Investment Shocks: Sources of Fluctuations in Small Open Economy

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Abstract

This paper contributes to the existing Real Business Cycle (RBC) literature by introducing Marginal Efficiency of Investment (MEI) shocks into small open economic model. Investment shocks are the most important drivers of business cycle fluctuations in small open economy because the fluctuations in all the macroeconomic variables showed a significant response to MEI shocks than productivity shocks. The anticipation of pro-cyclical behavior of the external accounts when the model was augmented with the form of share of consumption in the household utility function, μ, and an appealing, but complex, concave adjustment cost function becomes a standpoint that differentiates this study from other investment shocks literatures. The pattern of the rise investment in both shocks explains why investment shocks is so important in times of recession and it reveals the main source of fluctuations in a small open economy.

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1 Introduction

At the core of the standard Real Business Cycle (RBC), research agenda is the notion that economic fluctuations are driven principally by exogenous changes to real factors in the economy. More generally, the primary focus of this research is based on the idea that macroeconomic or business cycle fluctuations are caused by large and cyclically volatile exogenous shocks to Total Factor Productivity(TFP) [1] - which are captured by the Solow residuals. Indeed, since its inception in the 1980s, the RBC research program has metamorphosed to become a significant area of research in macroeconomics, and its concepts and methods becoming well diffused into the mainstream macroeconomic analysis of economic dynamics. In fact, RBC research program success was not only due to the widespread theoretical appeal of this approach but also to its exceptional empirical performance. However, the practice of employing the Solow residuals as the sole source of aggregate productivity innovations in standard small open economy models suffers from numerous inherent deficiencies. Small Open Economic (SOE) models driven by shocks to TFP have not been able to account for counter-cyclical movements in ratios of current account to output and trade balance to output without a recourse to a low and simple adjustment cost parameter. In light of this deficiency in the standard models, this paper examines the volatility and persistence of the innovations to TFP and the Marginal Efficiency of Investment (MEI) and discovers that MEI shocks model outperforms the TFP shocks framework in matching the counter-cyclical behavior of the external accounts. For example, In a recent paper (Justiniano, Primiceri, and Tambalotti (2008), JPT hereafter), they showed that an investment shock that determines the efficiency of newly produced investment goods, as in Greenwood, Hercowitz, and

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[1]Also known as productivity

Human (1988), is the key driver of business cycles in a medium-scale, estimated New-Neoclassical Synthesis model. Moreover, because consumption accounts for a larger part of the fluctuations in output, the choice of consumption parameter design in analyzing macroeconomic fluctuations becomes crucial in RBC model. So, this paper contributes to the extant literature by introducing the choice of share of consumption in the utility to examine, more closely, the pro-cyclical behavior of investment and output in relation to SOE's external accounts.

With that being said, another objective, therefore, will be to extend the literature on the dynamic performance of the standard small open economy by considering shocks to MEI captured by innovations to a complex form of adjustment cost [2], induced by exogenous movements in the efficient production of next period's capital goods. It can be argued that shocks to MEI can account for a significant fraction of business cycle fluctuations, and thus be regarded as an important propagation mechanism for studying and understanding modern macroeconomic dynamics in the standard small open economy. The approach presented here is particularly important since it provides an empirically relevant measure of productivity innovations that has been largely ignored in the open economy literature.

The paper proceeds as follows: Section 2 presents a general framework of the model Economy. Section 3 discusses the applicability of Mendoza (1991). Section 4 describes the calibration and the result of the Dynamic Stochastic General Equilibrium (DSGE) model for the small open economy.

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[2]The idea of low adjustment cost will be defeated will be defeated afterwards

2   The General Framework of the Model Economy

As it is standard in RBC literature,the author will limit the model to the case of one country with a-two-sector [3] economy receiving the streams of shocks both in technology and in Investment. Consider a small open economy populated by a large number of infinitely-lived identical agents acting as price takers in all markets in which they participate. These residents are connected to the rest of the world only through their access to a frictionless incomplete international capital market and a market for a non-tradeable composite consumption good.

2.1   Household

A small open economy populated by a large number of identical households is described with the following preferences of expected utility function :

$$\bar{h} = [(1 - \alpha)(\frac{\alpha}{r + \delta})]$$

$$E_0 \sum_{t=0}^{\infty} \theta_t U(c_t, h_t) \tag{1}$$

where c_t denotes consumption, h_t denotes hours worked and θ_t denotes the discount factor. The discount factor is written in this general form to allow for an endogenous specification discussed in the later section. Moreover, $\beta_c < 0, \beta_h > 0$ This preference specification allows the model to be stationary in the sense that the non-stochastic steady-state is independent of initial conditions.

The evolution of financial wealth, b_t, is given by

$$b_{t+1} = (1 + r_t)b_t + tb_t \tag{2}$$

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[3]A representative household and firm

where r_t denotes the interest rate at which domestic residents can borrow in international markets in period t, and tb_t denotes the trade balance. In turn, the trade balance is given by

$$tb_t = y_t - c_t - i_t - \phi(1 - \Psi(\frac{i_t}{k_t}))k_t \tag{3}$$

Following Backus and Crucini (2000), physical capital formation is subject to adjustment costs, where y_t denotes domestic output, i_t denotes gross investment, assuming that Ψ is concave, therefore, in steady state, $\Psi > 0, \Psi' > 0$ and $\Psi'' < 0$. Furthermore, $\Psi(\frac{i_t}{k_t}) = (\frac{i_t}{k_t})^\eta$ and $\eta \in (0,1)$. The shocks, captured by ϕ_t, to the MEI represents an exogenous disturbance to the process by which investment goods are transformed into installed capital to be used in production. It is therefore assume that MEI follows the stochastic process;

$$\log \phi_t = \rho_\phi \log \phi_{t-1} + \epsilon_{\phi,t} \tag{4}$$

Where $\epsilon_{\phi,t}$ is $i.i.dN(0,\sigma_\phi^2)$

SOE models typically include capital adjustment costs to avoid excessive investment volatility in response to variations in the domestic-foreign interest rate differential. The restrictions imposed on ϕ ensure that in the non-stochastic steady-state, adjustment costs are zero and the domestic interest rate equals the marginal product of capital net of depreciation. Output is produced by means of a linearly homogeneous production function:

$$y_t = A_t F(k_t, h_t) \tag{5}$$

where A_t is an exogenous stochastic productivity shock, its law of motion is given by;

$$\log A_t = \rho_A \log A_{t-1} + \epsilon_{A,t}, t \geq 0 \tag{6}$$

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$\epsilon_{A,t}$ is $i.i.dN(0, \sigma_A^2)$

Following Backus and Crucini (2000), the stocks to capital evolve according to

$$k_{t+1} = i_t + (1 - \delta)k_t + \phi(1 - \Psi(\frac{i_t}{k_t}))k_t \tag{7}$$

where $\delta \in (0, 1)$ denotes the rate of depreciation of physical capital.

The model can be solved after specifying the functional form of preferences and technologies.

2.2 Endogenous Discount Factor

The most commonly used approach, introduced by Obstfeld (1981), endogenizes the discount factor. Suppose that, instead of being equal to θ_t, the discount rate is given by the following recursive relation:

$$\theta_0 = 1 \tag{8}$$

$$\theta_{t+1} = \beta(c_t, h_t)\theta_t \tag{9}$$

These form of preferences were introduced by Uzawa (1968) and are discussed thoroughly in Obstfeld (1990) and some of the papers using these preferences include Mendoza (1991, 1995), Uribe (1997) and Cook and Devereux (2000). It is assumed that $\beta'(c_t) < 0$ i.e, agents become more impatient the more they consume. The reason for making the steady-state independent of initial conditions becomes clear from inspection of the Euler equation $U'(c_t) = \beta(c_t)(1 + r_t)E_t U'(c_{t+1})$. In the steady-state, this equation reduces to $\beta(c)(1 + r) = 1$, which pins down the steady-state level of consumption solely as a function of r and the parameters defining the function $\beta(.)$.

The budget constraint of the representative household can then be summarized as follows:

$$b_{t+1} = (1 + r_t)b_t - y_t + c_t + i_t \tag{10}$$

Households choose processes $\{c_t, h_t, y_t, i_t, k_{t+1}, b_{t+1}, \theta_{t+1}\}_{t=0}^{\infty}$

$t = 0$ so as to maximize the utility function (1) subject to Equations (2) and (10) and a no-Ponzi constraint of the form

$$\lim_{j \to \infty} E_t \frac{b_{t+j}}{\Pi_{s=1}^{j}(1 + r_t)} \leq 0 \tag{11}$$

Again Households choose $\{c_t, h_t, y_t, i_t, k_{t+1}, b_{t+1}, \theta_{t+1}\}_{t=0}^{\infty}$ $t = 0$ so as to maximize the utility function (1) subject to Equations (2), (10) and (11). It can as well be summarized as follows:

$$E_0 = \sum_{t=0}^{\infty} \theta_t U(c_t, h_t) + \lambda_t[(1 + r_t)b_t + A_t F(k_t, h_t) + (1 - \delta)k_t -$$

$$c_t - k_{t+1} - \phi\Psi(1 - (\frac{i_t}{k_t}))k_t - b_{t+1}] + \lambda_t^p[\frac{\theta_{t+1}}{\theta_t} - \beta(c_t, h_t)]$$

Initial condition for exogenous state variables(A_0, ϕ_0)

Initial condition for endogenous variables(k_0, b_0)

and the first-order conditions of the household's maximization problem which hold with equality becomes;

$$\lambda_t = \beta(c_t, h_t)(1 + r_t)E_t\lambda_{t+1} \tag{12}$$

$$\lambda_t = U_c(c_t, h_t) - \lambda_t^p \beta_c(c_t, h_t) \tag{13}$$

$$\lambda_t^p = -E_t U(c_{t+1}, h_{t+1}) + E_t\lambda_{t+1}^p \beta_c(c_{t+1}, h_{t+1}) \tag{14}$$

$$-U_h(c_t, h_t) + \lambda_t^p \beta_h(c_t, h_t) = \lambda_t A_t F_h(k_t, h_t) \tag{15}$$

$$\lambda_t = \beta(c_t, h_t) + E_t \lambda_{t+1}[A_{t+1}F_k(k_{t+1}, h_{t+1}) + 1 - \delta + \phi_{t+1}(1 - \Psi'(\frac{i_t}{k_t}))k_t] \qquad (16)$$

These first-order conditions appear standard, except for the fact that the marginal utility of consumption is now given by $U_c(c_t, h_t) - \beta_c(c_t, h_t)\lambda_t^p$ which replaces the conventional form of marginal utility found in the literature. The first term is the conventional marginal utility of consumption while the second term in this expression reveals the fact that an increase in current consumption lowers the discount factor $\beta_c < 0$. Consequently, a decline in the discount factor reduces utility in period t by λ_t^p. Intuitively, λ_t^p equals the present discounted value of utility from period $t+1$ onward. This has been explained previously. Additionally, the marginal dis-utility of labor is capture by $U_h(c_t, h_t) - \beta_h(c_t, h_t)\lambda_t^p$. The interest rate faced by domestic agents in world financial markets is assumed to be constant and given by;

$$r_t = r \qquad (17)$$

A competitive equilibrium is a set of processes $\{b_{t+1}, c_t, h_t, y_t, i_t, k_{t+1}, \lambda_t \lambda_t^p\}$ satisfying Equations (2),(3),(4),(5),(7) and (11)-(16).

3   Application : Mendoza (1991)

The model mimics Mendoza (1991) and the major contribution of this paper is the introduction of μ, the consumption share of output, and the form of the law of motion for MEI shocks. The baseline model will be closed using the endogenous discount factor approach. Assume that the utility function has the following form:

$$U(c_t, h_t) = \frac{[c_t^{\mu_t} - \frac{h_t^\omega}{\omega}]^{1-\gamma} - 1}{1 - \gamma} \qquad (18)$$

where
$$\omega > 1, \gamma > 1, \mu > 0$$

The functional forms of the period utility function and the discount factor imply that the marginal rate of substitution between consumption and leisure depends only on labor.

$$\beta_t = \beta(c_t, h_t) = [1 + c_t^{\mu_t} - \frac{h_t^\omega}{\omega}]^{-\psi} \tag{19}$$

The production function is given by

$$F(k_t, h_t) = k_t^\alpha h_t^{1-\alpha} \tag{20}$$

where $\alpha \in (0,1)$ is the share of capital in national income of capital expenditure. Finally, the cost of adjustment function has the form:

$$\Phi(1 - \Psi(\frac{i_t}{k_t}))k_t = \phi(1 - (\frac{i_t}{k_t})^\eta)k_t \tag{21}$$

where $\phi > 0$ and $\Psi(\frac{i_t}{k_t}) = (\frac{i_t}{k_t})^\eta$

These specifications along with the calibrated parameters in Table 1 follow Mendoza (1991). However, the following sets of equation satisfy the steady state equations,

combining equations (13) and (15) yield

$$h_t^{\omega-1} = A_t F_h(k_t, h_t) \tag{22}$$

The equation impliess that the labor supply depends only upon the wage rate and independent of the level of wealth. The right-hand side is the marginal product of labor, which in equilibrium equals the real wage rate while the left-hand side is the marginal rate of substitution of leisure for consumption.

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In steady states,

$$\bar{h} = [(1-\alpha)(\frac{\alpha}{r+\delta})^{\frac{\alpha}{1-\alpha}}]^{\frac{1}{\omega}-1} \tag{23}$$

$$\frac{\bar{h}}{\bar{k}} = (\frac{r+\delta}{\alpha})^{(\frac{1}{1-\alpha})} \tag{24}$$

$$\bar{k} = \frac{\bar{h}}{\frac{\bar{h}}{\bar{k}}} \tag{25}$$

$$\bar{i} = \delta\bar{k} \tag{26}$$

$$\bar{y} = \bar{k}^{\alpha}\bar{h}^{1-\alpha} \tag{27}$$

$$\bar{c} = ((1+r)^{\frac{1}{\psi}} + \frac{\bar{h}^{\omega}}{\omega} - 1)^{\frac{1}{\mu}} \tag{28}$$

$$\bar{\lambda} = (\bar{c}^{\mu} - \frac{\bar{h}^{\omega}}{\omega})^{-\gamma} \tag{29}$$

$$\bar{tb} = \bar{y} - \bar{c} - \bar{i} \tag{30}$$

$$\bar{nfa} = \frac{\bar{tb}}{r} \tag{31}$$

$$\bar{tb}_y = \frac{\bar{tb}}{\bar{y}} \tag{32}$$

$$\bar{ca}_y = \frac{-r * \bar{nfa} + \bar{tb}}{\bar{y}} \tag{33}$$

$$\bar{A} = 1 \tag{34}$$

$$\bar{\phi} = 1 \tag{35}$$

and in equilibrium,

$$\beta_c = \frac{(1 + c_t^{\mu} - \bar{c})^{-\psi}}{1+r}; \psi \geq 0 \tag{36}$$

since $\frac{1}{c_t} = (1+r)\beta_c E_t \frac{1}{c_{t+1}}$

Therefore, the set of equations that will characterize first-order log-linearization includes

$$\lambda_t = \beta(c_t, h_t)(1 + r_t)E_t\lambda_{t+1} \tag{3.1}$$

$$\lambda_t = U_c(c_t, h_t) - \lambda_t^p \beta_c(c_t, h_t) \tag{3.2}$$

$$\lambda_t^p = -E_t U(c_{t+1}, h_{t+1}) + E_t \lambda_{t+1}^p \beta_c(c_{t+1}, h_{t+1}) \tag{3.3}$$

$$-U_h(c_t, h_t) + \lambda_t^p \beta_h(c_t, h_t) = \lambda_t A_t F_h(k_t, h_t) \tag{3.4}$$

$$\lambda_t = \beta(c_t, h_t) + E_t \lambda_{t+1}[A_{t+1}F_k(k_{t+1}, h_{t+1}) + 1 - \delta + \phi_{t+1}(1 - \Psi'(\frac{i_t}{k_t}))k_t] \tag{3.5}$$

$$tb_t = y_t - c_t - i_t - \phi(1 - \Psi(\frac{i_t}{k_t}))k_t \tag{3.6}$$

$$\log A_t = \rho_A \log A_{t-1} + \epsilon_{A,t}, t \geq 0 \tag{3.7}$$

ϕ_t can be comparable to a form of technological progress restricted to the production of investment goods in a representation of economy that follows the stochastic process.

$$\log \phi_t = \rho_\phi \log \phi_{t-1} + \epsilon_{\phi,t} \tag{3.8}$$

This procedure allows us to rewrite the non-linear original system of the form

$$E_t f(x_{t+1}, x_t) = 0 \tag{37}$$

where all the variables are elements of the vector x_t, to a linear system of the form

$$AE_t x_{t+1} = Bx_t \tag{38}$$

where A and B are 8x8 matrices whose elements are functions of all the structural parameters. The 8 equations that form the linearized equilibrium model contain 4 state variables, $\hat{k}_t, \hat{b}_t, \hat{\theta}_t$ and $\hat{A}_t$ and 4 control variables $\hat{c}_t, \hat{h}_t, \hat{\lambda}_t$, and $\hat{\lambda}_t^p$. Finally, the

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system has 4 initial conditions $\hat{k}_0, \hat{b}_0, \hat{A}_0$ and $\hat{\theta}_0$. However, the author imposes the boundary condition;

$$\lim_{j \to \infty} |E_t x_{t+j}| = 0 \tag{39}$$

4 Calibration and the Result of Small Open Economy

The calibration of the model implies choosing values for the model parameters such that certain features of the model match the corresponding values observed in the time series of the real economy over a certain time horizon[4]. The parameters of the model are chosen such that features of the non-stochastic steady state of the model match as much as possible the data averages over certain time period. In addition, the parameters of the shock processes are set such that the simulated stochastic properties of the model match the statistical properties of the fluctuation in the observed data, the observed data are found in extant RBC literatures. The capital adjustment cost parameter η is set so that the standard deviation of investment is about three times that of output. The values of parameters σ and ρ are chosen to mimic the variability and the first order serial autocorrelation of output, Gross Domestic Product(GDP) to be approximately 3% of the fluctuations, values of the parameters can as well be determined by the Solow residuals but McCallum (1989) opined that once adjustment costs and fluctuations in the terms of trade are considered, Solow Residuals are not a good proxy for productivity shock. The world interest rate r is set to the values suggested by Kydland and Prescott (1982) for the U.S economy. The parameter γ takes two different values in an attempt to avoid confusion in using point estimates. Prescott (1986) opined that γ is not likely to be

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[4]For the time series data, refer to Mendoza (1991)

greater than 1. The depreciation rate, δ has the value commonly used in the RBC literature. The parameter ω is in the range of the estimates of James Heckman and Thomas Macurdy (1980) obtained for the inter-temporal elasticity of substitution in labor supply and this value enables the model to mimic the percentage variability of hours. β is determined by the steady state condition that equates the rate of time preference with the world interest rate.

The function Ψ captures the presence of adjustment costs in investment which can be evaluated in η while ϕ is the shocks to the MEI which appear to be the basis of this paper. in fact, MEI innovations influence the efficiency with which goods can be turned into capital ready for production. The construction of the adjustment cost in this paper is one of the features that set this model from those in most existing studies.

Table 1: Calibrated Parameter Values for the Model

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	Household	
β	0.11	The Consumption Elasticity of the Rate of Time Preference
α	0.32	Share of Capita
δ	0.1	Shopping Time Technology
γ	1.001	Constant Relative Risk Aversion
ω	1.455	1 Plus the Inverse of the Inter-temporal Elasticity of Substitution in Supply
ψ	0.1114	Discount Rate
r	0.04	World Interest Rates
η	0.6	Adjustment Cost Parameter
ρ_A	0.42	Persistent Parameter in Productivity Shock
ρ_ϕ	0.6	Persistent Parameter in MEI Shocks
μ	0.7	Share of Output in Utility
σ_A	0.01277	Productivity Shocks Process
σ_Ψ	1.00	Share of Consumption in Output
σ_ϕ	0.00656	MEI Shocks Process

4.1 Approximate Solution

Though Mendoza (1991) solves the model by iteration, the author approximates the solutions by log-linearizing the equilibrium conditions around the steady-state.

4.2 Standard Deviation Shocks of Productivity ($\epsilon_{A,t}$)

This subsection presents impulse response functions of the simulated economy and describes some features of the models. Standard solution techniques can be applied once growing real variables are normalized so that all variables in the deterministic version of the model converge to a constant steady state. The responses of all the variables to a positive productivity shocks, A is considered in Figure 1. The positive shocks cause the ratio of capital account to output, ratio of trade balance to output and Bonds to decrease but later increase before returning to the steady states, while there is an apparent increase in consumption, capital, labor supply

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and gross investment sequel to the shocks. Another feature of the impulse response of the productivity shocks is the fact that all variables of the economy capture in this model converge to a steady state after their initial increase. The decrease in investment after the shocks can be explained by the impulse responses of the ratio of capital account to output, ratio of trade balance to output and bonds. The results are plausible as the reaction of economy to the technology shocks is analogous to that published in the real business cycle literature. While output and labor supply sluggishly returns to their steady states in periods 25 and 45 respectively, consumption returns to its steady state very slowly making consumption response non-contemporaneous . The responses of trade balance,current account investment and bonds are contemporaneously observed and they all return to their steady faster and quicker than consumption, labor supply, output and productivity. The slow adjustment to steady states of consumption is actually affected by, first, the endogenous time preference and, secondly, its relative share of utility. The closer the share of consumption in utility is to zero, the faster the consumption returns to its steady state and the closer it is to 1, the longer it takes for consumption to return to its steady states. The intuition behind these results is simple; in this economy, agents become more impatient as consumption increases but less impatient as consumption decreases. Thus, as the elasticity of the discount factor increases, the representative household is willing to trade off a lower consumption today for the future.

4.3   Impulse Response: Productivity Shocks
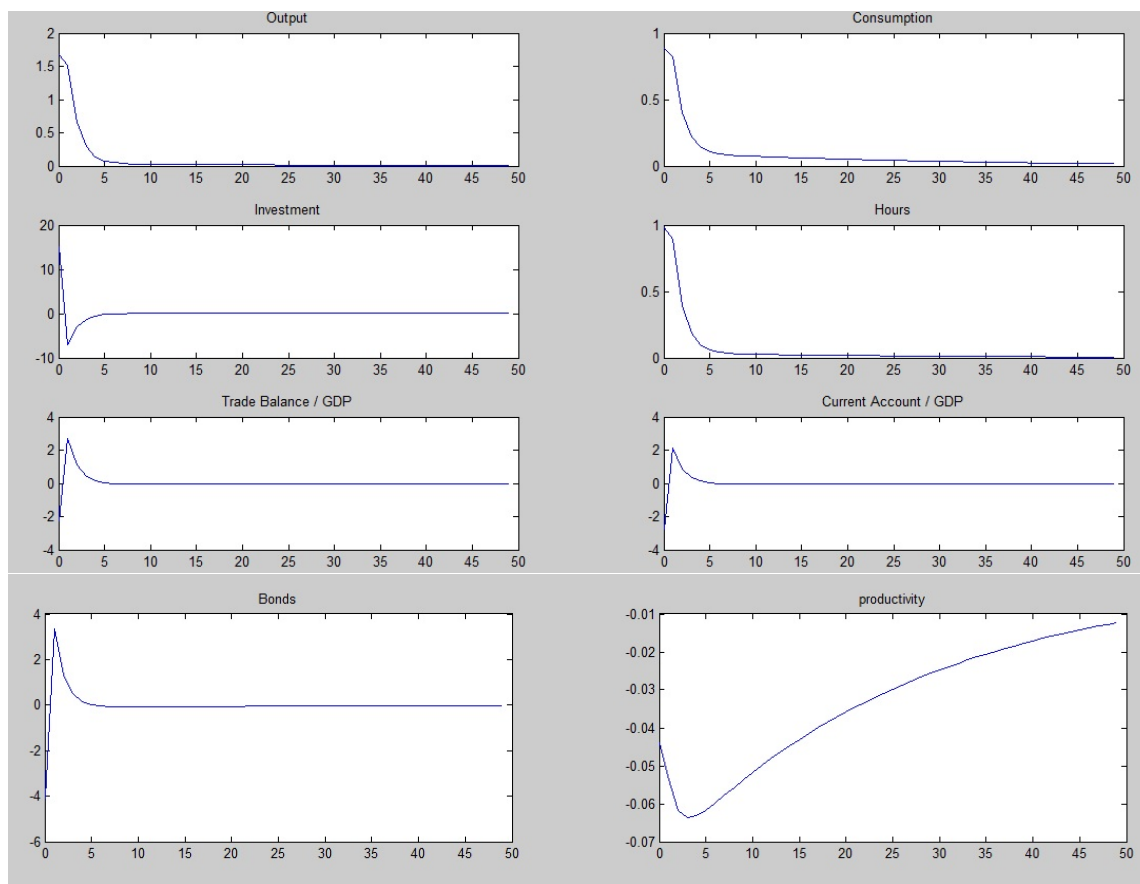
Figure 1: Impulse Response: Productivity Shocks

The expansion in consumption, investment and labor supply are caused by productivity shocks . The implication of this is that as investment and consumption increase, trade balance is expected to decline because of the inverse relationship that exists between them. Moreover, since the relationship between bonds and trade balance is positive and because trade balance indicates a negative response to the increase in consumption and investment thus, bonds is also negatively responsive to the shocks. The same effect is obtained in current account; the pro-cyclical responses of these

economic variables are strongly determined by cycles of investment. So, holding every other thing constant, an increase in output with corresponding increase in domestic investment and consumption will cause labor schedule to rise [5]. Because the increase in output is larger than the increase in consumption and because a rise in investment occurs through an increase in savings so, in good times, a small open economy will do well by saving. Increase in saving consequently, deteriorates trade balance, current account and bonds[6]. The deterioration results in countercyclical responses that freeze the opportunity for foreign exchange earnings.

The volatility of the variables in one percent standard deviation shocks is captured in Table 2 and Table 3 below. In table 2, the fluctuations of the variables are examined with $\gamma = 1.001$ while in table 3, the fluctuations are considered with $\gamma = 2.0$

Table 2: Standard Deviation, Correlation Co-efficient and Serial Auto Correlation ($\epsilon_{A,t}$) when $\gamma = 1.001$

$\gamma = 1.001$	Standard Deviation (%)	Correlation with Output	Serial Correlation	Canadian Data σ Mendoza '91
σ_y	3.0284	1.00	0.6708	2.81
$\frac{\sigma_c}{\sigma_y}$	0.5686	0.9781	0.7198	2.46
$\frac{\sigma_i}{\sigma_y}$	7.1655	0.3022	-0.2822	9.82
$\frac{\sigma_h}{\sigma_y}$	0.5937	0.9994	0.6776	2.02
$\frac{\sigma_k}{\sigma_y}$	0.7105	0.9442	0.4405	1.38
Ca_y	4.6001	-0.0763	-0.2779	7.31
Tb_y	4.7334	-0.0567	-0.2758	1.87

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[5]The contemporaneous rise in consumption is augmented by an increase in investment.
[6]Foreign debt holding

Table 3: Standard Deviation, Correlation Co-efficient and Serial Auto Correlation ($\epsilon_{A,t}$) when $\gamma = 2.00$

$\gamma = 2.0$	Standard Deviation (%)	Correlation with Output	Serial Correlation	Canadian Data σ Mendoza'91
σ_y	3.0092	1.00	0.6730	2.81
$\frac{\sigma_c}{\sigma_y}$	0.5591	0.9763	0.7187	2.46
$\frac{\sigma_i}{\sigma_y}$	7.0900	0.3071	-0.2822	9.82
$\frac{h}{\sigma_y}$	0.5927	0.9970	0.6862	2.02
$\frac{\sigma_k}{\sigma_y}$	0.7113	0.9462	0.4535	1.38
Ca_y	4.5377	-0.0971	-0.2772	7.31
Tb_y	4.6535	-0.2719	-0.0813	1.87

Tables 2 and 3 above reveal the fluctuations (volatility) of the variables. These results are close to and similar to Mendoza (1991) results with virtually same a-priori expectations. The slight difference in the results is associated with the introduction of 2 other parameters, μ and η, and 1 other equation, law of motion for MEI shocks. The models predict that the components of aggregate demand and hours are pro-cyclical and that the correlation of the trade balance, current account with GDP is very low. The models also estimate the procyclicality of labor in that its correlation with GDP is perfect. In the data, Mendoza (1991) examined the correlation between hours and output to be 0.799 but his models imply a perfect correlation. The same perfect correlation between hours and output is obtained in this study and this is driven by $\frac{h_t^w}{y_t} = (1 - \alpha)$ with $\alpha < 1$.

What can be inferred from this analysis is that when shocks to total factor productivity is considered, the model behavior is generally consistent with the predictions of the neoclassical macroeconomic theory. A significant success of these models framework is its ability to mimic the negative correlation between the $\frac{CA}{Y}$ and $\frac{TB}{Y}$ ratios and output observed in the data found in mendoza (1991). Moreover, these models

provide volatility statistics for output, consumption, investment, bonds, productivity and labor supply that are similar to those found in their empirical counterparts. However, the models generated volatility of output that were considerably higher than those seen in the data. The inverse relationship between trade balance and current account also explains the reason for a subsequent rise in savings which translates into an increase in investment of a small open economy. Investment is more volatile [7] than every other macroeconomic variables especially, consumption, labor supply and capital[8] in the representative economy.

4.4   Standard Deviation Shocks of MEI ($\epsilon_{\phi,t}$)

This section presents the main results in terms of impulse responses of the macroeconomic variables to one standard deviation shocks of MEI . The results so far suggest that, to understand business cycles, we must understand investment shocks, because these shocks are the largest contributors to fluctuations in several key macroeconomic variables.

Figure 2 displays the impulse response to the MEI shocks ϕ_t. Following a positive shock, output, consumption, labor supply, and investment rise persistently in a hump-shaped pattern. This increase, unlike the productivity shocks, is non-contemporaneous.

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[7]This form the basis of this study.
[8]Capital is used synonymously with productivity

4.5 Impulse Response: MEI Shocks
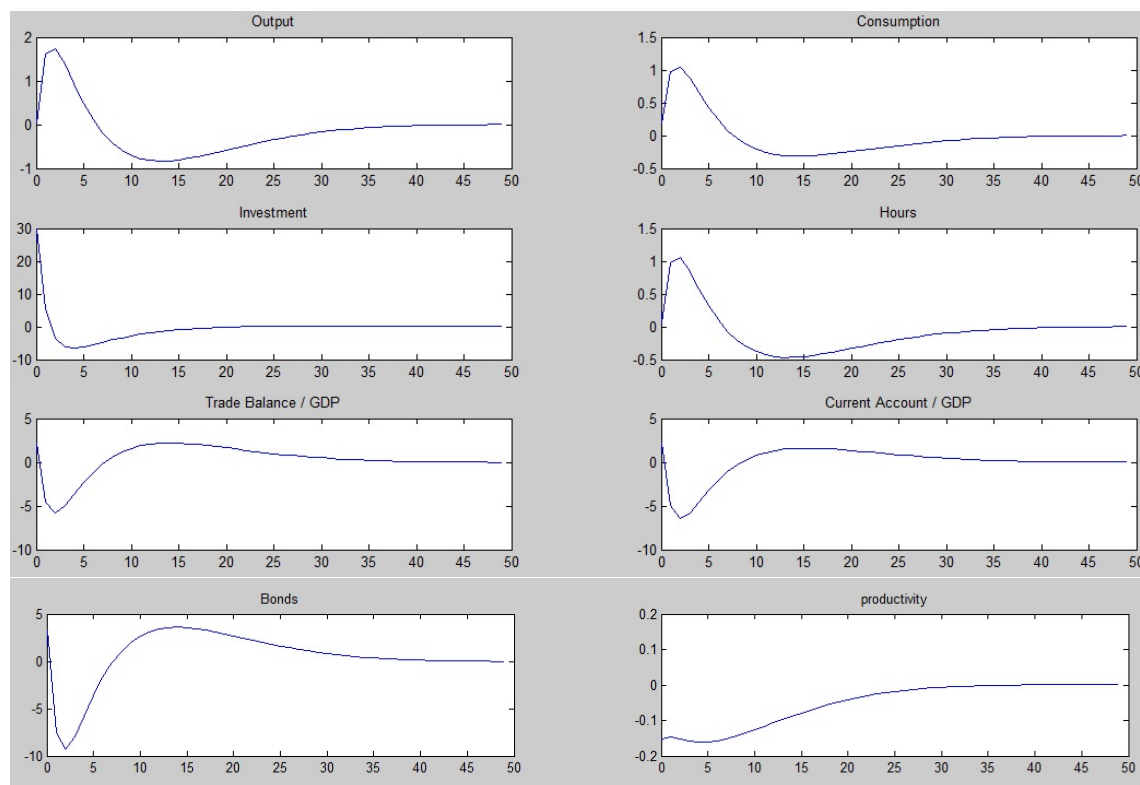
Figure 2: Impulse Response: MEI Shocks

There is a co-movement and immediate rise in investment, trade balance, current account and bonds while the increase in output, consumption and labor supply is delayed for one period episode with a very sluggish increase in productivity. A rise in consumption compresses trade balance and current account and the reason for the compression stems from the theoretical modeling of the variables which can be obtained in the computation of its correlation coefficients. These results confirm JPT (2008) conclusion which summarily assume that the observability of the relative price of investment does not significantly affect the interference on the MEI shock ϕ_t.

The impulse responses in figure 2 support the business cycle fluctuations found

in SOE literatures. Therefore, the decrease in output between periods 10 to 20 is associated with the decrease in investment after the shocks. These temporary shocks are typical textbook explanations of investment shocks. One time decrease in investment causes output to experience few episodes of decrease which consequently decreases consumption and labor supply. This period is the actual recession for the simulated economy. So the macroeconomic variables sluggishly recover from recession even when investment recovers faster after hitting recession because of the delay process of the growth transmission mechanism through other macroeconomic variables. The rise investment is greater than the rise in any other macroeconomic variables; same as what is obtainable in productivity shocks. It is pro-cyclical pattern that explains why investment shocks are so important in times of recession and it reveals the main source of fluctuations in SOE.

A shock to investment results in upward movement in the ratio of trade balance to output and ratio of current account to output. These results are contrary to what the author observed in the productivity shocks. However, there is a deep decrease in these two macroeconomic variables after the the initial rise before returning to their steady states. The same explanation is applicable to bonds. One nice feature of these results is the fact that, while output, consumption, labor supply, trade balance, bonds and current account returns to their steady states in 35th period, investment returns to its steady state in 20th period. Moreover, trade balance, current account[9] and bonds experience another episodes of an increase after their initial decrease. These results also explain how sensitive a small open economy can respond to initial experience of recession. An increase in economic output is expected to mitigate the short fall in domestic investment. Additionally, a rise in investment in SOE promotes

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[9]The author implies the ratio of trade balance to output and ratio of current account to output

exportation which further enhances the accumulation of foreign exchange. With that being said, the opportunity cost for such economy is the present consumption that is foregone.

4.6   Second Moments of 1 % Shocks in MEI

In a real Neoclassical model, technology shocks appear to be the main source of business cycles because they can easily spawn same responses of output, consumption, investment, labor supply, etc. To emphasize these results, Barro and King (1984) argue that investment shocks are unlikely candidates to generate recognizable business cycles because the co-movement among the variables in response to the shocks is somewhat problematic. Barro and King (1984) provided a basis that a positive shock to the marginal efficiency of investment will create an increase the interest rate which will consequently, induce agents to postpone or delay consumption. With lower consumption, the increase in marginal utility of income causes a right shift in labor supply while holding the labor demand constant. But contrary to Neoclassical assertion, investment shocks generate pro-cyclical movements in all the macroeconomic variables identified in this study and as such, emerge the important source of business cycles fluctuations. In a Neoclassical baseline model, efficiency equilibrium is attained when the Marginal Rate of Substitution (MRS), which depends positively on consumption and labor, equals Marginal Productivity of Labor (MPL), a decreasing function of labor supply. For an equilibrium to hold in Neoclassical model of Barro and King (1984), a good shock to labor supply must generate a corresponding fall in consumption; which is why the rigidity of investment shocks could not account for the fluctuations in macroeconomic variables. In this study, the author focuses on labor demand schedule instead of labor supply. The share of

consumption of output affects the MRS and the shocks to the productivity affect labor productivity and consequently labor supply. There is always a time lag for an increase in income of households to adjust to a change in consumption. This time lag creates a lax willingness that makes it impossible for consumption to fall in the wake of investment shocks.

Moreover, endogenizing capital utilization acts as a shift lever to MPL such that an efficient utilization of new investments - due to a decrease in relative prices- create a rise in the utilization of existing capital and through a functional transmission mechanisms, higher capital utilization causes an increase in MPL which in turn shifts labor demand to the right by holding labor supply schedule constant.

Table 4: Standard Deviation, Correlation Co-efficient and Serial Auto Correlation (ϕ_t) when $\gamma = 2.00$

$\gamma = 2.0$	Standard Deviation(%)	Correlation with Output	Serial Correlation
σ_y	3.0096	1.00	0.9154
$\frac{\sigma_c}{\sigma_y}$	0.5338	0.9863	0.9127
$\frac{\sigma_i}{\sigma_y}$	7.666	0.0367	0.3135
$\frac{\sigma_h}{\sigma_y}$	3.0744	0.9985	0.9141
$\frac{\sigma_k}{\sigma_y}$	1.9141	0.9142	0.9164
Ca_y	9.2262	-0.8631	0.8143
Tb_y	9.2528	-0.977	0.8394

Table 5: Standard Deviation, Correlation Co-efficient and Serial Auto Correlation (ϕ_t) when $\gamma = 1.001$

$\gamma = 1.001$	Standard Deviation (%)	Correlation with Output	Serial Correlation
σ_y	2.6831	1.00	0.8983
$\frac{\sigma_c}{\sigma_y}$	0.5284	0.9552	0.9054
$\frac{\sigma_i}{\sigma_y}$	8.2800	-0.0076	0.3186
$\frac{\sigma_h}{\sigma_y}$	0.5853	0.9988	0.8987
$\frac{\sigma_k}{\sigma_y}$	1.8835	0.8962	0.8982
Ca_y	8.5656	-0.8947	0.8065
Tb_y	8.2579	-0.9713	0.8187

Tables 4 and 5 report the contribution of the MEI shocks in the model to the fluctuations of macroeconomic variables at business cycle frequencies. These results are in line with the findings in Schmitt-Grohe and Uribe (2008). The important point that emerges from Tables 4 and 5 is that MEI shocks are the key drivers of business cycle fluctuations with a share of consumption playing a larger role in household utility. The volatilities of the macroeconnomic variables caused by MEI shocks are greater than those obtained in productivity shocks.

The result shows that business cycles are driven primarily by shocks that affect the transformation of investment goods into installed capital (MEI shocks), rather than that of consumption into investment goods (IST shocks) as claimed in Fisher (2005) . In the model, the MEI shocks represent disturbances to the process by which investment goods are converted into capital goods. This process explains an excess capacity and inefficient use of physical resources when the rates of investment are determined by adjusting the randomness of the innovations captured by ϕ_t. Sometimes the creation of productive capital is a smooth and efficient process and sometimes it is not.

From Tables 2 to 5 above, where the ability of the two models[10] to mimic key moments in the data is compared, both models perform unsatisfactorily in matching the corresponding statistics observed in the Canadian data. The volatilities and first-order autocorrelation statistics of the variables of interest in both models are lower than those observed in the data - and in some cases the statistics are significantly larger. Comparatively, in the MEI shocks framework, the volatilities of all the macroeconomic variables are even larger in size than those obtained in productivity shocks. So, while some results are different from those obtained in the data, some are closely approximated. In the productivity shocks model setup, the ranking of the volatility of consumption and output departs from its counterpart in the data and the volatilities of trade balance and current account surpass that of investment in MEI shock.

Despite having second moments that are somewhat similar, it becomes apparent by looking at the respective impulse responses for the productivity shocks and MEI shocks models provided in Figure 1 and Figure 2 respectively, that the dynamic behavior of the model economy under the two propagating mechanisms are considerably different. In fact, in both models, the dynamic path taken by the variables considered differ appreciably. This outcome is not entirely surprising because the nature and initial impact of the two innovations under consideration are different. It is quite evident that the lack of income effect in the first period from the MEI shocks contribute significantly to these differences in the initial periods. For example, in the case of the standard productivity shocks, current output [11] were affected contemporaneously and consequently, firms respond by increasing the amount of labor

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[10]Where γ is 2.0 and 1.001

[11]As well as marginal productivity of labor and current capital

allocation in the first period which synchronizes the immediate increase in current output. Whereas in MEI shocks model, the response is not only more delayed but cyclical. Indeed, changes in labor supply and capital decisions will only occur in the second periods onwards and the response of labor supply to that shocks will be more sluggish than it is generally the case. The slow response to MEI shocks explain the hump-shape dynamic path in output, consumption and labor supply compared to the productivity shocks model. There is co-movement in labor supply, consumption and output. This co-movement is due to perfect correlation the variables have with output. A different co-movement also occurs in trade balance, current account and bonds; the same justification for the preceding conclusion. So, the shocks to investment in SOE create an immediate rise in foreign exchange earnings due to exportation.

5 Conclusion and Suggested Further Studies

Over the course of some years, many of the goods we consume have experienced dramatic changes in quality and taste . Most of these changes have been due to innovations that occurred slowly but steadily but this has become a fact that has been largely ignored by the international real business cycle literature and it is in the author's opinion to explain justifications for the discrepancies that exist between theoretical model predictions and actual data estimates. Interestingly, these discrepancies have dwindled in recent years. How can we arrive at a theory that explains both the reasons for these puzzles as well as their gradual vanishment?

The models described in this study provide some clarifications for looking at the

impact of innovations to MEI[12] when the level of investment goods changes in a small open economy. As with the standard productivity shocks model[13], shocks to MEI were able to generate significant macroeconomic fluctuations in the small open economy. The author confirmed this from the second moments of the two (2) shocks and compared it to the Canadian data of Mendoza '91. Most significantly, the model was able to generate the pro-cyclical behavior of the external accounts when the model was augmented with share of consumption in the utility, μ, and an appealing adjustment cost parameter. This is in contrast to the productivity shocks model in which the external accounts remains counter-cyclical; this result supports the empirical evidence of the small open economy. Moreover, the conjecture that the standard productivity shocks model requires an artificially low value for the adjustment cost parameter to generate the counter-cyclical movement in the external account has been confirmed otherwise in this paper. In fact, a shock to a complex and appealing adjustment cost parameter produces a profound and valid pro-cyclical pattern of investment and this explains why investment shocks are so important in times of recession and thus, reveals the main source of fluctuations in a small open economy.

Despite these plausible results, the models are limited by some unavoidable deficiencies. First, some of the volatilities of productivity shocks are oversimplified when compared to data especially, output, investment, ratio of trade balance to output and current account while the volatilities of MEI shocks are all oversimplified. Secondly, the choice of frictions used in this paper might as well limit the result of this research work. Therefore, these limitations attract future studies. The author suggests further studies to include frictions in relative price of investment and Invest-

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[12]Is captured by shocks to adjustment costs
[13]Is generally consistent with Neoclassical economic predictions

ment Specific Technology (IST). Additionally, other sectors of the economy must be studied and this does not exclude the financial sector. Impact of fiscal and monetary policies must also be examined in the future; these policies should consider frictions that have lasting impact on the economy. Extension should also be considered in the area of Moral Hazard.

Above all, this study has helped to attribute investment shocks as the major source of macroeconomic fluctuations in a small open economy by a careful, in a way that has never been done by any author, construction of a continuous adjustment cost function and by embedding the form of the share of consumption in utility. Consequently, the results of the productivity shocks are compared with the MEI shocks and the author established that the variabilities in MEI shocks are more pronounced than the variabilities in productivity shocks. The author's choice of models sets his study apart from other relevant studies.

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