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Growth Shocks under Alternative Macro Regimes in a Developing Economy

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ABSTRACT
A key challenge facing most developing economies today is how to simultaneously maintain monetary independence, exchange rate stability, and financial integration, subject to the constraints imposed by the impossible trinity. In this paper, we contribute to the literature by examining and comparing alternative macroeconomic policy choices for a developing economy with growth shocks. To that end, we introduce a three-sector "almost small" open economy macroeconomic model, and calibrate this model to proxy the China in 2005 when it made the transition from being an economy that was bounded by the impossible trinity. We design two alternative macroeconomic policy regimes and apply the calibrated model to analyze both the short-run and the long-run responses to several domestic and external growth shocks, which appeared important for a developing economy like China during its economic reform period in the 2000s. The model simulation shows that most growth shocks cause an expansion in the real GDP level. Moreover, greater flexibility in the exchange rate allows the central bank to conduct independent monetary policy, the benefit from which increases as financial capital becomes more internationally mobile. Our findings draw policy implication for those developing countries considering alternative macroeconomic policy regimes to achieve sustainable economic growth.

KEYWORDS
Impossible trinity; exchange rate regime; financial capital mobility; sustainable growth; developing economy

JEL CLASSIFICATION
F41, F43, F47, O24

1. Introduction

In international macroeconomics, the impossible trinity is a concept, developed by Fleming (1962) and Mundell (1960, 1963), which states that it is impossible for a country to have all three of the following at the same time: a stable exchange rate, free access to international capital markets, and independent monetary policy. But no country can achieve all three goals. There are three options. The *first* option is to have a floating exchange rate, while allowing free capital flows and maintaining independent monetary policy. An example of a country that chooses this option is the United States. The *second* option is to have a fixed exchange rate without capital control, giving up monetary independence. An example of an economy that chooses this option is Hong Kong. The *third* option is to have a fixed exchange rate with capital control, in which case the country does not get full access to international capital markets. An example of a country that practices this option is China before 2005, during which time the Chinese RMB was pegged to the USD from 1994 to July 21, 2005. As a developing economy, China was bounded by the impossible trinity before 2005. But since July 2005, the RMB exchange rate has been allowed to float in a narrow margin around a fixed base rate determined with reference to a basket of world

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currencies. So with the change of its monetary policy objectives over time, China is no longer bounded by the impossible trinity after 2005.

A key challenge that is faced by most developing economies today is how to simultaneously maintain exchange rate stability, monetary independence, and financial integration, subject to the constraints imposed by the impossible trinity. Aizenman et al. (2013) introduce the "trilemma indexes" that measure the extent of achievement in each of the three policy goals of the impossible trinity. Aizenman and Ito (2014) apply the "trilemma indexes" by Aizenman et al. (2013), and they empirically prove that the hypothesis of the impossible trinity is binding, that is, the three measures of the trilemma are linearly related to one another, such that policy makers face a tradeoff in choosing a combination of two among the three open macroeconomy policies. For developing economies, it is an irreversible trend to move further toward financial globalization. The question is how to proceed with financial liberalization, due to its nature as a double-edged sword. On the one hand, financial liberalization can supplement domestic financial intermediation. On the other hand, financial opening can make a developing economy vulnerable to economic and financial turmoil, jeopardizing its economic growth.

This paper is dedicated to the challenging issue related to the macroeconomic policy choices for a developing economy. To that end, we develop a three-sector "almost small" open economy macroeconomic model, and calibrate this model to proxy the China in 2005 when it made the transition from being an economy that was bounded by the impossible trinity to one that is not bounded by the impossible trinity. We contribute to the literature by examining and comparing alternative macro policy regimes for a developing economy. We design two alternative macroeconomic policy regimes and apply the calibrated model to analyze both the short-run and the long-run responses to several domestic and external growth shocks, which appeared important for a developing economy like China during its economic reform period in the 2000s. The results from the model simulation draw policy implication for those developing countries considering alternative macro regimes to achieve sustainable growth.

The rest of this paper is structured as follows. In *Section 2*, we present our analytical framework by introducing a three-sector "almost small" open economy macroeconomic model for a developing economy. In *Section 3*, we conduct economic experiment and apply the calibrated model to analyze both the short-run and the long-run responses to several distinct growth shocks to the model economy. *Section 4* concludes and indicates policy implication.

2. Analytical framework

In this section, we introduce a three-sector "almost small" open economy macroeconomic model, which extends that of the two-sector "almost small" open economy model in Rees and Tyers (2004). This three-sector model includes saving, investment; money, bonds; and forward-looking agents. The model has a government, which implements monetary policy and fiscal policy in the home economy.

2.1. Model features

In our three-sector "almost small" open-economy macroeconomic model, there are four main modeling features, which are described as follows.

2.1.1. An "almost small" open economy

In our model, we have an "almost small" open economy, which is common in single-country CGE (computable general equilibrium) models, following Dixon et al. (1982), and Harris (1984).

What "almost small" means is that an economy does not have the power to influence the world market, but to take the world prices as given.

Corden (2002) assumes that a country is a "small" one, in terms of its influence on the international capital market, that is, it does not have a significant impact on the world prices and interest rates. Corden (2002) emphasizes that except for the United States, Japan, and Germany, all other countries are "small" ones, including Britain, France, and China.

2.1.2. Dynamic behavior

In our model, the macroeconomics is introduced without explicit dynamics by solving the model for the long run. The long-run results are used to form expectation in the short-run analysis of economic growth shocks. In the short run with myopic agents, the growth shocks are not expected. But the policy response is expected in the short run with forward-looking agents.

2.1.3. Long run and short run

There are four distinct features in the long-run version of the model. *First*, agents form the expectation that stimulated changes are permanent. *Second*, there are no nominal rigidities, and the labor market clears in the long run. But in the short run, the labor market does not clear, and nominal wages are rigid. *Third*, we assume that physical capital is mobile inter-sectorally. In the literature, there exists an assumption that production and consumption decisions are driven by larger elasticities in the long run (Pitchford, 1988), which we do not apply to simplify interpretation. *Fourth*, there is no inventory adjustment. These four assumptions collectively make money neutral in the long run.

2.1.4. Inter-temporal choice

In our model, we apply the method in Rees and Tyers (2004) to solve the optimization problem on the inter-temporal choice of the optimal levels of current and future consumption.[1] In this optimization problem, consumers have a rate of time preference. They choose a consumption level of C_1 in the current year and a consumption level of C_F in *every* subsequent year, in order to maximize their utilities over a finite time horizon.

2.2. Model details

2.2.1. The supply side

In Rees and Tyers (2004) paper, the supply side of the model follows the standard Heckscher-Ohlin-Samuelson (HOS) two-factor, two-sector structure with perfect competition in both the factor market and the product market. In our three-sector macro model, we extend the Rees and Tyers (2004) model by adding a third factor: land, and a third sector: service.

The production levels in the three sectors: agriculture (Y_1), industry (Y_2), and service (Y_3) are all Cobb-Douglas[2] (C-D) in the three primary factors: labor (L), capital (K), and land (A). The production functions for the land-intensive agriculture sector, the labor-intensive industry sector, and the capital-intensive service sector are:

$$Y_i = \alpha_i (L_i)^{\beta_{Li}} (K_i)^{\beta_{Ki}} (A_i)^{\beta_{Ai}}$$

The total demands of the three primary factors are therefore:

$$\overline{L} = \sum_{i=1}^{3} L_i, \quad \overline{K} = \sum_{i=1}^{3} K_i, \quad \overline{A} = \sum_{i=1}^{3} A_i$$

With perfect competition in both the factor market and the product market, the solution to the firms' profit maximization problem shows that the unit factor rewards in each sector i are the respective H$value of the marginal products at producer prices. Because labor is mobile across sectors, we have:

$$W_i = p_{H_i} MP_{L_i}$$

both in the short run and in the long run.

Correspondingly, the H$value of the rental rates per unit of physical capital is:

$$R_i = p_{H_i} MP_{K_i}$$

which only equates across sectors in the long run.

The H$value of the land rates per unit of land is:

$$Z_i = p_{H_i} MP_{A_i}$$

which equates across sectors both in the short run and in the long run.

In the short run, the unit factor demands stem from the technology, via the firms' cost minimization problem, where the firms minimize the total factor cost:

$$WL_i + R_i K_i + ZA_i$$

subject to:

$$1 = \alpha_i L_i^{\beta_{Li}} K_i^{\beta_{Ki}} A_i^{\beta_{Ai}}$$

The unit factor demands in the short run are derived as:

$$L_i = \frac{1}{\beta_i} \frac{\beta_{Li}}{W} \left(\frac{W}{\beta_{Li}}\right)^{\beta_{Li}} \left(\frac{R_i}{\beta_{Ki}}\right)^{\beta_{Ki}} \left(\frac{Z}{\beta_{Zi}}\right)^{\beta_{Zi}}$$

$$K_i = \frac{1}{\beta_i} \frac{\beta_{Ki}}{R_i} \left(\frac{W}{\beta_{Li}}\right)^{\beta_{Li}} \left(\frac{R_i}{\beta_{Ki}}\right)^{\beta_{Ki}} \left(\frac{Z}{\beta_{Zi}}\right)^{\beta_{Zi}}$$

$$A_i = \frac{1}{\beta_i} \frac{\beta_{Ai}}{Z} \left(\frac{W}{\beta_{Li}}\right)^{\beta_{Li}} \left(\frac{R_i}{\beta_{Ki}}\right)^{\beta_{Ki}} \left(\frac{Z}{\beta_{Zi}}\right)^{\beta_{Zi}}$$

The producer i's price (p_{H_i}) in the home economy becomes:

$$p_{H_i} = \quad WL_i + R_i K_i + ZA_i$$

The GDP price (P_Y) is a constant weighted index of the producer price (p_{H_i}):

$$\frac{P_Y}{P_Y^0} = \frac{\sum_{i=1}^{3} p_{H_i} Y_i^0}{\sum_{i=1}^{3} p_{H_i}^0 Y_i^0}$$

In the absence of intermediate inputs, our aggregate measure of economic activity is real GDP at producers' prices:

$$Y = \frac{1}{P_Y} \sum_{i=1}^{3} p_{H_i} Y_i$$

This is linked to the demand side of the model by the volume accounting relation:

$$Y_i = C_{H_i} + I_{s_i} + (I_{V_i} - I_{V_i}^0) + G_{S_i} + X_i$$

which sums the sectoral product demands for the consumption of home products, investment (including investment adjustments applying to the short run only), government spending, and exports.

2.2.2. The demand side

Consumption is derived in three stages. In the *first* stage, an aggregate volume of consumption is determined, along with corresponding savings via intertemporal optimization. For this purpose, the utility function of the collective household is assumed to be concave in the aggregate consumption. In the *second* stage, this aggregate is assumed to be CES (constant elasticity of substitution) in the consumption of the three goods. The products that are produced in the home economy are also differentiated from those that are supplied in the rest of the world. To achieve the differentiation of home products from foreign products, however, the *third* stage is needed. The consumption of each product is then assumed to be CES in the volumes consumed of the home produced and imported varieties.

In the *first* stage, the collective household is forward-looking, consuming C_1 in the current year and C_F in *every* subsequent year. They observe their current nominal disposable income, which excludes direct taxes (T_Y), and includes net income flows from abroad (N).

$$Y_D = P_Y Y - T_Y + N$$

They also observe the current aggregate consumer price level (CPI), P_C; and the current real interest rate net of capital income tax, $r_N = \frac{r}{1+\tau_K}$. Correspondingly, they form expectations about the future consumer price level (P_C^F); their future nominal disposable income (Y_D^e); and the future real interest rate net of capital income tax (r_N^F), all of which are presumed to prevail in every subsequent year.

The optimal level of current consumption is derived[3] as:

$$C_1 = \frac{Y_D + R_2(T)Y_D^F - \Delta W(1 + r_N)}{\left[\frac{R_2(T)}{R_1(T)}\right]^{\frac{1}{1-\omega}} + R_2(T)} \left[\frac{R_2(T)}{R_1(T)}\right]^{\frac{1}{1-\omega}}$$

where

$$R_1(T) = \frac{1 - \left(\frac{1}{1+\nu}\right)^{T-1}}{\nu}$$

$$R_2(T) = \frac{1 - \left(\frac{1}{1+r_N^F}\right)^{T-2}}{r_N^F}$$

Here, ΔW is the real change in the present value of wealth over a finite time horizon T; ν is the rate of time preference; and ω is the elasticity of utility to current consumption. To calibrate these equations, we first choose ν and T for an initially stable consumption path, which is consistent with the assumed underlying steady state. We then obtain ΔW from the C_1 equation and the initial conditions.

As the aggregate consumption C is a CES composite of the three goods, the collective household is assumed to choose the consumption C_{s_i} for each good, in order to minimize the cost of the aggregate consumption.

$$C_{s_i} = s_i C \left(\frac{p_i}{P_C}\right)^{-\sigma}$$

where s_i is the initial expenditure share on good i, and σ is the elasticity of substitution in consumer demand between the three goods. The aggregate consumer price level (CPI) is:

$$P_C = \left(\sum_{i=1}^{3} s_i p_i^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$$

In the *third* stage, the consumption of each product is divided between the home produced and imported varieties. A similar cost minimization problem takes place for each product i, but the expenditure to be minimized becomes:

$$p_i C_{s_i} = p_{H_i}(1+\tau_C)C_{H_i} + \frac{p_i^*}{E}(1+\tau_C)(1+\tau_{M_i})M_i$$

where E is the exchange rate in F\$/H\$, τ_C is the consumption tax rate, τ_M is the import tariff rate, and M is the volume of imports. The optimal levels of consumption for the home produced and imported varieties are:

$$C_{H_i} = s_{H_i} C_{s_i} \left[\frac{p_{H_i}(1+\tau_C)}{p_i}\right]^{-\sigma_s}$$

$$M_i = (1 - s_{H_i}) C_{s_i} \left[\frac{\frac{p_i^*}{E}(1+\tau_C)(1+\tau_{M_i})}{p_i}\right]^{-\sigma_s}$$

The composite price of good i is:

$$p_i = \left\{ s_{H_i}\left[p_{H_i}(1+\tau_C)\right]^{1-\sigma_s} + (1 - s_{H_i})\left[\frac{p_i^*}{\mathrm{E}}(1+\tau_C)(1+\tau_{M_i})\right]^{1-\sigma_s} \right\}^{\frac{1}{1-\sigma_s}}$$

Private saving is the residual after consumption (gross of consumption tax) is deducted from disposable income.

$$S_P = Y_D - P_C C = Y_D - \sum_{i=1}^{3}\left[p_{H_i}(1+\tau_C)C_{H_i} + \frac{p_i^*}{E}(1+\tau_C)(1+\tau_{M_i})M_i\right]$$

Direct tax applies to labor income and capital income net of depreciation at a common depreciation rate, δ.

$$T_Y = \tau_w W\bar{L} + \tau_K\left[\frac{B^*}{E} + \sum_{i=1}^{3}(R_i - \delta P_K)K_i\right]$$

where B^* is the domestic holding of foreign bonds, and P_K is the price of capital goods.

Indirect tax revenue stems from consumption tax, which is levied at the rate τ_C on both home produced and imported goods.

$$T_C = \tau_C \sum_{i=1}^{3}\left[p_{H_i}C_{H_i} + \frac{p_i^*}{E}(1+\tau_{M_i})M_i\right]$$

as well as from both export and import taxes.

$$T_X = \sum_{i=1}^{3} \tau_{X_i} p_{H_i} X_i$$

$$T_M = \sum_{i=1}^{3} \tau_{M_i} \frac{p_i^*}{E} M_i$$

Government saving is defined as the surplus of current revenue over current expenditure[4]:

$$S_G = T_Y + T_C + T_X + T_M - P_G G$$

Real government expenditure G is split between the three goods, by CES disaggregation.

$$G_i = s_{G_i} G \left(\frac{p_{H_i}}{P_G} \right)^{-\sigma_G}$$

where σ_G is the elasticity of substitution in government demand between the three home-produced goods.

The composite price is:

$$P_G = \left(\sum_{i=1}^{3} s_{G_i} p_{H_i}^{1-\sigma_G} \right)^{\frac{1}{1-\sigma_G}}$$

The final two sources of demand are investment and exports. The net inflows on the capital account are the differences between investment and total domestic saving, $S_D = S_P + S_G$. The balance of payments (BOP), measured in H\$, is:

$$KA = I - S_D = \frac{S_{NF} - \Delta R}{E} = -CA = -(NX + N)$$

where I is investment, S_{NF} is the private component of the net inflow of financial capital (net foreign saving) in F\$, and ΔR is the annual addition to official foreign reserves in F\$. More specifiically, net foreign saving is the annual inflow associated with acquisitions of home bonds by foreign investors net of the outflow associated with acquisitions of foreign bonds by home investors.

The current account (CA) includes net inflows associated with merchandise trade (NX); and net inflows associated with income from abroad (N).

Financial capital is assumed to be less than perfectly mobile internationally, such that the interest rate parity (IRP) does not hold in general. Financial investors are assumed to manage an investment portfolio that includes the national bonds of each country, the base period of which accounts for risk factors that are unaltered by the shocks considered here. Other things being equal, a rise in the after-tax home (nominal) bond yield induces a rebalancing of this portfolio, which in turn causes a corresponding rise in the net inflows on the home capital account. Such a rise might also be caused by an expected appreciation in the exchange rate. We therefore make these net inflows (in F\$) depend on a "parity ratio":

$$S_{NF} = a_{FS} + b_{FS} \left[\frac{\frac{i}{1+\tau_K} + \hat{E}^e}{i^*} \right]$$

where $\hat{E}^e$ is the expected proportional change in the exchange rate; and i^* is the yield on foreign bonds net of capital income tax, the rate of which is determined aboard.

The interest rate parity (IRP), at least in proportional change terms, can be approximated by making the elasticity of net foreign saving to the interest parity ratio (ε_{FS}) arbitrarily large, from which the slope parameter (b_{FS}) is derived. This relationship is made linear to facilitate changes of direction following large growth shocks to the model economy.

The investment that is financed by these domestic and foreign savings is comprised, conventionally, of the net investment (I_N) and depreciation replacement ($\delta\overline{K}$). The net investment (I_N) is calculated by the ratio of the expected future real net return on physical capital to the current real financing cost:

$$I = I_N + \delta_K = K \left[\gamma \left(\frac{r_K^e}{r} \right)^{\varepsilon_I} + \delta \right]$$

In the long run, the rate of return on installed physical capital is made endogenous, that is, the expected future value is forced into equality with the endogenous value. In the short run, the rate of return on installed physical capital is exogenous, and it is shocked by the amount that emerges from the long-run simulation. In the long-run solution, the net investment increases the total stock of physical capital in annual increments over the time period, T_{LR}.

To obtain the real return on physical capital, we first take an economy-wide average of the gross H$values of the rental rates per unit of physical capital, R.

$$R = \sum_{i=1}^{3} \left(\frac{K_i}{\overline{K}}\right) R_{\mathrm{i}}$$

The corresponding gross return on physical capital investment is the quotient of the gross rental rate (R), and the price of capital goods (P_K). We then net out the rate of depreciation and the expected inflation to obtain the *real* rate of return.

$$r_K^e = \frac{1 + \frac{R^e}{P_K^e}}{(1+\delta)(1+\hat{P}_C^e)} \approx \frac{R^e}{P_K^e} - \delta - \hat{P}_C^e$$

To construct this real return in the model, expectations are formed via long-run solution over the gross rental rate (R), the price of capital goods (P_K), and the consumer price level (P_C).

The aggregate investment I is a CES composite and meets demands on the capital good.

$$I = \left(\sum_{i=1}^{3} \psi_i I_{s_i}^{-\zeta}\right)^{\frac{1}{1-\zeta}}$$

To minimize the investment expenditure, $P_K I = \sum_{i=1}^{3} p_{H_i} I_{s_i}$, we have :

$$I_{s_i} = s_{I_i} I \left(\frac{p_{H_i}}{P_K}\right)^{-\sigma_I}$$

$$P_K = \left(\sum_{i=1}^{3} s_{I_i} P_{H_i}^{1-\sigma_I}\right)^{\frac{1}{1-\sigma_I}}$$

Related to investment is the accumulation of inventories, which respond to changes in the producer prices and are incorporated to capture product price sluggishness in the short run.

$$I_{V_i} = I_{V_i}^0 \left(\frac{p_{H_i}}{p_{H_i}^0}\right)^{-\varepsilon_V}$$

In the external sector, the real exchange rate is defined as the value of a home production bundle in terms of the corresponding foreign bundle. It can therefore be measured as the ratio of the home currency price of home output to the (before import tax) home currency price of foreign output.

$$e_{\mathrm{R}} = \frac{P_Y}{\frac{P^*}{E}} = E\frac{P_Y}{P^*}$$

where E is in F$/H$.

Foreign consumption of each good i is:

$$Q_i = \left(\lambda_i X_i^{\rho_i^*} + \lambda_i^* C_i^* \rho_i^*\right)^{\frac{1}{\rho_i^*}}$$

where X_i^* represents the export demand for home output by foreigners, C_i^* denotes the consumption of all other goods by foreigners, and $\rho_i^* = \frac{\sigma_i^* - 1}{\sigma_i^*}$.

Foreign expenditure on good i is:

$$Q_i = \left(\lambda_i X_i^{\rho_i^*} + \lambda_i^* C_i^* \rho_i^*\right)^{\frac{1}{\rho_i^*}}$$

where X_i^* represents the export demand for home output by foreigners, C_i^* denotes the consumption of all other goods by foreigners, and $\rho_i^* = \frac{\sigma_i^*-1}{\sigma_i^*}$.

Foreign expenditure on good i is:

$$P_i^F Q_i = (1+\tau_{X_i}) E p_{H_i} X_i + p_i^* C_i^*$$

Optimization for each good i yields the export demand for home output by foreigners.

$$X_i = \lambda_i^{\sigma_i^*} Q_i \left[\frac{p_{H_i}(1+\tau_{X_i})}{P_i^F}\right]^{-\sigma_i^*}$$

The composite foreign price of foreign consumption for good i is:

$$P_i^F = \left[\lambda_i^{\sigma_i^*}\left[E p_{H_i}(1+\tau_{X_i})\right]^{1-\sigma_i^*} + \lambda_i^* \sigma_i^* p_i^* (1-\sigma_i^*)\right]^{\frac{1}{1-\sigma_i^*}}$$

With exports defined, the H$net inflows on the current account of the balance of payments (BOP) that are associated with merchandise trade are:

$$NX = \sum_{i=1}^{3}\left[p_{H_i}(1+\tau_{X_i})X_i - \frac{p_i^*}{E} M_i\right]$$

The remaining component of the current account, the net factor income N, depends on the base-period holdings of domestic debt by foreigners B_H^* in H$, and of foreign debt by domestic residents B_F^* in F$. In the short run, the net factor income N, measured in H$, take the form:

$$N = -\frac{iB_H^*}{E(1+\tau_K)} + \frac{i^* B_F^*}{E}$$

Finally, the home money market is given a textbook treatment, with transaction demand for home money driven by GDP while the opportunity cost of holding home money is the nominal yield on home bonds. Real money balances (m_D) are measured in terms of purchasing power as indexed by the consumer price level (CPI).

$$m_D = a_M Y^{\varepsilon_{M_Y}} i^{\varepsilon_{M_i}} = m_s = \frac{M_s}{P_C}$$

2.2.3. Expectation formation

Expectations are formed by consumers over their future nominal disposable income (Y_D^e), and the future consumer price level (P_C^e). Consumers choose the levels of current consumption (C) and future consumption (C_F), the latter of which is assumed to be constant in all future periods. Expectations are also formed by investors over the average domestic real return on installed capital (r_K^e). The values of Y_D^e, P_C^e, and r_K^e emerge from the long-run simulation, which in turn are used to form expectation in the short run.

The formation of expectations by domestic and foreign financial investors is less straightforward. Their net acquisition of domestic bonds (S_{NF}) contributes to the financing of domestic investment, which appears as the private component of net inflows on the capital account of the balance of payments (BOP). With imperfect international financial capital mobility, S_{NF} is determined by the "parity ratio", $\frac{\frac{i}{1+\tau_K}+\hat{E}^e}{i^*}$, where the nominal bond yield is: $i = (1+r)(1+\pi^e) - 1$, and $\pi^e = \hat{P}_C^e$.

Table 1. Three-sector macro model – initial equilibrium: volumes 1.

Volumes at Home	**Economy**	**Agriculture**	**Industry**	**Service**
Aggregate output, Y	1800	270	954	576
Consumption, C_H	550.16	79.47	246.23	232.46
Investment, I_S	500	100	212.50	187.50
Government spending, G	213.33	19.20	38.40	155.73
Exports, X	528.51	71.33	456.87	0.31
Starting inventories, I_V	180	27	95.40	57.60
Volumes including Foreign varieties	**Economy**	**Agriculture**	**Industry**	**Service**
Aggregate home consumption, C_S	777.16	239.52	304.29	233.34
Imports, M	155.55	85.55	69.30	0.70

In forming the expectation of $\hat{P}_C^e$ and $\hat{E}^e$, one key issue is the information available to financial investors. We can assume that financial investors form their expectations *ex ante*, that is, they only know the long-run equilibrium before any short-run behavior is revealed. As an alternative, we can also assume that financial investors form their expectations *ex post*, after the short-run behavior is revealed. Because financial investors are generally among the best informed of decision makers, we assume that they have perfect foresight about short-run behavior, and form their expectations *ex post*. The expected annual rates of inflation and currency appreciation are then:

$$\hat{P}_C^e = \left(\frac{P_C^e}{P_C}\right)^{\frac{1}{T_{LR}}} - 1$$

$$\hat{E}^e = \left(\frac{E^e}{E}\right)^{\frac{1}{T_{LR}}} - 1$$

where T_{LR} is the number of years beyond which the long-run equilibrium prevails; P_C and E are the endogenous short-run values of the consumer price level and the exchange rate, respectively.

2.3. Model calibration

Like other CGE models, most parameters in this model are not econometric in nature, but are calibrated. We collect our data from the China Statistical Yearbook and our parameters from the GTAP database for the year 2005, in order to proxy a developing economy like China. We model the agriculture sector to be a net importing sector, the industry sector a net exporting one, and the service sector a near autarkic one. In Tables 1–7, we detail the numerical structure of this three-sector macro model.

3. Economic experiment

In this section, we apply the three-sector macro model and conduct economic experiment to analyze both the short-run and long-run responses to several domestic and external growth shocks to the model economy. In our economic experiment, these growth shocks include a productivity gain among all three sectors in the domestic economy; a trade liberalization in the agriculture sector; a consumption tax reform as a fiscal instrument to correct the distortion from the trade reform in the agriculture sector; an increase in the private saving rate in the domestic economy; and a reduction in the risk premium on investment in the domestic economy. The reason why we choose these distinct growth shocks is that they appear important for a developing economy like China during its economic reform period in the 2000s.

In our economic experiment, there are two alternative macroeconomic policy regimes. In the first macro policy regime, the central bank adopts a fixed exchange rate with low financial capital mobility. In the second macro regime, the central bank adopts a floating exchange rate with high

Table 2. Three-sector macro model – initial equilibrium: volumes 2.

Aggregate output:	Economy-wide
Real GDP at producers' prices (factor cost), Y	1800
Real GDP (including indirect tax revenue)	1918.97
Stocks:	
Physical capital, K	8211.60
Home holdings of Foreign bonds, B^*	164.88
Foreign holdings of Home bonds, B_H^*	410.58

Table 3. Three-sector macro model – initial equilibrium: prices 1.

Individual product prices:	Agriculture	Industry	Service
Home (producer) price, p_H , H$/unit	1.00	1.00	1.00
Foreign (trading) price, p^*, F$/unit	1.00	1.00	1.00
Aggregate consumption, p_s, F$/unit	0.81	1.22	1.15
Imports (after tariffs), p_M, H$/unit	1.04	1.10	1.00

Table 4. Three-sector macro model – initial equilibrium: prices 2.

Aggregate prices:	Economy-wide
GDP price, P_Y , H$/unit	1.00
Consumer price, P_C , H$/unit	1.09
Capital goods (investment) price, P_I , H$/unit	1.00
Government service price, P_G , H$/unit	1.00
Nominal exchange rate, E, F$/H$	1.00
Yields and Rates:	
Home bond yield, i	0.0486
Foreign bond yield, i^*	0.0427
Gross rental rate per unit of home physical capital, R_K	0.10
Real rate of return on home physical capital, r_K	0.04
Real home bond yield net of capital income tax, r_N	0.0423
Depreciation rate, δ	0.06
Rate of time preference, ν	0.06454

Table 5. Three-sector macro model – accounting identities: initial values.

Capital Market Identities:	**H$ value**
Investment, $P_I I$	446.99
Government spending, $P_G G$	213.33
Tax revenue, T	213.33
Private saving, S	819.96
Net foreign saving (private net capital account inflows), S_{NF}	2.03
Annual increment to official foreign reserves, ΔR	375
Balance of Payments (BOP):	
Current account net inflows, CA	372.97
Capital account net inflows, KA	−372.97
Tax revenue:	
Total tax, T	213.33
Income tax (labor and capital), T_Y	94.37
Consumption tax, T_C	108.61
Export tax, T_X	0.01
Import tariff, T_M	10.35

financial capital mobility. Our first macro regime is similar to option 2 (fixed exchange rate without capital control) under the impossible trinity. Our second macro regime is similar to option 1 (floating exchange rate with free capital flows) under the impossible trinity.

In each economic experiment, we run a new model simulation in which the determinant in question is shocked once-and-for-all. We then compare the economy's responses to those growth shocks. In particular, we focus on the proportionate change in the GDP level, the price level, and

Table 6. Three-sector macro model – key parameters 1.

Sectoral shares:	Agriculture	Industry	Service
Labor expenditure	0.54	0.55	0.33
Inputs to capital goods production	0.22	0.40	0.66
Inputs to services	0.24	0.05	0.01

Table 7. Three-sector macro model – key parameters 2.

Elasticities:	**Economy-wide**
Money demand to GDP, ε_{MY}	0.5
Money demand to the nominal interest rate, ε_{Mi}	0.1
Net foreign saving to the interest parity ratio, ε_{FS}	5.0
Real net investment to real capital return, ε_{I}	1.0
Inventories to producer price, ε_{V}	0.0
Utility to aggregate consumption volume, ω	0.4
Elasticities of substitution:	
In consumption, among each good, σ	1.5
In consumption, between home and imported varieties, σ_S	2.5
In foreign consumption, between home and foreign goods, σ^*	2.5
In capital goods production, among each good, σ_I	0.5
In government consumption, among each good, σ_G	0.5
Tax rates:	
Labor income, τ_L	0.05
Capital income, τ_K	0.15
Consumption, τ_C	0.15
Exports, τ_X , good 1	0
Exports, τ_X , good 2	0
Exports, τ_X , good 3	0
Imports, τ_M , good 1	0.04
Imports, τ_M , good 2	0.1
Imports, τ_M , good 3	0

Table 8. Economic experiment - macro regime 1: fixed exchange rate + low financial capital mobility.

Growth Shocks	real GDP	price	real exchange rate
Productivity Gain	increase	*deflation*	*depreciation*
Agriculture Trade Reform	decrease	inflation (LR)	appreciation (LR)
+ Consumption Tax Reform	increase (LR[5])	inflation (LR)	appreciation (LR)
Saving rate increase	increase	*deflation* (LR)	*depreciation* (LR)
Risk premium reduction	increase (LR)	*deflation* (LR)	*depreciation* (LR)

the real exchange rate to make the comparison between the two alternative macro policy regimes in the model economy.

In Tables 8 and 9, we provide a summary of our findings from the analysis of these growth shocks in our economic experiment.

In our economic experiment, most of the growth shocks have expansionary effects on the model economy, which are represented by the increase in the real GDP level in the model simulation. When the economy adopts a floating exchange rate with high financial capital mobility, most growth shocks will cause deflation in the price level and deprecation in the real exchange rate over both the long run and the short run, which in turn will further boost exports and improve trade balance.

Take the economic experiment of consumption tax reform as an example. In this experiment, we use consumption tax reform as a fiscal instrument to correct the distortion from the trade reform in the agriculture sector. If the economy adopts a fixed exchange rate with low financial capital mobility, then there will be a deflation in the price level and a depreciation in the real exchange rate only in the short run. But if the economy adopts a floating exchange rate with high financial capital mobility, then there will be deflation and real deprecation in both the short

Table 9. Economic experiment - macro regime 2: floating exchange rate + high financial capital mobility.

Growth Shocks	real GDP	price	real exchange rate
Productivity Gain	increase	inflation	appreciation
Agriculture Trade Reform	decrease	inflation (LR)	*depreciation*
+ Consumption Tax Reform	increase (LR)	*deflation*	*depreciation*
Saving rate increase	increase	*deflation*	*depreciation*
Risk premium reduction	increase	inflation	appreciation

run and the long run. So the fiscal correction, combined with the monetary policy, is more effective under the second macro policy regime.

From Table 8, we can see that when the central bank adopts a fixed exchange rate with low financial capital mobility, the price level moves in the same direction as the real exchange rate. This is because the nominal exchange rate is the monetary target in this macroeconomic environment. The price level makes the adjustment in order to defend the fixed nominal exchange rate, and the change in the real exchange rate is completely born by the produce price level in the home economy over the long run. In other words, the monetary policy is constrained by the exchange rate target. The central bank is not able to practice independent monetary policy under this macro regime. But from Table 9, we can see that when the central bank adopts a floating exchange rate with high financial capital mobility, the correspondence between the price level and the real exchange rate breaks down. The central bank is able to practice at least some degree of independent monetary policy under this alternative macro regime.

Overall, we find that greater flexibility in the exchange rate allows the central bank to conduct independent monetary policy in the home economy, the benefit from which increases as its financial capital becomes more internationally mobile.

However, when we assess the economic performance under these two alternative macro policy regimes, we also have to take into account the origin of the shock – whether it is a domestic shock or an external shock; and the nature of the shock – whether it is a supply-side shock or a demand-side shock; and how large the shock is. As can be seen from Tables 8 and 9, there is no one macro regime that performs better than the others across all growth shocks. Another concern is the stability of economic performance across a broad range of growth shocks, that is, when the economy faces a few domestic and external shocks at the same time.

4. Conclusion

In this paper, we contribute to the literature by examining and comparing alternative macro policy regimes for a developing economy. To that end, we develop a three-sector “almost small” open economy macroeconomic model, and calibrate this model to proxy the China in 2005 when it made the transition from being an economy that was bounded by the impossible trinity. We design two alternative macroeconomic policy regimes, with different assumption on the exchange rate and the degree of financial capital mobility. We then apply the calibrated model to analyze both the short-run and the long-run responses to several domestic and external growth shocks, which appeared important for a developing economy like China during its economic reform period in the 2000s. The model simulation shows that most growth shocks cause an expansion in the real GDP level. Moreover, greater flexibility in the exchange rate allows the central bank to conduct independent monetary policy, the benefit from which increases as financial capital becomes more internationally mobile. Our findings draw policy implication for those developing countries considering alternative macro policy regimes to achieve sustainable growth.

Notes

1. See Dai (2006: Appendix 4.3) for the derivation.
2. In Fung (2010, Fung, 2015) and Yao (2010, Yao, 2015), Cobb-Douglas (C-D) production function is also used to analyze China's industrial structure and productivity growth.
3. See Dai (2006: Appendix 4.3) for the derivation.
4. If we include the outstanding stock of government bonds and the associated burden of debt services, there is little change in the short-run solution, and hence they are omitted from the model discussion here for parsimony.
5. LR = long run.

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