2}{\lambda^2} \left\{ 2 \left[\phi_2^2 \pi_0^2 (\eta (1 - \pi_0)^2 - \beta \phi_1 \pi_0) (\eta (1 - \pi_0)^2 - (\beta \phi_1 - \alpha \lambda - \beta \phi_2 \lambda) \pi_0) \right] - \right. \\ & \left. - \left[\phi_2 \eta (\pi_0 - 1) \pi_0 + \phi_1 (\eta - (\beta \phi_2 + \eta) \pi_0 + \phi_2 ((\alpha + \beta \phi_2) \lambda \pi_0 + (\pi_0 - 1)(\lambda + \pi_0))) \right] (1 - \pi_0^2) \right\} \end{aligned} \quad (51)$$

$$\begin{aligned} \frac{\partial \sigma_y^2}{\partial \text{Cov}(z_t, v_t)} = & -\frac{2B_2}{\lambda} \left\{ \phi_1 \left[-\beta^2 \phi_2^2 \pi_0^2 + \frac{1}{B_2} \right] + \phi_2 \left[\lambda + (\beta \phi_2 (\alpha + \beta \phi_2) \pi_0^2 - \frac{1}{B_2} + \alpha \pi_0 B_3) + \right. \right. \\ & \left. \left. + \eta (1 - \pi_0)^2 \pi_0 (-\beta \phi_2 \pi_0 - \eta (1 - \pi_0^2)) \right] \right\} \end{aligned} \quad (52)$$

$$\frac{\partial \sigma_y^2}{\partial \text{Cov}(z_t, u_t)} = -\frac{2B_4}{\lambda} \left\{ \phi_1 [-\beta \phi_2 \pi_0 + B_3] + \phi_2 [-\eta ((1 - \pi_0)^2 \pi_0 + \lambda (\alpha + \beta \phi_2) \pi_0 - B_3)] \right\} \quad (53)$$

$$\frac{\partial \sigma_y^2}{\partial \text{Cov}(v_t, u_t)} = -2B_4 [\beta \phi_2 \pi_0 - B_3] \quad (54)$$

On the other hand, contemporaneous shocks in trade balance and government spending impose a negative impact on output volatility, given by the following equation:

$$\frac{\partial \sigma_y^2}{\partial \text{Cov}(\omega_t, u_t)} = 2\gamma B_4 [\beta \phi_2 \pi_0 - B_3] < 0 \quad (55)$$

At this point we compute the pairwise relative effect of selected variances and covariances in order to conclude which effect on the output variance is greater. Therefore, we make several comparisons between variances and covariances.

In all cases parameter values determine which effect on output variance is stronger. For instance, the impact of the variance of a government spending shock on the output variance is greater than that of the variance of an output shock, $(\partial\sigma_y^2/\partial\sigma_\omega^2) > (\partial\sigma_y^2/\partial\sigma_v^2)$, under the condition $\gamma > 1$. The intuition of this relative effect lies to the greater impact of government spending shock (and its variance) on output (and its variance) than that of an output shock (and its variance). If $0 < \gamma < 1$ then the inverse conclusion is drawn. The rest comparisons of comparative statics require the satisfaction of several sets of parameter restrictions.

Just in the case of the covariance effects, we find that $(\partial\sigma_y^2/\partial\text{Cov}(\varepsilon_t, \omega_t)) < (\partial\sigma_y^2/\partial\text{Cov}(\omega_t, u_t))$, meaning that the effect of the coexistence of policy shocks (fiscal and monetary) on output variance is weaker than the contemporaneous shocks in government spending and trade balance.

6. Conclusions

This study examines the issue of volatility on exchange rates and output. We follow and extend the work of Driskill and McCafferty (1980) by including an output demand equation and define the determinants of exchange rate and output as well. Assuming that rational expectations hold for exchange rates, we conclude that the level of the exchange rate is affected by monetary and price shocks and shocks in government spending, output demand and the trade balance. These factors appear to determine the output volume too.

The most important aspect of this paper is the *determination* of both exchange rate volatility and output volatility. Computing the variance of exchange rate and output and considering that the various shocks are pairwise correlated, we prove that the variance of both exchange rate and output is determined by the variance and covariance of these shocks. We conclude that the variance of each shock, as well as, the covariance of selected shocks affects the variance of exchange rate and output. More specifically, the existence of uncertainty which affects money supply, price level, government spending, output and trade balance imposes a positive impact on the uncertainty of exchange rate and output as well. In addition, the contemporaneous occurrence of shocks in money supply and government spending affects affirmatively the uncertainty of exchange rate and output as well.

Contrary to the previous findings, the coexistence of changes in government spending and trade balance impinges a negative effect on both exchange rate and output volatility. Further, we provide evidence indicative of the ambiguous effect of the contemporaneous existence of (i) money supply shocks and price shocks, (ii) price shocks and output shocks and (iii) unanticipated changes in price level and trade balance on both types of uncertainty. Moreover, we find that contemporaneous unanticipated changes in output and trade balance affect positively exchange rate volatility and ambiguously output volatility. The conclusions for exchange rate volatility and output volatility are illustrated in the context of the IS-LM-BP model.

Another aspect of this paper is the examination of the *relative effects* of the determinants of exchange rate and output volatility. We show that in both types of volatility the degree of impact of the determinants is very sensitive to the parameter values. Therefore, we have ambiguous results apart from the case where we clearly find that the effect of the coexistence of policy shocks is weaker than that of the contemporaneous shocks in government spending and trade balance.

Finally, we describe briefly the optimizing behaviour model of Obstfeld and Rogoff (1995, 1996) and we compute the exchange rate volatility which is found to be affected by money supply volatility, government spending volatility, as well as, by the covariance of money supply and government spending shocks in the home and foreign country. The comparative-statics are indicative of the positive relationship between exchange rate volatility and the volatility of money supply and government spending, as well as the coexistence of money supply and government spending shocks in both countries. Both models reach the same conclusions regarding these two determinants of exchange rate volatility. Lastly, the contemporaneous occurrence of (i) money supply shocks in both countries, and, (ii) government spending shocks in both countries, are linked negatively with exchange rate volatility.

References

Bayoumi, T. and B. Eichengreen, "Exchange Rate Volatility and Intervention: Implications of the Theory of Optimum Currency Areas," *Journal of International Economics* 45 (1998): 191-209.

- Betts, C. and M. B. Devereux, "The Exchange Rate in a Model of Pricing-To-Market," *European Economic Review* 40 (1996): 1007-1021.
- Canales-Kriljenko, J. and K. Habermeier, "Structural Factors Affecting Exchange Rate Volatility: a Cross-Section Study," International Monetary Fund, working paper 147 (2004).
- Caporale, T. and B. McKiernan, "The Relationship between Output Variability and Growth: Evidence from Post War UK Data," *Scottish Journal of Political Economy* 43 (1996): 229-236.
- Driskill, R. and S. McCafferty, "Exchange Rate Determination: An Equilibrium Approach with Imperfect Capital Substitutability," *Journal of International Economics* 23 (1987): 241-261.
- Driskill, R. and S. McCafferty, "Exchange-Rate Variability, Real and Monetary Shocks, and the Degree of Capital Mobility Under Rational Expectations," *The Quarterly Journal of Economics* 95 (1980): 577-586.
- Fatas, A. and I. Mihov, "Policy Volatility, Institutions and Economic Growth," CEPR, discussion paper 5388 (2005).
- Fatas, A. and I. Mihov, "The Case for Restricting Fiscal Policy Discretion," *Quarterly Journal of Economics* 118 (2003): 1419-1447.
- Fatas, A. and I. Mihov, "The Macroeconomic Effects of Fiscal Rules in the US States," *Journal of Public Economics* 90 (2006): 101-117.
- Fiaschi, D. and A. M. Lavezzi, "On the Determinants of Growth Volatility: a Nonparametric Approach," Collana di E-papers del Dipartimento di Scienze Economiche, Universita di Pisa, discussion paper 25 (2003).
- Fountas, S., M. Karanasos and A. Mendoza, "Output Variability and Economic Growth: The Japanese Case," *Bulletin of Economic Research* 56 (2004): 353-363.
- Fountas, S., M. Karanasos and J. Kim, "Inflation and output growth uncertainty and their relationship with inflation and output growth," *Economics Letters* 75 (2002): 293-301.
- Furceri, D., "Is Government Expenditure Volatility Harmful for Growth? A Cross-Country Analysis," *Fiscal Studies* 28 (2007): 103-120.

- Grier, K. B. and M. J. Perry, "The Effects of Real and Nominal Uncertainty on Inflation and Output Growth: Some GARCH-M Evidence," *Journal of Applied Econometrics* 15 (2000): 45-58.
- Imbs, J., "Growth and Volatility," *Journal of Monetary Economics* 54 (2007): 1848-1862.
- Karras, G., "Trade Openness, Economic Size, and Macroeconomic Volatility: Theory and Empirical Evidence," *Journal of Economic Integration* 21 (2006): 254-272.
- Manuelli, E. R. and J. Peck, "Exchange Rate Volatility in an Equilibrium Asset Pricing Model," *International Economic Review* 31 (1990): 559-574.
- Obstfeld, M. and K. Rogoff, "Exchange Rate Dynamics Redux," *The Journal of Political Economy* 103 (1995): 624-660.
- Obstfeld, M. and K. Rogoff, *Foundations of International Macroeconomics*, MIT Press, Cambridge, Massachusetts, (1996).
- Ramey, G. and V. A. Ramey, "Cross-Country Evidence on the Link between Volatility and Growth," *American Economic Review* 85 (1995): 1138-1151.
- Speight, A. E. H., "UK output variability and growth: some further evidence," *Scottish Journal of Political Economy* 46 (1999): 175-184.
- Stock, H. J. and M. W. Watson, "Has the Business Cycle Changed and Why?," National Bureau of Economic Research, Inc., working paper 9127 (2002).
- Turnovsky, J. S. and J. S. Bhandari, "The Degree of Capital Mobility and the Stability of an Open Economy under Rational Expectations," *Journal of Money, Credit and Banking* 14 (1982): 303-326.