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Large Fluctuations in Consumption in Least Developed Countries

Masahiro Kodama*

Abstract

The objective of this paper is to shed light on mechanism which increases fluctuation in consumption of least developed countries. In general large fluctuation in consumption makes consumers worse off. This fact suggests that accumulation of knowledge on the generating mechanism of the large consumption fluctuation very likely contributes to welfare improvement of the least developed countries, through policies stabilizing consumption. We specifically investigated the fluctuation in consumption, through the numerical analysis with a dynamic macroeconomic model.

Keywords: consumption, LDC
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* Research Fellow, International Economics Studies Group, Development Studies Center, IDE (mkodama@ide.go.jp)

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INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO
3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI
CHIBA 261-8545, JAPAN

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1. Introduction

The objective of this paper is to shed light on mechanism which increases fluctuation in consumption of low income countries. Dynamic macroeconomic theory predicts consumption is smoothed across periods and its volatility is small; the theory expects consumption does not vary by a great deal even if income fluctuates across periods. For example, let us suppose an economy where wheat is the sole good. We also postulate that economic agents produce wheat and consume it. Then, in this economy, the agents will not consume up all the extra wheat in a rich harvest year. If they know that some time in the future they may have a poor harvest year as well as a rich harvest year, they will save a part of the extra harvest for the poor harvest year. This behavior makes consumption less volatile, even if wheat harvest (income) is volatile. In a word, consumption is smoothed across periods.

As the theory expects, industrial G7 countries' consumption fluctuation, except a case of Italy, is actually smaller than income fluctuation in Figure 1.

FIGURE 1

Consumption's relative standard deviations to GDP's standard deviations, hereafter relative SD(C), are smaller than unity in the G7 countries. By contrast, in Figure 1, relative SD(C)s of low income countries are, on average, much larger than unity.[1] From the point of view of the macroeconomics' prediction and G7's results, this finding is very striking. When we face the striking fact, we will have a natural question of why the low income countries' consumption fluctuation is greatly large, deviating from the theoretical prediction and G7's data. It is our objective to solve this puzzle on the large consumption fluctuation in the low income countries.

In general volatile consumption makes consumers worse off. The fact suggests that accumulation of knowledge on the generating mechanism of the large consumption fluctuation very likely contributes to welfare improvement of the low income countries, through stabilization of consumption. Accordingly, researches on the large consumption fluctuation will be relevant from a viewpoint of policy implications.

To my knowledge, although the phenomenon is interesting, very little has been written on large consumption fluctuation of low income countries. One of the appropriate approaches to the puzzle is analysis by a dynamic stochastic general equilibrium model (hereafter, DSGE model) which is developed for examining fluctuations of macroeconomic variables. However, the previous studies adopting DSGE models of developing countries have not focused on this subject.

Mendoza (1995) is one of the important early studies which develops a field of a DSGE model of developing countries. The study finds that terms of trade (TOT) shocks in developing countries is extremely large, and it investigates the influence of the excessive TOT shocks on the developing economies. While Mendoza successfully develops developing countries DSGE model, adopting TOT shock as one of the external shocks, in reference to large consumption fluctuation he does not point the presence of the puzzle.

Following Mendoza's work, many scholars investigate developing economies, utilizing DSGE models. Kose and Riezman (2001) construct a DSGE model of sub-Saharan African countries, emphasizing those countries characteristic economic structure – monoculture economy; the countries mainly export primary goods and mainly import capital and intermediate goods. Kose and Riezman also realize that consumption fluctuation of sub-Saharan African countries is large. They briefly conjecture a cause of the large consumption fluctuation; they speculate the fluctuation is attributable to the presence of durable goods.[2] They, however, do not inspect the validity of their conjecture.

Neumeyer and Perri (2005) examine emerging upper middle income countries. They analyze the cause of large consumption fluctuation of the emerging economies. They find that the interest rate of international loan to the emerging economies is countercyclical since a part of country risk premium included in the interest rate is countercyclical. The countercyclical mechanism is explained as follows. When the emerging economy is in a recession, the international creditors demand high interest rate to the economy, fearing default. Under the existence of countercyclical interest rate, the fluctuation in consumption is amplified: in a recession, because of the high interest rate, the economy is unable to borrow well, and it decreases its import good consumption. The combination of the decrease in domestic good consumption through recession and the decrease in import good consumption suppresses total consumption by a great deal. While this explanation on large consumption fluctuation of upper middle income countries is persuasive, the mechanism will not work in low income countries which are our research target countries (and not Neumeyer and Perri's research target countries). This is because the amount of private loan, which sensitively demands country risk premium, is rather limited in the low income countries.

Arellano et al. (2009) introduce international aid, as an external shock, to their DSGE model. Obviously, aid is an external shock characteristic of developing countries. They examine the influence of aid on developing countries. In their simulation, they succeed in replicating key macroeconomic indices' behaviors of the sample economy – Cote d'Ivoire – rather well. Meanwhile, concerning the puzzle of large consumption fluctuation, they do not investigate the puzzle, since their sample economy's consumption fluctuation is not large.

As we have seen above, detailed research on the cause of low income countries' large consumption fluctuation has not been made. The previous studies' interest is in different subjects, and not in low income countries' large consumption fluctuation. To the best of my knowledge, this is the first research which focuses on the cause of large consumption fluctuation in low income countries.

In this study we utilize a DSGE model in examining the large consumption fluctuation puzzle. We construct a DSGE model which inherits some important features from preceding studies: the model involves TOT shocks, aid shocks, and monoculture-economy structure. In addition to these features, we introduce a type of debt constraint as well. We investigate how strongly the tightness of the debt constraint affects the consumption fluctuation.

The remainder of this document is organized as follows: in Section 2 we briefly look at possible causes of the large consumption fluctuations. In Section 3 we depict a DSGE model utilized in our analysis. Section 4 introduces parameters which calibrate our benchmark case. As it has already been explained, in Section 2 we find candidate factors which may have significant influence on consumption volatility. Then in Section 5 we examine how strongly these elements affect on consumption volatility. Section 6 concludes our discussion.

2. Sources of Volatile Consumption

In this section, we will take a look at the candidates of large-consumption-fluctuation causes. On the basis of the analysis we will construct a DSGE model for the examination of large-consumption-fluctuation puzzle.[3]

To come to the right point, as we will see below, the direct driver which amplifies total consumption fluctuation is import-good consumption. The import-good consumption in low income countries is extremely volatile, which makes the total consumption fluctuation large. Table 1 clearly shows this tendency.

TABLE1

Before plugging into the analysis of the table, we take a brief look at the source of the table's data. "Africa Database", issued by the World Bank, breaks down merchandise-trade-base import into four components – food import, non-food consumption good import, raw material import, and capital import. The import component data are available in limited low income countries. As a sample case we choose the statistics of Kenya. The tendency of the data described in the following discussion is shared by other data-available low income countries. The items of the table are calculated from the merchandise-trade-base statistics and GDP-expenditure-base statistics. In the table, we display standard deviations (SD) of real-base per capita variables. The variables are natural logarithmed, and detrended with HP(100). We denote a ratio of a variable's standard deviation to GDP's standard deviation as relative SD.

Table 1 shows that the difference in the standard deviation between merchandise-trade-base total import (M) and GDP-expenditure-base import (M^*) is small. From the fact, regarding the standard deviations of the components of merchandise-trade import as comparable numbers to GDP expenditure's import, we continue our argument. At this point, it may be inappropriate to directly compare the merchandise-trade-base indices with GDP-expenditure-base indices in Table 1. In fact the indices of M and the indices of M^* are slightly different. In order to compare C^{M*} indices with GDP indices, we adjusted C^{M**} as explained in Appendix B.

Now we realize the volatility of the import good consumption (C^{M**}) is extremely large, compared to the volatility of GDP expenditure's consumption (C). This finding tells that the extremely volatile import-good consumption contributes to the total consumption's large volatility by a great deal. This finding also provides the reason why it is possible that the consumption fluctuation is larger than the GDP (income) fluctuation. In Introduction, we implicitly assumed that the income fluctuation was the sole origin of fluctuation. On the other hand, if there exsists another source of fluctuation and if the source has the strong influence on consumption, then it is possible that the consumption is more volatile than income.

Then let us move our discussion one step further; what makes the excessive volatility in import-good consumption? In this study we will attempt to answer this question. Specifically, we will examine the roles of TOT shocks, aid shocks, and constraints in the debt from the foreign countries (hereafter, debt constraint), in the amplification of large consumption fluctuation through import good consumption. The reason why we specifically focus on these three elements is twofold; qualitatively, these elements posses mechanism which amplifies volatility in consumption-good import (import-good consumption). Quantitatively, impacts of these elements on consumption-good import (import-good consumption) appear to be sufficiently large. In the rest of this section, we briefly look at these three elements, in terms of the amplification mechanism and the quantitative aspects.

First, we analyze the impact of TOT shocks and aid shocks. It will be obvious that there exists a mechanism where TOT and aid have direct influence on consumption-good import. At the same time, quantitative influence of these shocks appear to be large enough. Table 2 summarizes the volatilities of TOT and aid.

TABLE 2

The numbers in the table are means of SD and relative SD across the group member countries in the respective groups.[4] The SD of TOT is rather larger than that of GDP in both G7 countries and low income countries. Further, the relative SD of low income countries' TOT is more than twice as large as that of G7 countries.[5] Now let us take a look at the impact of aid. Researches on aid volatilities and the volatile aid's impact on the developing economies are expanding.[6] Needless to say, aid is a shock characteristic of developing countries. Hence, the data of G7 are not available. The volatility of aid is also by far larger than that of GDP in Table 2. On the basis of these observations, it is natural to expect that TOT shocks and aid shocks are candidates of main causes which produce large fluctuation in import good consumption.

Second, we inspect the influence of a constraint in the debt from the international financial market (debt constraint). Volatilities in import-good consumption in low income countries depend on the extent of how easily they can borrow from the international financial market. Purchase of the import goods are financed by the country's export, foreign aid, and foreign debt. When the export contracts due to a recession, if the country can borrow from the international financial market, the borrowing covers the contraction of export in the finance for the import-good purchase. So, in a recession, the import good consumption does not decrease extremely if the country can borrow well. On the other hand, in an economic boom, the country repays the debt with an extra export brought by the economic boom. In other words, the extra export in the economic boom is not fully spent on finance of import. Then the expansion of import and import-good consumption in the economic boom become moderate. In short, if an economic agent can borrow well from the international financial market, the consumption-good import is smoothed across the periods. To put this another way, strength of restriction on borrowing (i.e. tightness of debt constraint) has a direct influence on the volatility in consumption-good import. Generally, the low income countries have difficulties in the borrowing from the international financial market. Haque and Montiel (1989) and Vaidyanathan (1993) empirically examined the borrowing constraint, They found that the borrowing constraint is tighter in low income countries than in other countries. Based on this argument, in addition to TOT shocks and aid shocks, we will examine the influence of the debt constraint on the consumption fluctuation in the latter section.

3. The Model Economy

This section describes an economic model which replicates macroeconomic behavior of low income countries. In our model economy we presume three types of goods – tradable (exportable) goods, non-tradable goods, and importable goods. These types are denoted by putting superscripts on variables. The superscript T, N, and M express tradable, non-tradable, and importable goods, respectively. Kose (2002) shows that, in a developing country's case, the tradable (exportable) goods are mainly primary goods. Furthermore, they are so called "cash crops" which are produced for foreign demand.[7] Based on the facts, we consider the tradable good sector to be a primary good production sector, and assume that they are not domestically consumed in the model economy.

In our model economy there is a representative economic agent who lives infinitely. The agent determines its economic behavior, so that the lifetime utility is maximized. We postulate the following expected lifetime utility, U.

$$U = \mathrm{E}_t\left\{\sum_{t=0}^{\infty}[\beta^t \cdot u(C_t^N, C_t^M)]\right\}$$

$$u(C_t^N, C_t^M) = \frac{\left\{[(\omega^C)(C_t^N)^{-\rho^C} + (1-\omega^C)(C_t^M)^{-\rho^C}]^{\frac{-1}{\rho^C}}\right\}^{1-\gamma}}{1-\gamma} \tag{1}$$

u( ) represents an instantaneous utility function. We adopt CRRA function as the instantaneous utility function, where γ is a risk aversion parameter. C^N and C^M stand for consumption of non-tradable goods and consumption of importable good. The relationship between C^N and C^M are given by a CES function, where ω^C and ρ^C are the CES function's parameters.

While tradable good and non-tradable good are produced domestically, the production sectors require imported goods as intermediate goods. Bo the tradable and non-tradable goods are produced by combining three types of inputs – labor, capital, and imported intermediate goods. The production technologies are given as follows.

$$Y_t^T = [(\omega^{Y,T})(y_t^T)^{-\rho^{Y,T}} + (1-\omega^{Y,T})(m_t^{M,T})^{-\rho^{Y,T}}]^{-\frac{1}{\rho^{Y,T}}}$$
$$y_t^T = A_t^T (L_t^T)^{\alpha^{T1}} (K_t^T)^{\alpha^{T2}} (H)^{1-\alpha^{T1}-\alpha^{T2}} \qquad (2)$$

$$Y_t^N = [(\omega^{Y,N})(y_t^N)^{-\rho^{Y,N}} + (1-\omega^{Y,N})(m_t^{M,N})^{-\rho^{Y,N}}]^{-\frac{1}{\rho^{Y,N}}}$$
$$y_t^N = A_t^N (L_t^N)^{\alpha^N} (K_t^T)^{1-\alpha^N}$$

(3)

Y^T and Y^N express outputs of tradable goods and outputs of non-tradable goods, respectively. We introduce land as one of the inputs in the tradable sector which is a primary sector. H is the amount of inelastically supplied land. $m^{M,T}$ stands for imported intermediate goods employed in the tradable good production. Similarly, $m^{M,N}$ stands for imported intermediate goods employed in the non-tradable good production. L and K represent labor and capital, respectively. We write a level of productivities as A, which is given as exogenous stochastic shocks to the representative agent. ωs ,ρs, and αs are parameters. The standard definition of value added is written as,

$$y_t^{V,j} = P_t^j Y_t^j - P_t^M m_t^{M,j}, \quad \forall j = T, N \qquad (4)$$

Here $y^{V,j}$ denotes "value added" in a good-j production sector. We adopt the tradable good as numeraire, and we denote a price of good j in terms of the tradable good as P^j. By definition of numeraire, P^T is equal to unity. P^M corresponds to an inverse of TOT. The prices are determined in the international market. Since the low income countries are a small economy, the countries behave as a price taker. In this model these two prices are given as stochastic exogenous variables. The stochastic processes are introduced later in this section. P^N is the non-tradable good's price which satisfies the subsequent standard relationship between prices and marginal utilities.

$$\frac{\partial u_t / \partial C_t^N}{P_t^N} = \frac{\partial u_t / \partial C_t^T}{P_t^T} \qquad (5)$$

By definition, non-tradable good is not traded in the international market, and its price is endogenously determined in the model economy. When we evaluate the variables under constant prices, we adopt the steady state values of these three prices.

In reference to investment's law of motions, we presume the following equation.

$$K_{t+1}^j = (1-\delta^j)K_t^j + I_t^j - \frac{\phi^j}{2}(K_{t+1}^j - \overline{K}^j)^2, \quad \forall j = T, N \qquad (6)$$

K and I stand for capital and investment, respectively. The last term of the right hand side corresponds to adjustment cost of investment, where $\overline{K}$ is a steady state value of K. [8] The investment in good-j sector (I^j) in the equation is composed of two types of components; imported investment goods and domestic non-tradable goods.

$$I_t^j = [(\omega^{I,j})(I_t^{N,j})^{-\rho^{I,j}} + (1-\omega^{I,j})(I_t^{M,j})^{-\rho^{I,j}}]^{-\frac{1}{\rho^{I,j}}}, \quad \forall j = T, N \tag{7}$$

$I^{N,j}$ represents non-tradable good which is produced domestically and inputted in a production sector j, where the sector j corresponds to tradable good sector or non-tradable good sector. Similarly, $I^{M,j}$ represents tradable good which is imported and inputted in a sector j. ωs andρs are parameters.

In this model we have three market clearing conditions, corresponding to three types of goods; tradable goods, non-tradable goods, and importable goods. In many low income countries, a large share of whole export is composed of so-called cash crops, where crops do not have to be agricultural products. In this case we write a tradable good market clearing condition as,

$$Y_t^T = X_t \tag{8}$$

The non-tradable good is domestically consumed or invested. Since, by definition, the good is not exported, the market clearing condition of the non-tradable good is consumed or invested.

$$Y_t^T = C_t^T + I_t^T . \tag{9}$$

The total import, denoted as M, is defined by the subsequent equation, where C^M stands for consumption of imported goods.

$$M_t = C_t^M + I_t^{M,T} + I_t^{M,N} + m_t^{M,T} + m_t^{M,N} \tag{10}$$

The transaction of the agent in the international market satisfies a balance of payment.

$$X_t - P_t^M M_t = P_t^M (1+r) B_{t-1} - P_t^M B_t - P_t^M D_t + \frac{\mu}{2} \cdot P_t^M (B_t - \overline{B})^2 \tag{11}$$

The equation (11) implies the agent finances its import with its export, aid, and borrowing. Aid, denoted as D, is considered to be a grant aid. We assume the aid donation is determined exogenously, and we will introduce the exogenous stochastic process later. The agent can borrow from the international market, by issuing non-contingent bond. We denote the amount of the bond's outstanding and its interest rate as B and r, respectively. Following Neumeyer and Perri (2005), Uribe and Yue (2006), Aguiar and Gopinath (2007) and many others, we adopt adjustment cost in borrowing which corresponds to the last term of the right hand side in (11). $\overline{B}$ in (11) stands for the steady state of B.

By combining (8)—(11), GDP expenditure identity is derived;

$GDP_t = C_t + I_t + X_t - M_t$.

Here we define GDP, C, I, X, and M as,

$$GDP_t = (Y_t^T + P_t^N Y_t^N) - (P_t^M m_t^{M,T} + P_t^M m_t^{M,N})$$

$$C_t = C_t^T + P_t^N C_t^N + P_t^M C_t^M$$
$$I_t = P_t^N I_t^{N,T} + P_t^N I_t^{N,N} + P_t^M I_t^{M,T} + P_t^M I_t^{M,N}$$
$$X_t = X_t^T$$
$$M_t = C_t^M + I_t^{M,T} + I_t^{M,N} + m_t^{M,T} + m_t^{M,N}$$

The definition of GDP is based on the standard definition; GDP is equal to output minus intermediate goods.

Finally we introduce the generating process of exogenous shock variables. As we have already seen, in our model, we have four exogenous shock variables; A^T, A^N, D, P^M. The shock variables obey a VAR process.

$$\mathbf{Z}_t = \mathbf{R} \cdot \mathbf{Z}_{t-1} + \boldsymbol{\varepsilon}_t$$

where $\mathbf{Z}_t = [\ln(A_t^T), \ln(A_t^N), \ln(D_t), \ln(P_t^M)]'$

$$\boldsymbol{\varepsilon}_t = [\varepsilon_t^{AT}, \varepsilon_t^{AN}, \varepsilon_t^{D}, \varepsilon_t^{PM}]' \tag{12}$$

$$\boldsymbol{\varepsilon}_t \rightarrow N(\mathbf{0}, \boldsymbol{\Sigma})$$

R: 3×3 diagonal matrix.

The representative agent determines the level of economic variables, maximizing its lifetime utility U under the given conditions. We will solve the dynamic optimization problem with a method of log-linearization.

4. Calibration

The benchmark model is calibrated to mimic main macroeconomic indicators of Kenya. We chose Kenya as our sample economy because, first, the country is one of the average low income countries which share the low income county's characteristics; volatile TOT, aid recipient, and mono-cultural economy. Second, the country releases various macroeconomic statistics across long periods. So we can calculate moments of the country's main macroeconomic indicators, based on relatively large sample.

Now let us take a look at Kenya's economy briefly. We adopt, as a data period, a period between 1975 and 2004. Except a conflict starting in 2007, Kenya has not experienced serious conflict since its independence in 1963. As of year 2004, the population of the country is 33,000,000, and the per capita GDP is 481 US dollar in nominal base. In real local-currency-unit value-added base, the share of agriculture, industry, and others are 27%, 17% and 56%, respectively, on average of the sample period.The average real GDP growth rate of our sample period is 3.5% in local currency unit base.

We calibrate the Kenyan economy of our sample period, 1975-2004. First, we go over a definition of tradable and non-tradable good sector in actual data. In line with Kose and Riezman (2001) and Kose (2002), we consider that the export goods are so-called cash crops, and they are produced for the foreign demand, and not for the domestic demand.[7] We then assume that the exported goods are produced in a production sector which focuses on production of export goods. For example, if a maize sector does not export at all and if a tea sector exports all the products, then we regard the maize sector as non-tradable good sector and we regard the tea sector as tradable good sector. Further, if 90% of the tea is exported and the rest of the tea is domestically consumed, then we regard 90% of the tea sector focuses on production of exportable tea. And we regard the 90% of the tea sector belongs to tradable sector and remaining 10% of the tea sector belongs to the non-tradable sector. We compose the non-tradable sector of these individual non-tradable sectors. Under this consideration, the amount of export matches the amount of tradable output, as assumed in the equation (7). Naturally, this definition of tradable and non-tradable sector affects the sectors' value added. The details of value added calculation is given in Appendix C.

Second, let us take a look at our parameter setting in the benchmark case. The summary of the parameters are exhibited in Table 3.

TABLE 3

We set β to 0.96 which is a value often used in the DSGE literature. Concerning a relative risk aversion parameter γ, Ostrey and Reinhart (1993) estimate the value of developing countries. We adopt the estimated value, 2.61, as our value of γ. ω^C controls a ratio between C^N and C^M at the steady state. We choose the value which closely replicate the actual ratio of C^N and C^M. In the DSGE literature, the preceding studies often set the parameter α's so that the ratio between labor distribution rate and profit distribution rate becomes 2-to-1. We also utilizes this ratio. In the tradable good sector we have one more input – land. We use the same distribution rate for land as in

Kose and Riezman (2001). In reference to δ we utilize a value, 0.05, which is often used in the DSGE literature. ω^{IT} determines a ratio between I^{NT} and I^{MT} at the steady state. Similarly, ω^{IN} determines a ratio between I^{NN} and I^{MN}. We do not have data for the two separate ratios; I^{NT}/I^{MT} and I^{NN}/I^{MN}. On the other hand we can calculate $(I^{MT}+I^{MN})/(I^{NT}+I^{NN})$, from the actual data. Then we adopt a value of ω, where $\omega = \omega^{IT} = \omega^{IN}$ so that our model produce $(I^{MT}+I^{MN})/(I^{NT}+I^{NN})$ close to that of data. $\overline{A}^N$ affects the non-tradable sector's value added ratio to GDP (y^{VN}/GDP) and $\overline{D}$ affects aid's ratio to GDP (aid/GDP). We employ the values of $\overline{A}^N$ and $\overline{D}$ so that the model's y^{VN}/GDP and aid/GDP in the steady state approach to these actual ratios. $\overline{P}^N$ is non-tradable good's price, at the steady state, in terms of the tradable good. We set it to the unity.

P^M is derived from GDP-expenditure-base deflators; we derive the index by dividing an implicit import deflator with an implicit export deflator. With respect to the aid data, we refer to OECD database.[9] For the realization of the data, after transforming the data into local-currency-base value, we divide it with implicit import deflator. In estimating shock processes of P^M and aid, we divide them with the population. Then we take natural logarithm of the per capita values, and detrend them with HP(100), where HP(100) refers to a detrend filter developed by Hodrick and Prescott (1997). We econometrically estimate the shock processes from the filtered data. We obtain the value of R_{33}, R_{44}, Σ_{33}, and Σ_{44}, from the estimation, where R_{ij} and Σ_{kl} refer to the i-j element of matrix R and the k-l element of matrix Σ. We set Σ_{34} and Σ_{43} so that the model generates P^M-D correlation close to the actual data's correlation.

We presume that $\rho^{YT} = \rho^{YN} = \rho^{Y}$, $\rho^{IT} = \rho^{IN} = \rho^{I}$, and $\phi^{T} = \phi^{N} = \phi$. And then, in line with Arellano et al. (2009) we jointly estimate these remaining parameters; ρ^{C}, ρ^{Y}, ρ^{I}, ϕ, μ, R_{11}, R_{22} and remaining elements of $\boldsymbol{\Sigma}$. For the explanation, we write a standard deviation of variable X as SD(X), and write a standard deviation ratio of SD(X)/SD(GDP) as relative SD(X). Then, in the estimation we choose these parameter values which make the model closely replicate the actual data in terms of the following indices; relative SD(C^M), relative SD(y^{VT}), relative SD(y^{VN}), relative SD(I), relative SD(TB), y^{VT}'s autocorrelation, y^{VN}'s autocorrelation, and correlations among y^{VT}, y^{VN}, D, P^M. Here, TB represents a ratio of export/import.

5. Results

In this section we observe our simulation results. First, the benchmark case results are displayed. Based on the results we inspect the ability of our economic model in terms of how well the model replicates the actual economy's data. Second, we examine the influences of the TOT shock, the aid shock, and the debt constraint on consumption fluctuation.

Hereafter in this section, we use a term of P^M shocks instead of a term of TOT shocks. Since P^M is an inverse of TOT, relationship between P^M and TOT is similar to coin's head and tail; they share many features. For example, if a standard deviation of P^M is large, then that of TOT is also large. Meanwhile, naturally, their direction of change is opposite: if P^M rises, TOT goes down. To avoid misunderstanding in this direction, hereafter in this section, we use a term of P^M in line with our model.

5.1 Benchmark Results

Table 4 summarizes our benchmark simulation results. On the whole, our benchmark model successfully replicates the behavior of the data.

TABLE 4

Now, our primary interest in this study is how the consumption fluctuation is amplified in low income countries. Concerning the import-good consumption (C^M), relative SD of the model matches relative SD of the data. In respect to total consumption (C), relative SD of the model's total consumption (1.252) slightly deviates from relative SD of the data (1.829). While the model slightly underestimates relative SD(C), the model successfully produces relative SD(C) which is clearly greater than unity by approximately 25%. In metaphor with wheat in Introduction, it appears to be impossible that the SD of consumption surpasses that of GDP. We expected, in section 2, a possibility of the phenomenon's realization in the case where external shocks are sufficiently large. The benchmark result confirmed our expectation.

While the benchmark model does not account for the total consumption volatility in perfect, the model successfully produces total consumption fluctuation clearly larger than GDP fluctuation. This result should not be interpreted in a way that the mechanism of the consumption smoothing does not exist in our model. The consumption-smoothing mechanism certainly exists in our model, but the extremely volatile external shocks and the debt constraint prevents the mechanism from producing consumption fluctuation smaller than GDP fluctuation.

In section 2 we considered three sources of large consumption fluctuation – debt constraints, P^M shocks (TOT shocks), and aid shocks. It was "theoretically" possible that these elements raise relative SD(C) through rises of import-good consumption volatility. In the subsequent parts of this section, we will "quantitatively" examine how strongly these elements amplify the consumption fluctuation.

5.2 Influences of a Debt Constraint

In this subsection we analyze the influence of a debt constrain on total consumption fluctuation. In our model's case, the adjustment cost on foreign debt is a type of a debt constraint. The tightness of the debt constraint is controlled by a parameter μ; when μ is large, the agent cannot borrow sufficiently. In the benchmark analysis we set μ to 100, adjusting the standard deviation of the trade balance. By changing the value of the parameter, we change the tightness of the debt constraint and observe changes in the total consumption fluctuation in response to the change in the parameter values. Through these experiments, we analyze the influence of the debt constraint on the total consumption fluctuation.

When we evaluate the tightness of the debt constraint, we will adopt the concept of marginal cost of borrowing, and we compare the cost with real-base LIBOR. LIBOR is one of the prevalent indices of international interest rates. We evaluate the marginal cost of borrowing, in terms of ratio to the LIBOR. The details on the calculation of the borrowing's marginal costs are given in Appendix D.

We exercised our experiments on the debt constraint, employing three different values of μ; 0, 1, and 100. The results are displayed in Table 5.

TABLE 5

The case of "μ = 100" of the table corresponds to the benchmark case. In a column of "DC1", the results corresponding to "μ = 0" are exhibited. Under the parameter value, the ratio of the marginal cost of borrowing to LIBOR is closed to unity (1.090), which implies the marginal cost is approximately equal to the LIBOR. In this case the model economy is able to borrow under the same condition as industrial countries. relative SD(C) of the case is rather small (0.608). The reason why relative SD(C) in "DC1" is smaller than in the benchmark case is straightforward; the mechanism of consumption smoothing works. In the benchmark case, due to high marginal cost in borrowing, the agent cannot borrow sufficiently from the international market, and the consumption is not smoothed well. By contrast, in "DC1", thanks to the reasonable marginal borrowing cost, the agent is able to borrow sufficiently, and the mechanism of consumption smoothing works well. The column of "DC2" is corresponding to the case of "μ = 1." In this case the marginal cost of borrowing is approximately twice as high as LIBOR

(1.960). relative SD(C) of the case (1.216) is not greatly different from that of the benchmark case (1.252) where the marginal cost of borrowing is extremely high. And in this case relative SD(C) is doubled, compared to the case of " $\mu = 0$." In addition, in DC2's case, SD(C) surpasses SD(GDP). From these observations, we can state that the debt constraint is very influential on the consumption volatility.

5.3 Impacts of External Shocks

In section 2 we confirmed that TOT fluctuation (P^M fluctuation) is by far larger in low income countries than in industrial G7 countries. In this subsection we investigate the impacts of external shocks.

First, we take a look at the influence of "P^M shocks" on consumption fluctuations. Before exercising our experiments, let us see how we will control magnitudes of P^M shocks. From the shock generating process of P^M shocks, we can derive the following equation.

$$SD(e^{PM}) = \left[1-(R_{44})^2\right]\cdot\left[RSD(P^M)\cdot SD(GDP)\right]^2, \qquad (12)$$

where R_{44} stands for the fourth-row forth-column element of the matrix R.

Suppose that we substitute Kenya's SD(GDP) and G7's average relative SD(P^M) into the above equation. By definition, we regard the derived SD(e^{PM}) as a standard deviation of e^{PM} based on G7's relative SD(P^M) fixing SD(GDP) at the level of our model economy. We denote this standard deviation of e^{PM} as SD$(e^{PM})^{G7}$. Meanwhile, the benchmark's SD(e^{PM}) is calculated from our sample low income country, Kenya. We write this benchmark index as SD$(e^{PM})^{Kenya}$. Using SD$(e^{PM})^{G7}$ and the benchmark's SD(e^{PM}), we define SD$(e^{PM})^*$ as follows.

$$SD(e^{PM})^* = \tau^{PM}\cdot SD(e^{PM})^{Kenya} + (1-\tau^{PM})\cdot SD(e^{PM})^{G7} \qquad (13)$$

By changing τ^{PM} we control the standard deviation of e^{PM} between low income country's (Kenya's) level and G7 country's level. As τ^{PM} approaches to zero, SD$(e^{PM})^*$ approaches to SD$(e^{PM})^{G7}$.

Table 6 provides the results of our experiments in P^M shocks. As SD$(e^{PM})^*$ approaches to SD$(e^{PM})^{G7}$, relative SD(C) goes down relatively rapidly.[10] The results suggest that the excessive volatility in P^M strongly affects the consumption fluctuation.

TABLE 6

Second, we investigate how strongly "aid shocks" contribute to consumption fluctuation. Similarly to the P^M shock analysis, we control the standard deviation of e^D. The procedure of the derivation of $SD(e^D)^*$ is almost exactly the same as the one of $SD(e^{PM})^*$. In the case of $SD(e^D)^*$, instead of (12) and (13), we make use of the following equations.

$$SD(e^D)^{G7} = \left[1-(R_{33})^2\right]\cdot\left[RSD(D)^{G7}\cdot SD(GDP)^{Kenya}\right]^2 \tag{14}$$

$$SD(e^D)^* = \tau^D \cdot SD(e^D)^{Kenya} + (1-\tau^D)\cdot SD(e^D)^{G7} \tag{15}$$

Table 7 gives a summary of the experiments.[10] In the experiments relative SD(C) does not vary by a great deal, in response to the change in τ^D. This result suggests that aid shock is not strongly influential on consumption volatilities.

TABLE 7

Next, let us briefly compare effects of P^M shocks and aid shocks. In (13) and (15), we introduced parameters; τ^{PM} and τ^D. τs represent the distance between the model's economy and G7, in terms of the magnitudes of shocks. If τ^{PM} and τ^D are both set to 0.75, this setting suggests that the distance of the model economy's SD(PM) from G7's $SD(P^M)$ is 0.75 and the distance of the model economy's SD(D) from G7's SD(D) is 0.75, respectively. Even if the distances from the G7 are set to an identical level (say, 0.75), the results of relative SD(C) are distinct between the case of τ^{PM} and the case of τ^D. Relative SD(C) of "τ^{PM} = 0.75" (1.155) in Table 6 is clearly smaller than relative SD(C) of "τ^D = 0.75" (1.236) in Table 7. In short, the effect of aid shocks is clearly weaker than that of P^M shock.

6. Conclusion

In this study we examined why the low income countries' fluctuation in consumption is large. Macroeconomic theory expects the fluctuation in consumption is relatively small, because of consumption-smoothing mechanism. In fact the consumption fluctuations of the industrial G7 countries, for example, are small. On the contrary to the theory and the observation on G7 countries, the consumption fluctuations of low income countries are rather large. In this study we attempted to cast light on this puzzle.

We found that volatile import-good consumption is the direct contributor to the large fluctuation of the total consumption. Then we conjectured what produces the large consumption fluctuation, through large import-good consumption fluctuation. Then we specifically investigated the influence of the three elements on consumption volatility; debt constraints, TOT shocks (P^M shocks), and aid shocks.

Through the numerical analysis with a DSGE model, we confirmed that the influences of debt constraint and TOT shocks (P^M shocks) significantly amplify the consumption fluctuation. The numerical analysis also suggested that the aid shocks are not very influential. Nevertheless, we have to be careful in understanding this result. The result is not stating that the the aid-shock influence on consumption fluctuation is weak in "any" country. The aid influence will probably strongly depend on aid properties – aid/GDP ratio, aid volatility, and aid disbursement timing (cyclical or countercyclical). Kenya's aid properties in terms of these three aspects are not special, compared to those of the other low income countries. Hence, Kenya's aid-impact result is not a special case, and the aid impact on consumption volatility is not very strong. However, at the same time, it will not be surprising that aid greatly amplify consumption fluctuation in a country which has high aid/GDP ratio, high relative SD of aid, and positive aid-GDP correlation.

Our results on debt constraints and TOT shocks are not specific to our sample low income country (Kenya). Kenya's import/GDP ratio and TOT's cyclicality are average figures of the low income country group. The excessive TOT is also common phenomenon in those countries. From these facts, it seems reasonably safe to conclude that, in general, the influence of debt constraints and TOT shocks on consumption fluctuation is large in low income countries.

The results of this study also provide us some hints of how we can stabilize the consumption in the low income countries. First, let us consider the problem from the view of TOT shock. The volatile TOT in the low income countries is attributable to the variety of export goods. Mendoza (1995) points that the number of export goods of developing countries is small.[11] And the share of some specific goods in whole export is rather large. Export deflator is a type of weighted average of individual export good prices. If the average is calculated from the limited number of export good prices, a change in an export good price easily reflects on the export deflator. For example, in Kenya's case, export of tea occupies not a small part of the whole export. Then if tea's international price goes down, it strongly pulls down the export deflator, which automatically causes drop in TOT. From this argument, one of the ways of how we make TOT more stable is obvious; if a low income country successfully increases the variety of export goods whose prices are not positively correlated, TOT will become more stable. And the stable TOT contributes to the stability of consumption.

Second, we think of the stabilization of the consumption, from the view of the debt constraint. This study clarified that relaxation of a debt constraint also non-trivially decreases the consumption fluctuations. If a low income country can borrow in a recession, the consumption fluctuation of the country will be smoothed well. Nevertheless, in actual, private creditors might be reluctant to lend to the low income countries. In particular, when the low income countries are in a recession, the private creditors will not wish to lend, fearing defaults. In fact Neumeyer and Perri (2005) find this tendency in the case of lending to upper middle income countries. Instead of private loans, we may be able to make use of aid which is planed to be disbursed countercyclically. The idea of countercyclical aid is introduced, for example, by Pallage and Robe (2006). In our study, we saw that aid did not have significant effect on the consumption fluctuation in our sample economy where aid/GDP ratio is not extremely large. However, in the case of a country where aid/GDP ratio is rather large, it may be possible that the countercyclical aid decreases the consumption fluctuation.

In this article we revealed the source of large fluctuation in consumption of low income countries. The analysis hopefully provides us some useful hints for increasing welfare of the low income countries, through stabilization of the consumption.

Footnotes

1: With respect to "low income", we use the definition of "World Development Indicators 2007" issued by the World Bank; "Low-income economies are those in which 2005 GNI per capita was $875 or less." Our sample low income countries and sample periods are summarized in Appendix A.

2: It is known that the presence of durable goods amplifies consumption volatility. For example, see Baxter (1996).

3: As a result of the analysis our approach to the puzzle is different from Kose and Riezman (2001)'s conjecture.

4: P^M in the following sections is equal to the inverse of TOT.

5: Focusing on the volatile TOT of developing countries, Mendoza (1995), Kose and Riezman (2001), and Kose (2002) examine its influence on developing economies' GDP.

6: For example, see Pallage and Robe (2001), Bulir and Hamann (2008), and Arellano et al. (2009).

7: "Cash crops" do not necessarily mean "agricultural" products in this document. For example, if copper ores are main export goods, we regard the ore as a cash crop.

8: In the DSGE literature, Baxter and Crucini (1993) and many others adopt the adjustment cost in investments.

9: We refer to an OECD data. OECD releases the data on its website "OECD. Stat." We utilize "ODA Total excl. Debt" of the OECD database.

10: If we set τ^D to a value smaller than 0.75, then $\sum$ includes imaginary numbers. Hence we do not exercise the smallerτ's case.

11: Kose and Riezman (2001) shows that the average numbers of export goods of 22 African countries and G7. In their sample, most of the African countries are low income countries. As a result they find that the African average is 54 and the G7 average is 213. Kose (2002) compared the average of developing countries and G7 countries, where developing countries are composed of 10 low income countries, 13 lower-middle income countries, and 5 upper-middle income countries. Based on these samples, Kose (2002) shows that the developing countries' average is 113 and the G7's average is 213.

Appendix A. Sample Countries and Periods

Bangladesh	1980 - 2004	Madagascar	1975 - 2004
India	1975 - 2004	Malawi	1975 - 2004
Pakistan	1986 - 2004	Mali	1975 - 2004
Benin	1975 - 2004	Mozambique	1993 - 2004
Burkina Faso	1975 - 2003	Niger	1975 - 1999
Burundi	1976 - 1993	Nigeria	1975 - 2004
Cameroon	1975 - 2004	Rwanda	1975 - 1990
Chad	1991 - 2001	Senegal	1975 - 2004
Comoros	1980 - 2004	Sierra Leone	1980 - 1991
Cote d'Ivoire	1975 - 2004	Somalia	1975 - 1989
Ethiopia	1981 - 1998	Sudan	1976 - 1983
Ghana	1975 - 2003	Tanzania	1988 - 2004
Guinea	1986 - 2004	Togo	1975 - 2004
Guinea-Bissau	1980 - 1997	Uganda	1986 - 2004
Kenya	1975 - 2004	Zambia	1975 - 2004
Lesotho	1975 - 2004	Zimbabwe	1980 - 2004

The sample periods depend on the data availabilities and “war” periods; referring to Gleditsch et al. (2002) and other documents, we specified war periods and excluded the data during the war periods.

Appendix B. Adjustment of standard deviations

For the explanation, we take "tradable-sector value added" as an example. Because of statistical discrepancies expenditure-base GDP (GDP^{EX}) and value-added-base GDP (GDP^{VA}) do not match. As a result, naturally, $SD(GDP^{EX})$ and $SD(GDP^{VA})$ do not match, where SD stands for standard deviations. Meanwhile, we wish to compare $SD(GDP^{EX})$ and $SD(y^{VT})$, where y^{VT} is a value added in the tradable sector and it is a component of GDP^{VA}. For the comparison, we adjust $SD(y^{VT})$.

Using the value-added GDP database, we calculate standard deviations of y^{VT} and GDP^{VA}. Now, we assume that the ratio of $SD(y^{VT})/SD(GDP^{VA})$ is accurate. Let $SD(y^{VT*})$ represent "the value of tradable-sector value added's standard deviation in the case where the GDP's standard deviation is $SD(GDP^{EX})$." Then $SD(y^{VT*})$ is derived by multiplying $SD(GDP^{EX})$ with the "accurate ratio";

$$SD(y^{VT*}) = SD(GDP^{EX})[SD(y^{VT}) / SD(GDP^{VA})].$$

Similarly, $SD(y^{VN*})$ and SD(CM**) are derived.

$$SD(y^{VN*}) = SD(GDP^{EX})[SD(y^{VN}) / SD(GDP^{VA})].$$

$$SD(C^{M**}) = SD(M)[SD(C^{M*}) / SD(M^{*})].$$

Appendix C. Derivation of sector value added

We postulate that tradable (export) goods are so called “cash crops” (which do not have to be agricultural products), and we postulate that the produced tradable goods are all exported. If we know individual export-good value added, by aggregating them we can derive tradable (export) good’s value added. However, we do not have data of the individual export-good value added. So we derive tradable-good value added (y^{VT}) as follows.

For the explanation, suppose that tea is a sole export good in an agricultural sector and copper and zinc are two export goods in a mining sector. And there is not any other export good in the target country. Then the following equations hold.

$$
\begin{aligned}
y^{VT} &= (\text{tea's value added}) + (\text{copper and zinc's value added}) \\
&= \left(\frac{\text{tea's value added}}{\text{total value added in agricultural sector}}\right) \times \text{total value added in the agricultural sector} \\
&\quad + \left(\frac{\text{copper's and zinc's value added}}{\text{total value added in mining sector}}\right) \times \text{total value added in the mining sector}
\end{aligned}
$$

Now we generalize this example. By generalizing the equation above we write the subsequent equation.

$$
y^{VT} = \sum_j \left[\left(\frac{\text{export good value added in sector j}}{\text{total value added in sector j}}\right) \times \text{total value added in sector j}\right]
$$

$$
\text{where j} = \text{agriculture, mining, manufacturing, construction, and service}
$$

Here, in fact, we do not have a data of the value-added ratio in this equation. Meanwhile, instead of “value-added” ratios, we can obtain “output” ratios, from an input-output table. Assuming that the difference between output ratio and value-added ratio is small, we rewrite the above equation as,

$$
y^{VT} = \sum_j \left[\left(\frac{\text{export good output in sector j}}{\text{total output in sector j}}\right) \times \text{total value added in sector j}\right]
$$

$$
\text{where j} = \text{agriculture, mining, manufacturing, construction, and service}
$$

We employ this equation for derivation of y^{VT}. And we derive y^{VN} as,
$y^{VN} = GDP - y^{VT}$.

Appendix D. Marginal cost of borrowing

If our model economy's debt outstanding (B_t) deviates from its steady state ($\overline{B}$), to the same extent as the actual data of the United States, then how much is the marginal cost of borrowing in the model? In this appendix we show the calculating procedure of the marginal cost. The adjustment cost of borrowing depends on the extent of this deviation. Here, a mean of "B_t - $\overline{B}$" in the data is zero since $\overline{B}$ is set to a mean of B_t. This fact suggests that the amount of "B_t - $\overline{B}$" in the case where B_t - $\overline{B}$ > 0 and the amount of "B_t - $\overline{B}$" in the case where B_t - $\overline{B}$ < 0, on average, balance. In this Appendix, first, we calculate how much B_t - $\overline{B}$ deviates from zero on average when B_t - $\overline{B}$ is positive. Second, based on the first step's result, we calculate the marginal cost of borrowing.

Let b represent the following index;

$$b = \frac{1}{S}\sum_{s}^{S}[(B_s - \overline{B})/\overline{GDP}], \quad s \in \{t | B_t - \overline{B} > 0\}$$

Now, using the model economy's GDP (GDP^{model}) and b calculated from the United States data, we rephrase our objective in this Appendix D; we calculate the marginal cost of borrowing in our model economy, when the agent of the model borrows B_t^*,

$$B_t^* = \overline{B}^{model} + b \times GDP^{model} .$$

By a simple calculation, the marginal cost of borrowing (MCB) is given as,

$$MCB = r + \mu(B_t - \overline{B}) .$$

In the case where $B_t = B_t^*$, MCB is written as,

$$MCB = r + \mu \cdot b \cdot GDP^{model} .$$

This result implies the subsequent fact; when its current debt outstanding is B_t^*, if the agent increases its debt outstanding by one additional unit, then the agent requires paying more by MCB units for the one additional unit of borrowing. In percent representation, it is written as, $\frac{MCB}{1} \times 100\ (\%)$, where denominator corresponds to "one" additional unit of borrowing. In the body text, we compare this MCB with real-base LIBOR.

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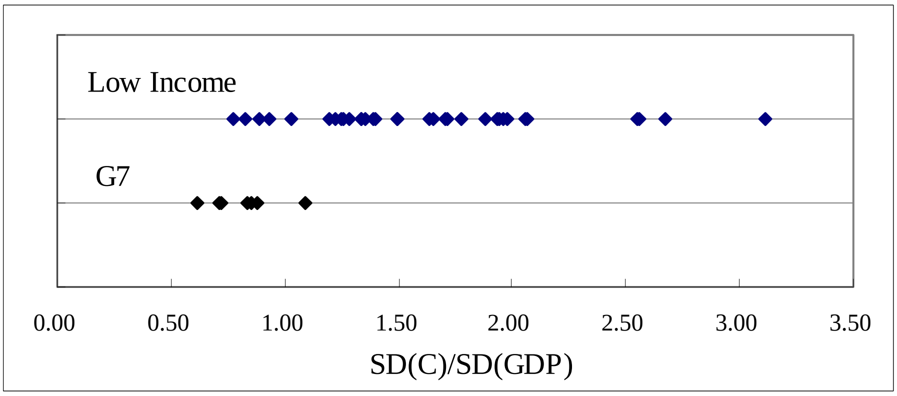
FIGURE 1



・SD in the figure refers to standard deviation.

TABLE 1

Standard Deviations of Selected Kenyan Indices

		GDP	C	M	M^*	C^{M*}	C^{M**}
Benin	SD (%)	3.08	4.60	11.50	12.88	17.80	15.90
1985-2001	Relative SD	1.00	1.49	3.73	4.18	5.78	5.16
Cameroon	SD (%)	6.54	8.37	13.47	20.73	31.75	20.63
1979-2004	Relative SD	1.00	1.28	2.06	3.17	4.86	3.16
Congo	SD (%)	7.16	9.70	13.37	20.72	43.16	27.86
1984-2004	Relative SD	1.00	1.36	1.87	2.89	6.03	3.89
Guinea	SD (%)	1.84	2.46	5.50	11.06	26.51	13.19
1986-2004	Relative SD	1.00	1.34	3.00	6.02	14.45	7.18
Kenya	SD (%)	2.50	5.16	13.05	15.82	31.00	25.57
1975-2004	Relative SD	1.00	2.06	5.22	6.33	12.40	10.23
Malawi	SD (%)	4.48	7.94	12.15	15.23	28.52	22.75
1985-2004	Relative SD	1.00	1.77	2.71	3.40	6.37	5.08
Mali	SD (%)	4.48	4.60	7.90	11.33	12.55	8.76
1984-2001	Relative SD	1.00	1.03	1.77	2.53	2.80	1.96
Mozambique	SD (%)	3.08	5.97	13.91	19.00	19.43	14.23
1994-2004	Relative SD	1.00	1.94	4.52	6.18	6.32	4.63
Togo	SD (%)	6.02	9.97	20.49	22.12	26.53	24.57
1982-1998	Relative SD	1.00	1.65	3.40	3.67	4.40	4.08
Zambia	SD (%)	3.19	9.96	7.28	13.32	39.47	21.59
1994-2003	Relative SD	1.00	3.12	2.28	4.17	12.35	6.76

・Variables without '*' refer to GDP-expenditure-base data.

・Variables with '*' refer to merchandise-trade-base data

・ C^{M**} indices are adjusted C^{M*} indices so that C^{M**} indices are comparable with GDP-expenditure-base indices. For the details of the adjustment, see Appendix B.

TABLE 2

Magnitudes of External shocks

	G7 Countries			Low Income Countries		
	GDP	PM	D	GDP	PM	D
SD (%)	1.88	3.58	NA	4.25	13.28	24.39
RSD	1.00	1.60	NA	1.00	3.79	5.85

TABLE 3

Benchmark Parameters

Utility

β	γ	ω^{C}	ρ^{C}
0.960	2.610	0.581	-0.850

Production

α^{T1}	α^{T2}	α^{N}	$\omega^{YT} = \omega^{YN}$	$\rho^{YT} = \rho^{YN}$
0.370	0.180	0.660	0.879	-0.100

Investment and Debt Constraint

$\delta^{T} = \delta^{N}$	$\varphi^{T} = \varphi^{N}$	$\omega^{IT} = \omega^{IN}$	$\rho^{IT} = \rho^{IN}$	μ
0.050	0.800	0.686	0.010	100

Exogenous Shocks

$\overline{A}^{T}$	$\overline{A}^{N}$	$\overline{D}$	$\overline{P}^{M}$
1.000	1.224	0.052	1.000

Matrix R

0.400	0	0	0
0	0.400	0	0
0	0	0.497	0
0	0	0	0.598

Matrix Σ ($\times 10^{-2}$)

0.010	0.017	0.116	-0.017
0.017	0.060	-0.016	-0.125
0.116	-0.016	4.487	0.708
-0.017	-0.125	0.708	0.719

TABLE 4：Benchmark Case Results

Steady State Values (Ratios to GDP)

	GDP	y^{VT}	y^{VN}	C	I	X	M	D
Data	1.000	0.202	0.798	0.844	0.165	0.222	0.231	0.043
Model	1.000	0.212	0.788	0.842	0.167	0.235	0.244	0.043

Other Steady State Values

	$y^{VT}/Y^{T} = y^{VN}/Y^{N}$	X/M	C^M/C	$(I^{MT}+I^{MN}) / (I^{NT}+I^{NN})$	$\overline{P}^{N}$
Data	0.904	0.963	0.101	0.458	-
Model	0.904	0.961	0.101	0.461	1.000

Standard Deviations

		GDP	y^{VT}	y^{VN}	C	C^M	I	TB	D	P^M
Data	SD (%)	2.510	3.650	2.340	4.590	0.255	14.410	13.560	24.119	10.580
	Relative SD	1.000	1.454	0.932	1.829	0.102	5.741	5.402	9.609	4.215
Model	SD (%)	2.424	4.595	2.405	3.034	0.248	14.503	9.129	24.119	10.541
	Relative SD	1.000	1.896	0.992	1.252	0.102	5.984	3.766	9.951	4.349

Correlation to GDP

	GDP	y^{VT}	y^{VN}	C	C^M	I	TB	D	P^M
Data	1.000	0.910	0.980	0.640	0.460	0.560	-0.370	0.080	-0.450
Model	1.000	0.682	0.925	0.794	0.537	0.783	-0.661	0.014	-0.603

・”Data” indices are calculated from real local-currency-unit base SNA data, except C^M, and D. C^M and D are calculated from merchandise-trade base statistics and OECD database statistics, respectively.

・TB refers to a ratio of export/import.

・Derivation of CM’s indices is explained in Section 2.

・Derivation of ys’ indices is explained in Appendix B.

TABLE 5

Debt Constraint

	Data	Benchmark	DC1	DC2
μ	–	100	0	1
MCB/LIBOR	–	90.360	1.090	1.960
Relative SD(C)	1.829	1.252	0.608	1.216

*MCB represents Marginal Cost of Borrowing

TABLE 6

Change in Import Price Shocks

	Data	Benchmark	PM1	PM2
τ^{PM}	–	1.00	0.75	0.50
Relative SD(P^M)	4.215	4.349	3.773	3.187
Relative SD(C)	1.829	1.252	1.155	1.059

• Relative SD refers to standard deviations relative to GDP standard deviations.

TABLE 7

Change in Aid Shocks

	Data	Benchmark	Aid1
τ^{D}	–	1.00	0.75
Relative SD(Aid)	9.609	9.951	7.449
Relative SD(C)	1.829	1.252	1.236