Macroeconomic Volatility and Counterfactual Inflation-Targeting in Hong Kong

G.C. Lim*and Paul D. McNelis†

June 2011

Abstract

This paper evaluates macroeconomic adjustment in Hong Kong with an estimated DSGE model under a fixed exchange rate regime. We find that exports and world inflation shocks are the dominant sources of GDP volatility, with the risk premium taking on importance during the Asian crisis after 1997. A counterfactual simulation, assuming a flexible exchange rate regime with inflation targeting, shows that inflation would have decreased slightly, but interest-rate volatility would have increased significantly. The welfare gains from switching out of the currency board system appear to be marginal.

Keywords: Bayesian estimation, counterfactual inflation targeting regime, sources of volatility

JEL Classification: E62, F41

*Melbourne Institute of Economic and Social Research, University of Melboure, Parkville, Australia. Email: g.lim@unimelb.edu.au

†Department of Finance, Fordham University, New York. Email: mcnelis@fordham.edu

1 Introduction

Since the inception of the currency board in 1984, overall macroeconomic volatility in Hong Kong has been relatively low, with the exception of the Asian Flu in 1997 and the Severe Acute Respiratory Syndrome (SARS) crisis of 2003, when there were steep falls in GDP growth. Figure 1 pictures the evolution of annualized GDP growth, terms of trade, real export and government spending growth, as well as domestic and foreign (proxied by the US dollar-denominated LIBOR) interest rates, and inflation.

Figure 1: Hong Kong Macroeconomic Indicators

Figure 1 shows that a significant spread between the domestic and foreign interest rates emerged at the time of the Asian Flu. At the time of the SARS crisis, domestic interest rates actually fell slightly below the US dollar-denominated LIBOR rates. Inflation became negative at the start of the Asian crisis and remained below zero until 2005.

Figure 1 also shows that export growth slumped severely at the time of the Asian Flu, but the slump was much less noticeable at the time of the SARS crisis. We also see that changes in terms of trade have been relatively stable between 1990 and 2008, relative to the growth rates of GDP and exports. Government spending has fluctuated more at the beginning of the sample than at the end of the sample.

This paper assesses the relative contribution of different shocks to real GDP volatility and inflation in Hong Kong. The shocks considered are: shocks to exports, government spending, world prices, as well as to foreign interest rates and the risk premium (defined as the spread between domestic and foreign rates). The analysis is based on a small open economy DSGE (dynamic stochastic general equilibrium) model with Bayesian estimates of the structural parameters and shock volatilities.

Admittedly we use a very simple model, one that abstracts from many important considerations, such as housing prices. A key aim of this paper is to show how even relatively simple DSGE models may be used to extract useful information about the structural dynamic processes of an economy and offer insights into policy evaluation.

We find that the export and world price shocks dominate output volatility, while shocks to world prices and world interest rates dominate inflation volatility. World price shocks affect output through their effects on the terms of trade. This result is consistent with the work of Mendoza (1995), who found that terms of trade effects dominate productivity shocks as the driving force of real business cycles in emerging-market economies.

The main finding is that the shocks affecting Hong Kong are predominantly external (export demand, world inflation and world interest rates) and that they represent both nominal and real factors. This then leads to the policy question: would overall macroeconomic volatility have been lower if Hong Kong had followed a flexible exchange-rate system with inflation targeting, instead of the currency board in place since 1984?

The motivation for the counterfactual comes from a number of important studies. Friedman (1953) argued that if shocks are foreign and prices are sticky, flexible exchange rates would provide better insulation for an economy by allowing prices to adjust more rapidly. Mundell (1968) later argued that the choice of exchange rate regime, under capital mobility, would depend on the nature of the shocks. An economy affected by predominately real shocks should have a flexible exchange rate regime. Finally, Lahiri, Singh and Vegh (2007) find that if assets markets are segmented, fixed rates are optimal for real shocks while flexible rates are optimal for monetary shocks.

The next section lays out the model we use for this paper. Section III discusses the Bayesian estimation results as well as the impulse-response functions, conditional variance decomposition and the historical shock decomposition. Section IV contains the counter-factual simulations, followed by the conclusion.

2 Model

Our model follows Gali and Monicelli (2008) rather than say the model in Devereux, Lane and Xu (2006) because it abstracts from capital accumulation. This assumption is more appropriate for Hong Kong mainly because the export base has become progressively more labor intensive, with export activity taking the form of re-exportation of goods from mainland China to the rest of the world. However,our model goes beyond Gali and Monicelli since it has explicit treatment of the accumulation of foreign assets and domestic debt.

2.1 Households - Consumption and Labor

A representative household, at period 0, optimizes the intertemporal welfare function V_0,

$$V_0 = \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t U_t(C_t, L_t)$$
$$U_t(.) = \frac{C_t^{1-\eta}}{1-\eta} - \frac{L_t^{1+\varpi}}{1+\varpi}$$

where β is the discount factor, C_t is consumption, L_t is labour services, η is the coefficient of relative risk aversion ϖ is the elasticity of marginal disutility with respect to labour supply and $\mathbf{E}_0$ is the expectation operator. The household budget equation can be written as:

$$W_t L_t + R_{t-1} B_{t-1} + (R^*_{t-1} + Q_{t-1}) F^*_{t-1} S_t + \Omega_t = B_t + S_t F^*_t + P^c_t C_t$$

where W is the wage rate, B represents domestic bonds, F^* is foreign assets, R is the gross interest rate on bonds, R^* is the gross foreign interest rate, Q is the risk premium, Ω_t is distributed profits, S_t is the exchange rate and P^c_t is the consumer price level. We abstract from taxes on consumption and labor income, since such tax rates are low in Hong Kong.[1]

Households take the wage rate as given and each household chooses consumption, labor, holdings of bond and foreign asset to maximize utility subject to the budget constraint. We assume that each household chooses non-trivial solutions in that $C_t > 0$, $L_t > 0$, $B_t > 0$ while F^*_t can be positive or negative. We assume all households face the same interest rate and wage rate - so the first order conditions are identical across all households and hold in aggregate.

$$C_t^{-\eta} = \Lambda_t P^c_t \quad (1)$$
$$\Lambda_t W_t = L_t^{\varpi} \quad (2)$$
$$\Lambda_t = \beta R_t \mathbf{E}_t[\Lambda_{t+1}] \quad (3)$$
$$\Lambda_t S_t = \beta(R^*_t + Q_t)\mathbf{E}_t[\Lambda_{t+1} S_{t+1}] \quad (4)$$

The last two equations yield the interest-parity relation. We assume that both the foreign interest rate and the risk premium follow autoregressive stochastic processes:

$$S_t R_t = (R^*_t + Q_t)\mathbf{E}_t(S_{t+1}) \quad (5)$$

$$\log(R^*_t) = \rho^r \log(R^*_{t-1}) + (1-\rho^r)\log(\overline{R^*}) + \epsilon^r_t; \qquad \epsilon^r_t \,\tilde{}\, N(0, \sigma_r^2) \quad (6)$$
$$\log(Q_t) = \rho^q \log(Q_{t-1}) + (1-\rho^q)\log(\overline{Q}) + \epsilon^q_t; \qquad \epsilon^q_t \,\tilde{}\, N(0, \sigma_q^2) \quad (7)$$

The risk factor for Hong Kong is an exogenous process. We model risk this way, rather than as a function of the external debt/gdp ratio, since Hong

[1] We have also not included a financial sector; rather we have chanelled all domestic and international lending and borrowing through the household sector. The highly open and competitive nature of the Hong Kong financial system allows us to simplify this aspect of activities.

Kong has been a net creditor. In Figure 1, a risk premium, shown by the jump in the domestic interest rate above the LIBOR, appeared at the time of the Asian crisis. This risk premium is a contagion effect which affected Hong Kong because of its geographical proximity to the crisis-center countries of Indonesia and Thailand. The risk premium for Hong Kong is exogenously determined, brought on by what Calvo and Mendoza (2000) called "information frictions" in global financial markets. In other words, countries with sound economic fundamentals suffer spillover effects from crisis-prone countries in their region, when international investors, beset with information frictions, simply decide to demand higher risk premia from all countries in a region.

2.2 Firms - Production & Pricing

Output is a function of labor only (since we abstract from issues associated with capital formation). We also abstract from productivity shocks, following Mendoza (1995) who argued that such shocks are less important for emerging market countries than terms of trade or export demand shocks. Production in Hong Kong is modelled as a highly labor-intensive activity.

$$Y_t = L_t \tag{8}$$

Total output is for both household and government consumption G_t, and for net exports X_t:

$$Y_t = C_t + G_t + X_t \tag{9}$$

$$\log(G_t) = \rho^g \log(G_{t-1}) + (1-\rho^g)\log(\overline{G}) + \epsilon_t^g; \qquad \epsilon_t^g \sim N(0,\sigma_g^2) \tag{10}$$

$$\log(X_t) = \rho^x \log(X_{t-1}) + (1-\rho^x)\log(\overline{X}) + \epsilon_t^x; \qquad \epsilon_t^x \sim N(0,\sigma_x^2) \tag{11}$$

where G_t and X_t are assumed to follow simple exogenous autoregressive processes.

We assume sticky monopolistically competitive firms and the marginal cost at time t, A_t,is:

$$A_t = W_t \tag{12}$$

In the Calvo price setting world, there are forward-looking domestic-goods price setters and backward looking setters. Assuming at time t that ξ is the probability of persistence, with demand for the product from firm j given by $Y_t\left(P_t^j/P_t\right)^{-\zeta}$, the optimal domestic-goods price, P_t^o can be written in forward recursive formulation, while the domestic price level P_t is a CES aggregator of forward and backward-looking prices:[2]

$$P_t^o = \left(\frac{\zeta}{\zeta-1}\right)\frac{N_t}{D_t} \tag{13}$$

$$N_t = Y_t P_t^{\zeta} A_t + \beta\xi N_{t+1} \tag{14}$$

$$D_t = Y_t P_t^{\zeta} + \beta\xi D_{t+1} \tag{15}$$

$$P_t = \left[\xi\left(P_{t-1}\right)^{1-\zeta} + (1-\xi)\left(P_t^o\right)^{1-\zeta}\right]^{\frac{1}{1-\zeta}} \tag{16}$$

[2]For simplicity, we have assumed that the firm's discount factor is also β.

2.3 Monetary and Fiscal Framework

The Treasury/Central Bank borrows to finance government expenditure, such that the evolution of domestic bonds become:

$$B_t = P_t G_t + B_{t-1} R_{t-1} \tag{17}$$

The foreign asset evolves as follows:

$$P_t^f X_t = S_t (F_t^* - F_{t-1}^* (R_{t-1}^* + Q_{t-1})) \tag{18}$$

Following Gali and Monacelli, we assume that traded goods are priced at the world price, P_t^* given by the following expression:

$$P_t^f = S_t P_t^*$$

In a flexible exchange rate environment, the gross interest rate is assumed to follow a Taylor-type rule:

$$\log(R_t) = \rho^k \log(R_{t-1}) + (1 - \rho^k)[\log(\overline{R}) + \rho^\pi \log(\Pi_t^c / \overline{\Pi^c}) + \rho^y \log(Y_t / \overline{Y})] \tag{19}$$

where $\overline{R}$ is the steady-state interest rate, ρ^k is the smoothing parameter and ρ^π is the inflation parameter ($\rho^\pi > 1$), while ρ^y is the parameter for output relative to steady-state output $\overline{Y}$. The term Π_t^c is gross CPI inflation equal to (P_t^c / P_{t-1}^c), while $\overline{\Pi^c}$ is its steady-state value. In log-deviation form, CPI inflation rate has the following form:

$$\begin{aligned} \pi_t^c &= \pi_t + \gamma(\Delta \mathbf{tt}_t) \\ \Delta \mathbf{tt}_t &= \Delta s_t + \pi_t^* - \pi_t \end{aligned}$$

where the parameter γ, as in Gali and Monicelli (2005) is an index of openness π_t is domestic-goods inflation while the effective terms of trade $\mathbf{tt}_t$ is the relative price (P_t^f / P_t) in log deviation form. We assume that the foreign price inflation follows an autoregressive process:[3]

$$\log(\Pi_t^*) = \rho^p \log(\Pi_{t-1}^*) + (1 - \rho^p) \log(\overline{\Pi^*}) + \epsilon_t^p; \qquad \epsilon_t^p \sim N(0, \sigma_{\pi^*}^2)$$

In the fixed exchange rate case, the exchange rate is pegged at $\overline{S}$, and the Taylor rule is not applicable. Instead, the domestic interest rate is equal to the foreign rate R_t^* plus the risk premium Q_t :

$$R_t = (R_t^* + Q_t) \tag{20}$$

The log-linearised deviation version of the model appears in the Appendix.

[3] We note that having a stochastic process for the foreign price inflation, which in turn affects the evolution of the terms of trade, contradicts the fact that firms have some control over their markets. We would expect that changes in net exports would feedback into an improvement in terms of trade. However, following Lubik and Schorfheide (2007), who noted that estimation with fully endogenous world prices would be problematic for Bayesian estimation, we model both export demand and world prices (affecting terms of trade) as exogenous stochastic processes.

3 Bayesian Estimation

We estimated the model using Bayesian techniques for the period 1990-2008 The observable variables are the rates of growth of real GDP, CPI inflation, real government spending, as well as quarterly nominal domestic and foreign interest rates. All variables are de-meaned.

Bayesian methods are well suited for estimation of structural parameters of a DSGE model. This method allows us to incorporate prior information, from economic theory, as well as other empirical studies about the likely distributions as well as upper and lower values of possible values. We know, for example, that certain coefficients such as the Calvo pricing parameter are between zero and one. Bayesian methods allow us to incorporate this information into the estimation process.

Another reason why Bayesian methods have become popular in DSGE estimation is that we recognize that we work with limited observations on data. In the classical approach, observed data are assumed to be one realization of possible data generated by the underlying "data generating mechanism". The Bayesian method does not assume that the model we use reveals the true underlying data-generating mechanism. Rather, it starts from the recognition that all models are misspecified – there is no true underlying data-generating mechanism, and that all we have to work with are the actual observed data. Also uncertainty applies to both the stochastic shocks as well as the parameters of the model and thus priors on the distributions of the parameters as well as on the standard devations of the shocks are informative.

Given that the Bayesian method is upfront about model uncertainty, we estimate both a pure DSGE model and a hybrid DSGE/VAR model, following Del Negro and Schorfheide (2004). The intuition for using the hybrid DSGE/VAR approach comes from recognizing that a pure DSGE model could suffer from specification errors, and that the explanatory power of the model could be improved by the use of a non-structural VAR model. In this approach, the weight of the pure VAR, relative to the pure DSGE model, is given by the ratio $1/(1+\lambda)$. If $\lambda = 0$, the pure VAR model explains all the variation in the data, and if $\lambda = \infty$, the pure DSGE explains the variation in the data without any input from the VAR. The advantage of using the hybrid DSGE/VAR Bayesian model is thus to provide a specification test of the DSGE model relative to the widely used non-structural alternative, the VAR, with $0 < \lambda < \infty$ indicating the merit of the DSGE relative to the VAR.

All of the structural parameters were estimated, except for the discount factor β which is calibrated for a steady-state annual gross interest rate of 1.04.[4] In the log-linearized model, we specified the steady-state share of consumpton to GDP at 0.65, and the steady-state share of government spending to GDP at 0.10. These ratios are the mean values of actual data. The net export ratio, of course, is 0.25.

[4] Since the model is in log-linear deviations, there is no need to calibrate the model for parameters which affect the steady state, as suggested by Christiano, Motto, and Rostagno (2007). The shares are sample averages.

3.1 Priors and Posteriors

The model is estimated in a pure DSGE framework as well as in a DSGE/VAR framework, following Del Negro and Schorfheide (2004), Adjemian, Darracq, and Moyen (2008) and An and Kang (2009).

For each parameter, we specify the distribution, the mean, as well as the standard deviation. The choice of prior distributions as well as their mean and standard deviation values match those used by Smets and Wouters (2003,2007). The volatility priors have inverse gamma distributions. Parameters restricted to fall between zero and one have a beta distribution, while coefficients outside this range are specified with a normal distribution with restrictions on their infimum and supremum. For the DSGE/VAR parameter, we follow the practice of setting a uniform distribution for λ, with a minimum value of 0, and a max of 2.

Regarding the posterior distribution, we present the mode, the mean as well as the lower and upper 5% confidence levels of the posterior distributions. The estimates come from Metropolis-Hastings Monte Carlo Markov Chain replications with ten sets of 500,000 draws[5] [See Lubik and Schorfheide (2005) and An and Schorfheide (2007) for fuller discussions of Bayesian estimation of open-economy macrodynamic models].

The main features of our structural estimates, in the Lucas (1976) interpretation, are presented in Table 1. We note first that the posterior estimates under both frameworks are similar. Information about the parameter λ which governs the weight of the pure DSGE model relative to the hybrid or pure VAR model is shown in Table 2. The best fit gives $\lambda = 1.875$ by both the Laplace and Harmonic Mean measurements of the Marginal Likelihood. This means that the pure VAR (with four lags) accounts for less than 35% of the variation in the data, relative to the pure DSGE model.

Table 1 shows that the parameters for the estimated shock processes are very different from values found in the existing literature (e.g. Andres, Lópes-Salido, and Vallés estimates for the Euro area).. In general, these processes are found to be much less persistent in the Hong Kong case. More importantly, the estimated standard deviations are very different; the volatility of the export and risk premium shocks are relatively larger than the volatility of government spending, and foreign prices and interest rates shocks. The standard deviation of the risk premium is particularly interesting as it allows for the possibility of extreme shocks, often observed during periods of financial crisis.

With respect to the other parameters, we note that the estimated Calvo (1983) stickiness parameter (ξ) is slightly lower than estimates reported by Smets and Wouters (2003, 2007) for a larger model estimated on the Euro Area and US data..The value of η and ϖ are more in line with estimates in the macro literature. The γ parameter, which measures the degree of openness for Hong Kong has an estimated mode of 0.65 in the DSGE/VAR model, with a 95% confidence band of [0.29 0.79]. This contrasts with a 95% confidence interval of [0.12 0.28] which Lubik and Schorfheide (2007) reported for Canada.

[5]All estimation was carried out using the Dynare package 4.2 developed by M. Julliard available at http://www.dynare.org.

	Prior Distributions			DSGE Posterior Distributions				DSGE/VAR Posterior Distributions			
	Distribution	Mean	Std	Mode	Mean	5%	95%	Mode	Mean	5%	95%
Shock Processes											
σ_x	Inv. Gamma	0.020	2.000	0.051	0.052	0.045	0.060	0.044	0.044	0.036	0.052
σ_g	Inv. Gamma	0.020	2.000	0.021	0.022	0.019	0.025	0.019	0.019	0.015	0.022
σ_p	Inv. Gamma	0.020	2.000	0.016	0.022	0.011	0.034	0.012	0.015	0.009	0.023
σ_r	Inv. Gamma	0.020	2.000	0.007	0.007	0.007	0.008	0.007	0.007	0.007	0.008
σ_q	Inv. Gamma	0.020	2.000	0.464	0.474	0.409	0.535	0.390	0.388	0.317	0.458
Structural Parameters											
γ	Beta	0.500	0.200	0.776	0.655	0.440	0.885	0.655	0.540	0.293	0.792
η	Normal	2.500	0.500	2.546	2.549	2.225	2.877	2.516	2.515	2.190	2.838
ϖ	Beta	0.500	0.200	0.753	0.607	0.352	0.887	0.646	0.518	0.212	0.838
ζ	Normal	6.000	0.500	6.000	6.010	4.420	7.720	6.000	5.978	4.336	7.621
ξ	Beta	0.500	0.200	0.455	0.520	0.314	0.728	0.553	0.609	0.396	0.832
ρ^x	Beta	0.500	0.200	0.275	0.290	0.140	0.429	0.245	0.284	0.112	0.434
ρ^g	Beta	0.500	0.200	0.121	0.150	0.101	0.200	0.131	0.174	0.101	0.251
ρ^p	Beta	0.500	0.200	0.626	0.612	0.519	0.707	0.530	0.450	0.232	0.651
ρ^r	Beta	0.500	0.200	0.679	0.664	0.460	0.895	0.711	0.691	0.497	0.911
ρ^q	Beta	0.500	0.200	0.626	0.624	0.492	0.759	0.567	0.534	0.308	0.754
λ	Uniform	[0, 2]		–	–	–		1.875	1.547	1.178	2.000

Table 1: Prior and Posterior Distributions

Table 2: Fit of DSGE and DSGE/VAR Models

		Marginal Likelihood	
Specification	λ	Laplace	Harmonic Mean
DSGE	Inf	1282.719	1283.001
DSGE/VAR	1.875	1292.077	1291.395

Analyzing these structural parameters individually or in small subsets, of course, does not give much information about the implications of the fully-estimated model for inflation and output volatility. This is the subject of the next sub-sections. We discuss below the results for the more accurate DSGE/VAR model parameters but the results were practically identical when we used the pure DSGE-model parameters.

3.2 Business Cycle Properties

Following Iacoviello and Neri (2010), Table 3 gives a summary of the actual and model predictions of two business cycle indicators, the standard deviations of output, CPI inflation, and the domestic interest rate, as well as the correlation coefficients of these variables. We see that both the DSGE and the DSGE/VAR models slightly underpredict the volatility of output and overpredict the volatilility of the interest rate, while the actual volatility of CPI inflation falls within the 95% confidence bounds of both models. Table 3 also shows that the correlation coefficients of all three variables fall within the 95% confidence bounds of both models.

	Std. Deviation			Correlation Coefficients		
	y	π^c	r	$\rho(y, \pi^c)$	$\rho(y, r)$	$\rho(r, \pi^c)$
Actual	0.018	0.011	0.005	0.010	-0.155	0.130
DSGE						
Mean	0.014	0.016	0.011	0.052	-0.178	0.360
5%	0.013	0.009	0.008	-0.127	-0.274	0.042
95%	0.016	0.021	0.014	0.253	-0.072	0.668
DSGE/VAR						
Mean	0.012	0.011	0.010	-0.127	-0.237	0.465
5%	0.011	0.005	0.007	-0.294	-0.380	0.092
95%	0.013	0.015	0.013	0.031	-0.088	0.778

Table 3: Business Cycle Properties

3.3 Innovations

Figure 2 pictures the smoothed shocks from the DSGE/VAR model. We see negative shocks to exports at the time of the Asian crisis and SARS. The risk premium increased sharply during the Asian crisis, while the world interest rate fell sharply after the SARS period.

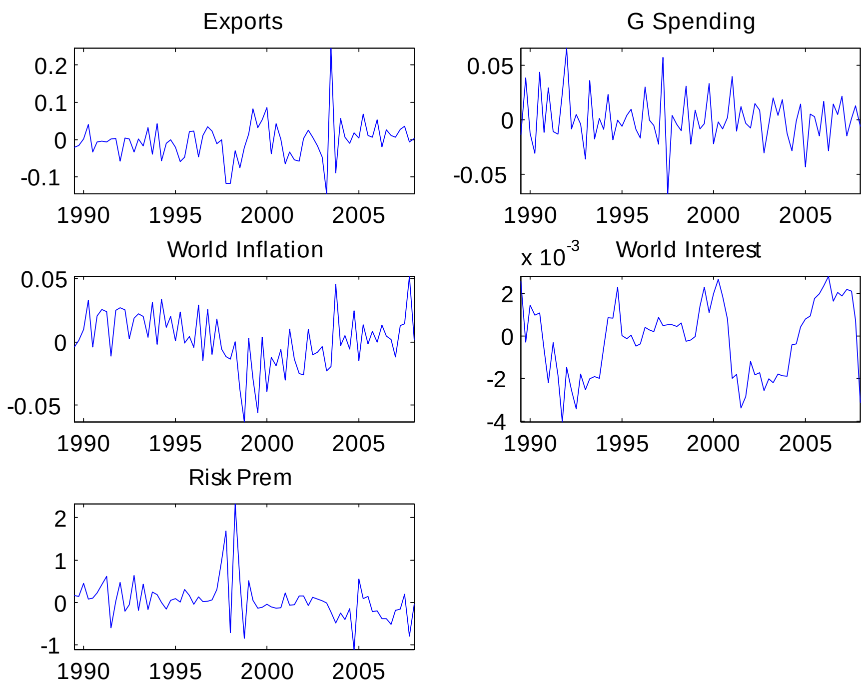

Figure 2: Smoothed Shocks from the DSGE/VAR Model

Following Iaccoviello and Neri (2010), we assess the performance of the model by testing the exogeneity or lack of predictability of these shocks, from the lags of the observable variables used in our Bayesian estimation, y, π^c, r, r^*, and g. Table 4 shows that the export, foreign interest rate and risk premium shocks are exogenous or are not caused, in the Granger sense, by any of the observable variables.

This is not true for innovations for world inflation and government spending. The government spending and world inflation shocks are specified for first-order autoregressive processes, as commonly done for forcing variables in DSGE models. The Granger test suggests that a higher-order autogressive specification might be more appropriate for these forcing variables. In particular, Table 4 shows that domestic CPI inflation Granger-cause world inflation innovation, but since a large component of CPI inflation consists of world inflation, this result is probably picking up the higher order autoregressive component in world inflation. Also, while the test is significant for government spending shocks, this is less of an issue as they are relatively unimportant for GDP volatility (as shown below). Given that the DSGE and DSGE/VAR models yield estimates of the standard deviation of the inflation shock which is very close to actual data (see Table 3), we stay with the more parsimonious first-order autorepressive process for both the world inflation and the government spending variables.

Table 4: Granger Causality Test: P-Value

	ϵ_t^x	ϵ_t^g	ϵ_t^p	ϵ_t^r	ϵ_t^q
y_{t-1}	0.748	0.923	0.673	0.960	0.204
π_{t-1}^c	0.153	0.873	0.000	0.876	0.946
g_{t-1}	0.096	0.015	0.762	0.187	0.494
r_{t-1}	0.115	0.957	0.137	0.638	0.215
r_{t-1}^*	0.501	0.269	0.315	0.879	0.412

3.4 Impulse Response Paths: Output and Inflation

Figure 3 pictures the impulse response paths of output following shocks to net exports x, government spending, g,world inflation π^*, the world interest rate r^*, and the risk premium, q. The paths represent areas covered by the 95% confidence intervals. Figure 4 pictures the reaction of inflation for the same shocks.

The qualitative responses show that output rises with export, government spending and world inflation shocks, and falls with foreign interest and risk premium shocks. Inflation, as expected, rises with world inflation, indicating a high degree of imported inflation. . Foreign interest rate shocks go hand-in-hand with domestic inflation since world interst rates rise with world inflation. The risk premium shocks, by lowering output, generate higher inflation, while export and government spending effects, which stimulate production and supply, have very short lived negative effects on inflation.

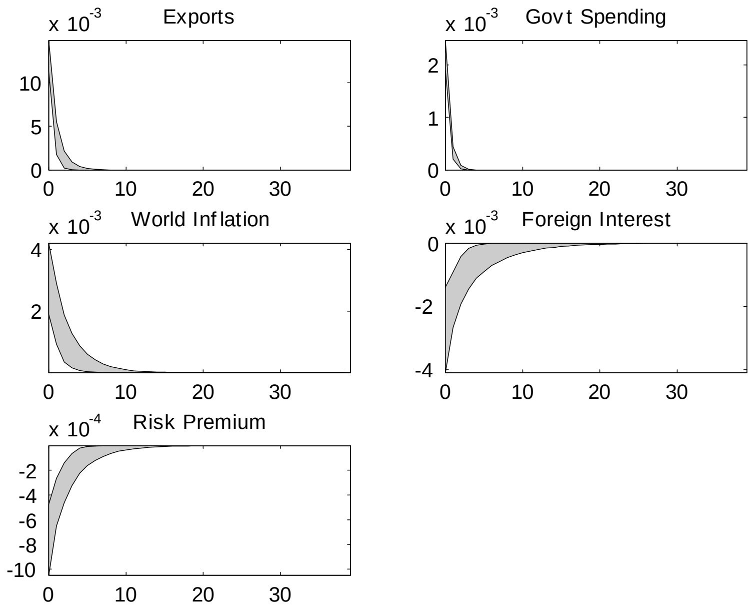

Figure 3: Output Response to Shocks

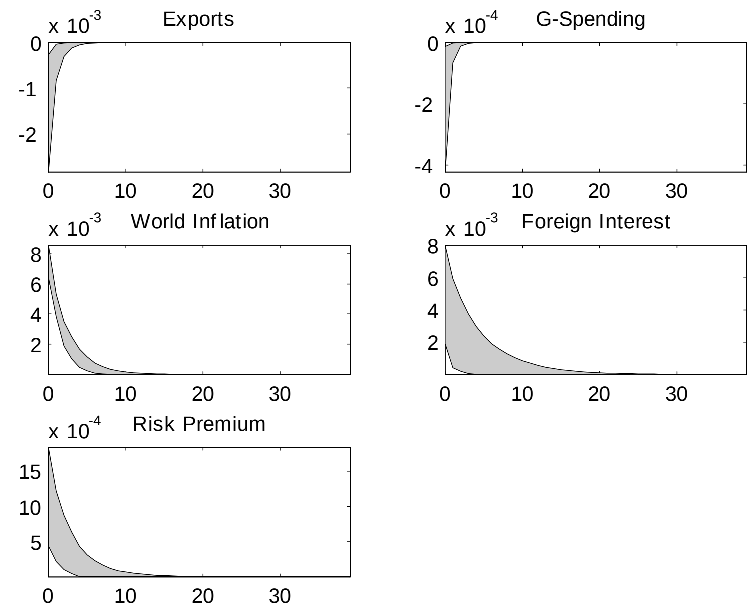

Figure 4: Inflation Response to Shocks

3.5 Conditional Variance Decomposition

Figures 5 and 6 present the conditional variance decomposition for output and inflation for horizons for one, two, eight, ten, and twenty quarters. Over short and long horizons, export-demand and world price shocks (which operate through the terms-of-trade effect) dominate the variance of output. For CPI inflation, world inflation and world interest rates account for practically all of the variation. This result is consistent with Genberg (2003), who reported that external factors account for more than fifty percent of unexpected fluctuations in the real GDP deflator at horizons of one to two years.

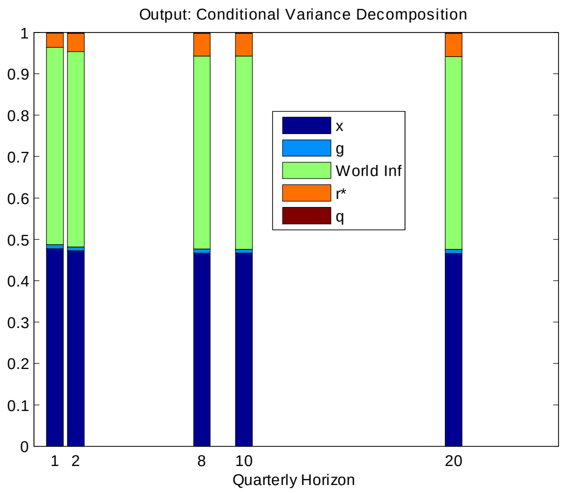

Figure 5: Conditional Variance Decomposition for Output

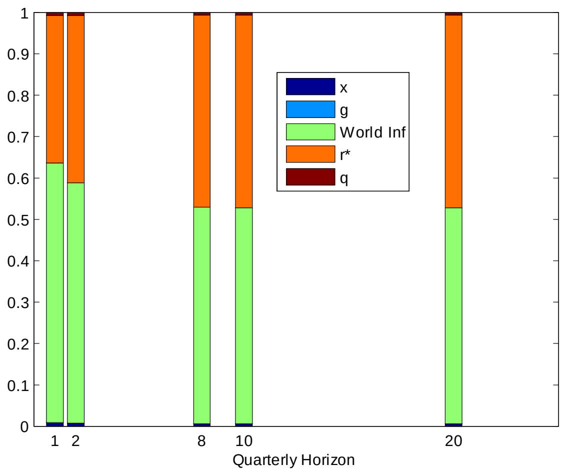

Figure 6: Conditional Variance Decomposition for Inflation

3.6 Historical Shock Decomposition

For historical decomposition, the smoothed shocks are fed into the model to compute the contributions of the shocks to each variable at each time period. For output, shown in Figure 7, we see that the positive risk premium and negative export shocks became prominent at the time of the Asian Crisis. For inflation, shown in Figure 8, we see that world interest rate shocks became important after the start of the SARS crisis. World inflation shocks appear be predominantly negative, while export shocks appear to be predominantly positive; but both are relatively insignificant.

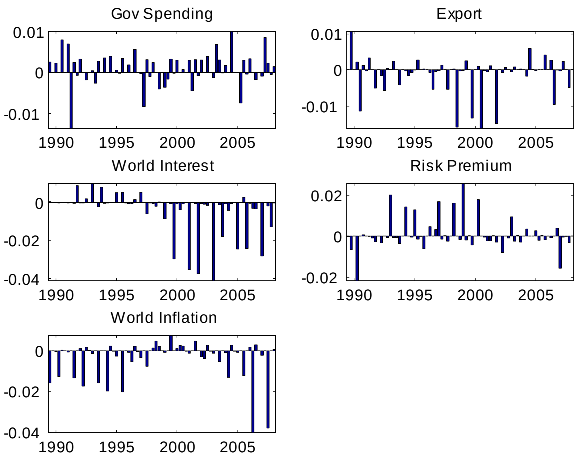

Figure 7: Historical Shock Decomposition of Output

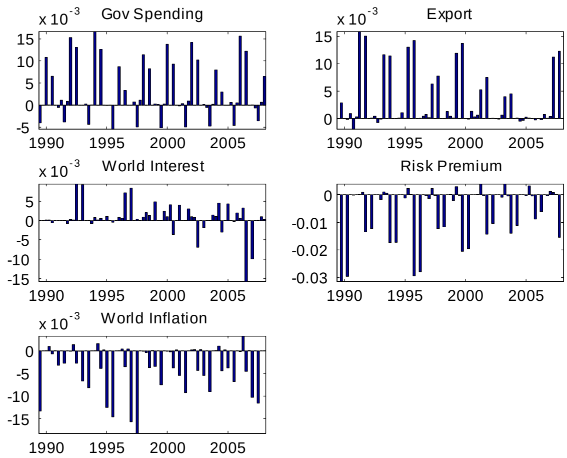

Figure 8: Historical Shock Decomposition of Inflation

4 Counterfactual Analysis

Since GDP, inflation and GDP components in Hong Kong respond significantly to both nominal and real foreign shocks, we conducted a counterfactual simulation to assess whether macroeconomic outcomes would be significantly changed if interest rates had been determined by the Taylor rule, in equation (19), instead of equation (20). We set the interest-rate smoothing parameter for the

Taylor rule, ρ^k at 0.635, and the inflation coefficient, ρ^π at 1.51 and the output coefficient ρ^y at 0.228.[6]

4.1 Counterfactual Simulation with Estimated Shocks

By way of illustration, Figure 9 shows the result of a simple exercise. First, we replaced the interest rate equation (20) with a Taylor rule plus allow the exchange rate to be market-determined. Second. we simulate the model using the estimated shocks which occurred during the period. We see straight away that there is not much differences between the two trajectories for consumption. By construction, the Taylor rule would smooth inflation. The interest rate is more volatile with the Taylor rule after 2006, but less volatile at the time of the Asian crisis after 1997.

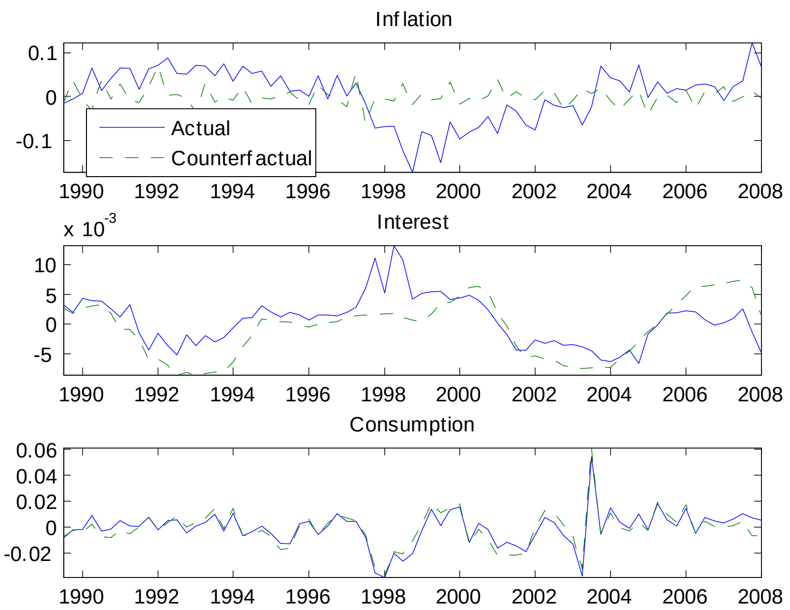

Figure 9: Actual and Counterfactual Model Simulations with Historical Shocks

However, this evidence is only suggestive since it is based on a single realization from the data generating processes. In order to provide a systematic comparison of the two regimes, we follow the literature on the evaluation of monetary policy regimes by conducting stochastic simulations. We thus examine the response of the economy to a wider set of shocks drawn from their estimated distributions.

[6] These Taylor-rule coefficients come from Bayesian estimation of a model due to Andres, Lópes-Salido, and Vallés (2006), which Fagan, Lothian and McNelis (2011) applied to data for the Great Moderation period in the United States.

4.2 Stochastic Simulations

4.2.1 Inflation and Volatility Distributions

Figure 10 pictures the Epanechnikov kernel densities of the distribution of consumption volatility, interest rate volatility, inflation and exchange rate volatility, under the base fixed exchange rate regime and the counterfactual flexible exchange rate and inflation targeting regime. We see, as expected, that the interest rate becames more volatile, as does consumption. But we also see that inflation is only slightly lower under the counterfactual inflation-targeting regime.

Figure 11 gives the corresponding distributions for bonds, foreign assets, and employment. Bonds, foreign assets, and employment are also more volatile under the inflation-targeting flexible exchange-rate system than under the currency board regime. The reason, of course, is that the more volatile interest rates generate more volatile consumption (through the Euler equation for consumption), which in turn, generates more volatility in labor, output, bond and foreign asset adjustments.

4.2.2 Welfare

To better interpret the differences in the welfare between the two regimes, we calculate the implied consumption compensation required to equalize the welfare of the representative household in the two regimes, following the suggestion in Schmidt-Grohe and Uribe (2007). A positive value implies that the household in the counterfactual scenario is worse off and needs a positive consumption compensation to have the same welfare as the household in the base scenario. A negative value means that the household is better off in the counterfactual scenario, and would have to have consumption reduced to be equal to the welfare realized in the base scenario.

The mean from the stochastic simulations is -0.0003%, implying that the household is only very slightly worse off under the base fixed exchange rate regime. The distribution of welfare gains and losses associated with switching from the base regime to the counter-factual regime is shown in Figure 11.

As a futher check on the robustness of the welfare comparison between the Taylor rule and the exchange rate policy rule, we obtain the optimal Taylor rule and the Ramsey rule for the interest rate. In this exercise, we determine the coefficients in the rule that optimizes the welfare function, given the other estimated deep parameters. For the optimal Taylor rule, the interest rate is a function of the variables in equation (19), while for the Ramsey rule (which is like a simple optimal rule) the interest rate depends on all the (backward-looking) state variables known at time t. The important result is that the welfare in the base (fixed exchange rate) case is very similar to the welfare obtained from using these optimal rules.[7] Thus, the results show little reason for Hong Kong to abandon its current regime, neither in favor of an inflation-targeting Taylor rule nor in favor of an optimal simple rule for the interest rate.

[7] The coefficients for the optimal Taylor rule are: $\widehat{\rho}^k = 0.545; \widehat{\rho}^\pi = 1.094; \widehat{\rho}^y = 0.057$. These results are consistent with Uribe and Schmidt-Grohe (2007), who found that higher weights on output make little difference on welfare, while increasing the inflation coefficient much above one also makes little difference.

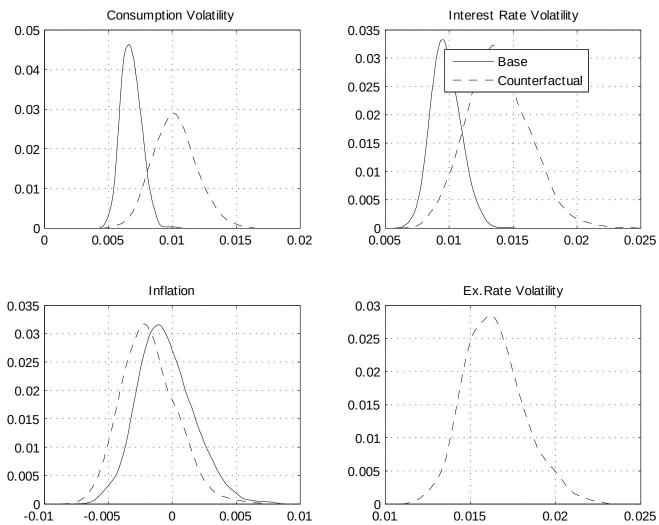

Figure 10: Volatility Distributions of Consumption, Interest Rate, Inflation and the Exchange Rate under Base and Counterfactual Regimes

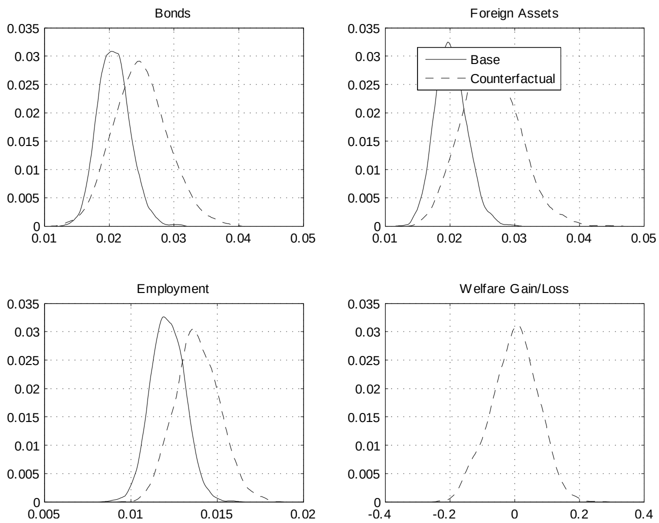

Figure 11. Volatility Distributions of Bonds, Foreign Assets, Employment and Welfare Gain/Loss the Base and Counterfactual Regimes

5 Conclusion

The aim of the paper was to estimate a DSGE model for Hong Kong and to use it firstly, to ascertain the contributions of various shocks to output and inflation and secondly to explore whether Hong Kong should consider a flexible exchange rate regime. The Bayesian estimation results show that the key determinants of output variation are export demand and foreign price shocks, while domestic inflation responds mostly to shocks in foreign prices and foreign interest rates. An exogenous risk premium had relatively strong effects on output at the time of the Asian crisis after 1997.

We also find through counterfactual simulation that switching to a flexible exchange-rate system with inflation targeting decreases inflation volatility slightly, while increasing the volatility of interest rates and consumption. The results of this paper show that there would be only very slight welfare gains if Hong Kong abandoned its fixed exchange rate currency-board system in favor of a flexible system with inflation targeting. For the sake of a very modest reduction in (already low) inflation, Hong Kong would pay a price in terms of increased volatility in the interest rate, which in turn affects the volatility of consumption, as well as domestic debt and foreign assets.

The results of this analysis should not be suprising once we take into account the high degree of imported inflation in Hong Kong. Given that the Hong Kong dollar is tightly and credibly fixed to the US Dollar, and that the US monetary authority has had, *de facto* if not *de jure*, an inflation-targeting rule, Hong Kong has effectively been importing such a rule for its own economy, at least for non-crisis periods. In these non-crisis circumstances, switching to a Taylor rule would make little or no difference, since its interest rates already follow closely the US interest rates set by a Taylor rule.

An important missing ingredient in our small model is the role of housing on overall macroeconomic volatility. We have abstracted from housing as a source of wealth for the households, as well as from capital in the productive sector. World prices are important shocks for output and inflation in our model through their effects on the terms of trade. However, the role of shocks to real estate prices on non-traded goods prices may be a more important factor. This is a subject for future research.

6 Appendix: The Log-linear Model

The log-linearised form is below. Lower case letters are log-deviations of the corresponding upper-case symbols in the model; except that w_t is real wage; b_t is real bond holdings and f_t is real foreign assets.

$$x_t = \rho^x x_{t-1} + \epsilon_t^x; \qquad \epsilon_t^x \sim N(0, \sigma_x^2) \tag{21}$$
$$g_t = \rho^g g_{t-1} + \epsilon_t^g; \qquad \epsilon_t^g \sim N(0, \sigma_g^2) \tag{22}$$
$$\pi_t^* = \rho^p \pi_{t-1}^* + \epsilon_t^p; \qquad \epsilon_t^p \sim N(0, \sigma_p^2) \tag{23}$$
$$r_t^* = \rho^r r_{t-1}^* + \epsilon_t^r; \qquad \epsilon_t^r \sim N(0, \sigma_r^2) \tag{24}$$
$$q_t = \rho^q q_{t-1} + \epsilon_t^q; \qquad \epsilon_t^q \sim N(0, \sigma_q^2) \tag{25}$$

$$-\eta c_t + w_t = \varpi l_t \tag{26}$$
$$-\eta c_t = -\eta c_{t+1} - \pi_{t+1} + r_t \tag{27}$$
$$y_t = l_t \tag{28}$$
$$y_t = \frac{\overline{C}}{\overline{Y}} c_t + \frac{\overline{G}}{\overline{Y}} g_t + \frac{\overline{X}}{\overline{Y}} x_t \tag{29}$$

$$\xi(\pi_t) - \beta\xi(\pi_{t+1}) = (1-\xi)(1-\beta\xi)(w_t) \tag{30}$$
$$\pi_t^c = \pi_t + \gamma \mathbf{\Delta tt}_t \tag{31}$$
$$\mathbf{\Delta tt}_t = \Delta s_t + \pi_t^* - \pi_t \tag{32}$$

$$\overline{(1-R)}(x_t + \pi_t^*) = f_t - \overline{R}(f_{t-1} - \pi_t) - \overline{R^*} r_{t-1}^* - \overline{Q} q_{t-1} \tag{33}$$
$$\frac{\overline{B}}{\overline{PY}} b_t = \frac{\overline{G}}{\overline{Y}} g_t + \frac{\overline{BR}}{\overline{PY}} (b_{t-1} - \pi_t + r_{t-1}) \tag{34}$$

Flexible exchange rate regime:

$$r_t = \Delta s_{t+1} + \frac{\overline{R^*}}{(\overline{R^*} + \overline{Q})} r_t^* + \frac{\overline{Q}}{(\overline{R^*} + \overline{Q})} q_t \tag{35}$$
$$r_t = \rho^r r_{t-1} + (1-\rho^r)\rho^\pi \pi_t + (1-\rho^r)\rho^y y_t \tag{36}$$

Fixed exchange rate regime:

$$s = 0, \quad \text{for all } t \tag{37}$$
$$r_t = \frac{\overline{R^*}}{(\overline{R^*} + \overline{Q})} r_t^* + \frac{\overline{Q}}{(\overline{R^*} + \overline{Q})} q_t \tag{38}$$

We assume each of the shock processes are normally distributed with mean zero and constant variance.

References

[1] Adjemian, Stephane, Matthiew Darracq, and Stephane Moyen (2008), Towards a Monetary Policy Evaluation Framework. Working Paper, CEPREMAP.

[2] An, Sungbae and Heedon Kang (2009), Oil Shocks in a DSGE Model for the Open Economy. Working Paper, School of Economics, Singapore Management University.

[3] An, Sungbae and Frank Schorfheide (2007), Bayesian Estimation of DSGE Models. *Econometric Reviews* 26:113-172.

[4] Andres, J,D. Lópes-Salido, and J. Vallés. (2006), Money in an Estimated Business Cycle Model of the Euro Area. *The Economic Journal* 116: 457-477.

[5] Calvo, Guillermo A. (1983), Staggered Prices in a Utility-maximizing Framework, J*ournal of Monetary Economics*, 12, 383–398.

[6] Calvo, Guilldermo A. and E. Meondoza,(2000), Capital-Market Crises and Economic Collapse in Emerging Markets: An Informational-Frictions Approach. *American Economic Review: Papers and Proceedings*, 90: 59-64.

[7] Del Negro, Marco and Frank Schorfheide (2004), Priors from General Equilibrium Models for VARS. *International Economic Review* 45, 643-673.

[8] Devereux, Michael, B., Philip R. Lane and Juanyi Xu (2006). Exchange Rates and Monetary Policy in Emerging Market Economies. *Economic Journal*, 116, 478-506.

[9] Fagan, Gabriel, James R. Lothian, and Paul D. McNelis (2011). Was the Gold Standard Destabilizing? Manuscript, Fordham University.

[10] Friedman, Milton (1953), The Case for Flexible Exchange Rates, in Essays in Positive Economics, Chicago: University of Chicago Press.

[11] Galli, Jordi and Tommaso Monacelli (2008), Monetary Policy and Exchange Rate Volatility in a Small Open Economy. *Review of Economic Studies* 72, 707-734.

[12] Genberg, Hans (2003), Foreign Versus Domestic Factors as Sources of Macroeconomics Fluctuations in Hong Kong" HKIMR Working Paper 17/2003.

[13] Iacoviello, Matteo and Stefano Neri (2010), Housing Market Spillovers: Evidence from an Estimated DSGE Model. American Economic Journal: Macroeconomics 2, 125-164.

[14] Lahiri, Amartya, Rajesh, Singh and Carlos Vegh (2007), Segmented Asset Markets and Optimal Exchange Rate Regmimes. *Journal of International Economics* 72:1-21.

[15] Lubik, Thomas and Frank Schorfheide (2005), A Bayesian Look at New Open Economy Macroeconomics. *NBER Macroeconomics Annual* 2005: 313-366.

[16] Lubik, Thomas and Frank Schorfheide (2007), Do Central Banks Respond to Exchange Rate Movements? A Structural Investigation. *Journal of Monetary Economics* 54, 706-727.

[17] Lucas, Robert E., Jr. (1976), Econometric Policy Evaluation: A Critique, in K. Brunner and A. Meltzer, eds, The Phillips Curve and Labor Markets, Amsterdam: North Holland, 19-46.

[18] Mendoza,Enrique (1995), The Terms of Trade, the Real Exchange Rate and Economic Fluctuations. *International Economic Review* 36, 101-137,

[19] Mundell, Robert A. (1968), International Economics New York: MacMillan.

[20] Schmidt-Grohe, S. and M. Uribe (2007), Optimal Simple And Implementable Monetary and Fiscal Rules Stephanie Schmitt-Grohe and Martin Uribe. *Journal of Monetary Economics*, 54, 1702–1725.

[21] Smets, F. and R.Wouters.(2003). An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area, *Journal of the European Economic Association.* 1:1123-1175.

[22] Smets, F. and R.Wouters (2007). Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach. *American Economic Review.* 97: 586-606.