The volatility of consumption and output with increasing industrialization

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16 October 2010

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August 2011

Abstract

Consumption is more volatile than output in developing countries while it is less volatile than output in developed economies. This paper shows that the relatively large home sector in developing economies contributes to this difference, and the driving force for this difference is technology. Thus this paper suggests that volatile market consumption is almost inevitable at the start of industrialization, when the technology level in the market sector is just above that of the home sector.

1 Introduction

In the business cycle literature, the notion that consumption is generally less volatile than output, is commonly known and widely accepted. Implied by the theory of consumption smoothing and supported by the data, less volatile consumption relative to output seems commonsense.

This rule, however, is not universally observed in the data. For many developing countries, such as Argentina, Brazil, Mexico, and South Africa, consumption is more volatile than output. Recently, this fact has been noticed and the related literature is growing. For example, Garcia-Cicco et al. (2009) calculate the ratio of the volatility of consumption to that of output for Argentina, $1900 - 2005$, to be 1.4; Aguiar and Gopinath (2007) find the same ratio to be 2.01 for Brazil and 1.24 for Mexico, and the average for developing countries is 1.45. The former attributes the relatively greater volatility of consumption in developing countries to preference shocks, but do not investigate the corresponding impact of the same shocks on developed countries. It cannot be argued that preference shocks cause the greater volatility of consumption relative to output in developing countries without first checking whether the same shocks cause the same or different effects in developed countries. Insofar as the effects are the same, the difference in relative volatilities remains unexplained. Insofar as they are different, and of the right size and direction, there may be an explanation, at least to some degree. The same methodology must hold for any factor proposed as a potential cause of the difference in relative volatilities, for example, productivity, literacy or mortality, and a check of the effects on each block, developing and developed, must be undertaken to establish potential causation.

Aguiar and Gopinath (2007) adopt the right methodology but concentrate on technology shocks. In their view, technology shocks are trend-growth related in developing countries, but transitory fluctuations around a stable trend for developed economies. When there is a shock on an economy, the representative agent in developed countries

will not adjust consumption much because the agent knows that the shock is not permanent, with the expectation that output will return to the long-run trend. By contrast, in developing counties, the agent will adjust consumption accordingly because the shock implies a permanent change in output.

This paper seeks to explain the difference in consumption volatility across economies in general, and between developed and developing economies in particular, by first asking a fundamental question: What is the principal difference between a developed and a developing economy, and how is such difference reflected in the data of each? The principal difference is that a developed economy, which is generally in an advanced stage of industrialization, encompasses a proportionally greater market sector, while a developing economy has a proportionally greater non-market or home sector. Moreover, the available data for consumption and output generally concentrate on market activity, the home sector being ignored to a large extent. Indeed, the home sector is evidently an important component of total output, whether on the household level or the aggregate level. For example, the U.S. time-use survey indicates that market work and home work constitute 33 and 25 percent of discretionary time for a typical household. On the aggregate level, Eisner (1988) suggests that household production is between 20 to 50 percent of GNP; more recently, Blankenau and Kose (2007) argue that this ratio is 40 to 50 percent for most industrialized economies. For its importance on data, more recently, Gomme and Rupert (2007) argue that

> "For the purposes of calibration and measurement, it is useful to include a home production sector even if the specific questions being studied do not explicitly call for a home sector."

The main objective of this paper is to investigate whether the difference in consumption volatility across countries can be explained by the difference in the relative importance of home sectors. The intuition is straightforward: the home sector in developing countries is considered to constitute a bigger share in total output than in developed e-

conomies. Aggregate consumption, which includes both market produced and home produced goods, may not be as volatile in developing countries as the data suggest.

The main work concentrates on finding key differences across countries that can affect relative volatility. The various factors taken into consideration here include differences in preferences, international linkages and technology. The difference in preferences is represented by the share of market consumption in total consumption and the elasticity of substitution between market goods and home produced goods. Sensitivity analysis shows that the effect of preferences on consumption volatility is ambiguous: the relationship between the volatility of market consumption and preferences is nonlinear. When the share of market consumption or the elasticity of substitution increases, the volatility of market consumption first increases and then decreases. This suggests that consumption tends to be volatile within the moderate range, not at the extremes.

Another notable difference between the developing and developed countries is the degree of international financial integration. Developed economies have access to world financial markets with fewer constraints and smaller costs, either because of more reliable financial systems or because of the large number of financial products available. Extensively discussed, the relationship between financial markets and macroeconomic volatility is still ambiguous. Mendoza (1994) finds that changes in the volatility of consumption and output are negligible in response to changes of financial openness. Baxter and Crucini (1995) find that financial integration increases the volatility of output while decreasing the volatility of consumption. Gavin et al. (1996) study the sources of macroeconomic volatility in developing countries over the period $1970 - 92$, and find that there is a significant positive association between the volatility of capital flows and output volatility.

This paper contributes to this debate by investigating the relationship between financial integration and consumption's relative volatility. The degree of financial integration is modeled as the ease with which a country's foreign assets may be adjusted through lending or borrowing. The paper shows that, relative consumption volatility decreases

monotonically with international financial integration. This result is consistent with conventional wisdom that financial markets help to smooth consumption through lending or borrowing.

One of the most salient differences between developed and developing countries is the disparity in total factor productivity, that is the market sector's productivity relative to the home sector. Since factors of production, like capital and labor, will flow to the sector that offers the greatest return (expressed in terms of utility), it is relative productivity, not absolute productivity, in the market and home sectors that determines the allocation of factors of production. It is generally believed that the productivity discrepancy between the two sectors is larger in the developed economies, for two reasons. First, one characteristic of developed economies is economies of scale, which typically occurs in the advanced stage of the process of industrialization. Developing countries lag behind in this process. Second and more important, developed economies characteristically invest more funds in research and development, the primary source of production enhancement. Even when measured as a percentage of GDP, the top eight countries are all from the developed group. [1]

Not only is the discrepancy in productivity levels different across countries, the technology transmission between sectors is also not the same. It is assumed that technology can only be transmitted from a more advanced sector to less advanced sectors, namely from the market sector to the home sector in this paper. For developed economies, advanced technology and sophisticated equipment are common in the market sector, and such equipment is virtually unattainable for households. Thus even when there is technological innovation in the market sector, it is difficult to adopt such innovation in the home sector. For developing economies, where domestic workshops are common, the situation is different; technological innovation in one sector will be applicable to the other sector. The paper shows that, the less productive the market sector is relative to the home sector,

[1] According to OECD, the top eight are Israel (4.53%), Sweden (3.73%), Finland (3.45%) Japan (3.39%), South Korea (3.23%), Switzerland (2.9%), Iceland (2.78%) and the United States (2.62%).

and the stronger the transmission effect, the more volatile market consumption(relative to market output) will become. Moreover, the volatility of market consumption varies to a greater extent with technology than with preferences and the international linkage; further changes to production are the only way to generate more volatile consumption, which implies that technology is the driving force for excess volatile consumption in many developing countries.

The structure of the paper is as follows. The next section, Section 2 sets up a two sector model; Section 3 calibrates the parameters and provides the simulation results for the benchmark economy; Section 4 undertakes sensitivity analysis, in which differences in preferences, production and the international linkage are presented and their effects on the volatility of consumption are analyzed. Section 5 summarizes the conclusions of this paper.

2 The Economic Environment

2.1 Preferences

In a small open economy, the infinitely lived representative agent derives utility from streams of a composite good c_t, and disutility from working n_t. The agent's preferences are summarized by:

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

$$\theta_0 = 1 \tag{2}$$

$$\theta_{t+1} = \beta[U(c_t, n_t)]\theta_t \tag{3}$$

where θ_t is the endogenous discount factor, β is a function of past utility with the restriction that its first-order derivatives are negative, $\beta' < 0$. [2] This restriction implies that the

[2]The endogenous discount factor is to overcome the indeterminacy problem, see Mendoza (1991) and Schmitt-Grohe and Uribe (2003) for details.

more people consume, the less patient they become. Any increase in current consumption reduces the subjective discount weight of all future periods.

In the small open economy literature, the functional form for preferences receives particular attention. The standard form for utility generally fails to produce a counter-cyclical trade balance, one of the stylized facts for open economies. The GHH utility, first proposed by Greenwood et al. (1988), performs better and is widely adopted in open economy models. Moreover, Chapter 1 shows that, in a two sector model, standard preferences lead to macroeconomic volatility, especially for consumption. For the purpose of concentrating on consumption volatility in this paper, the GHH form is preferred. GHH preferences have the form

$$u(c_t, n_t) = \frac{[c_t - \mu \frac{n_t^{\omega}}{\omega}]^{1-\gamma}}{1-\gamma} \tag{4}$$

in which aggregate consumption c_t consists of market goods c_t^m and home-produced goods c_t^h, and

$$c_t = [\pi (c_t^m)^{\frac{\rho-1}{\rho}} + (1-\pi)(c_t^h)^{\frac{\rho-1}{\rho}}]^{\frac{\rho}{\rho-1}} \tag{5}$$

n_t in equation (4) is the sum of working time in the market sector n_t^m, and the home sector n_t^h:

$$n_t = n_t^m + n_t^h \tag{6}$$

Finally μ in equation (4) is the weight in preferences on labor supply, ω is the elasticity of labor supply, and γ denotes risk aversion. In equation (5), π is the weight given to market consumption, and ρ is the elasticity of substitution between market produced goods and home made goods. Accordingly, the functional form of β is

$$\beta(c_t, n_t) = (1 + c_t - \mu \frac{n_t^{\omega}}{\omega})^{-b} \tag{7}$$

where b is the elasticity of discount factor.

2.2 Technology and investment

The production function for each sector has the standard form:

$$y_t^i = exp^{z_t^i}(k_t^i)^{\alpha^i}(n_t^i)^{1-\alpha^i}, \quad i = m, h \tag{8}$$

where in sector i, k_t^i is the capital stock, n_t^i is the labor supply, α^i is capital share in output and z_t^i is the sector specific technology shock with mean $\bar{z}^i$.

Let z_t be the 2×1 vector $[z_t^m, z_t^h]'$ with mean $\bar{z}$. Productivity shocks evolve according to,

$$z_t = \nu * z_{t-1} + (\mathcal{I} - \nu) * \bar{z} + \epsilon_t, \tag{9}$$

where $\mathcal{I}$ stands for the identity matrix, and $\epsilon_t = [\epsilon_t^m, \epsilon_t^h]'$ denotes the error terms with correlation coefficient $\xi = corr(\epsilon_t^m, \epsilon_t^h)$. The matrix ν is of the form,

$$\nu = \begin{bmatrix} \rho_{mm} & \rho_{mh} \\ \rho_{hm} & \rho_{hh} \end{bmatrix}$$

where diagonal elements ρ_{ii} denote the technology persistence, off-diagonal elements ρ_{ij} stand for the technology spill over from sector j to sector i.

The law of motion for capital in sector i is

$$k_{t+1}^i = (1 - \delta^i)k_t^i + x_t^i, \tag{10}$$

where for sector i, δ^i is the capital depreciation rate, and x_t^i is investment. As is common in the home production literature, it is assumed that home made products are used only for consumption. Thus investment can be formed only from market sector products. It is also assumed that a cost occurs to capital adjustment: the more rapid adjustment, the greater this cost. Capital adjustment cost is modeled as $\frac{\phi^i}{2}(k_{t+1}^i - k_t^i)^2$, and ϕ^i is the the capital adjustment cost parameter.

2.3 Linkage to international markets

In this small open economy, the representative consumer can export goods to accumulate foreign asset holdings, or import goods to finance domestic spending, with the restriction that only market sector goods can be exported or imported. Together with the condition that home produced goods can not be invested, this implies

$$y_t^h = c_t^h. \tag{11}$$

It is further assumed that whenever borrowing or lending, this consumer faces a fixed international interest rate r^*. Let tb_t denote the trade balance in period t, and d_t stand for the foreign asset (or debt) holdings, then

$$d_{t+1} = (1 + r^*)d_t + tb_t. \tag{12}$$

Since the ease of lending and borrowing reflects the degree of financial integration, it is appropriate to employ a cost, which depends on the amount of borrowing or lending, to represent the financial openness of a country. Specifically, this borrowing or lending cost is approximated as a quadratic function of trade balance, $\frac{\tau}{2}tb^2$. Backus et al. (1992) call this cost a trading cost. Whereas tb_t is the net of exports and imports, this term $\frac{\tau}{2}tb^2$ is called a financial friction in this paper.

Accordingly, the resource constraint for the market sector is,

$$c_t^m + d_{t+1} + x_t^m + x_t^h = y_t^m + (1 + r^*)d_t - \frac{\tau}{2}tb_t^2 - \frac{\phi^m}{2}(k_{t+1}^m - k_t^m)^2 - \frac{\phi^h}{2}(k_{t+1}^h - k_t^h)^2. \tag{13}$$

Finally, neither the home country nor the foreign country can play a Ponzi-game, which implies:

$$lim_{T\to\infty}(1 + r)^{-T}d_{t+T} = 0. \tag{14}$$

3 Calibration and Simulation

As stated in the introduction, the methodology of this paper concentrates on the differences between developed and developing countries, to identify the factors which explain consumption volatility. There is, however, no unanimous agreement on how to categorize a country as either developed or developing. Even in the same group, the level of development may vary widely. Therefore the difference across groups might become less apparent if averaged by groups. For this reason, it is, perhaps, more illustrative to focus on two countries, one representing the developed group and the other representing the developing group, than to average data from each of the groups. For data convenience and convention, Canada and Mexico, two typical small open economies, are chosen to represent each group respectively.[3]

For the market sector in Canada, the share of labor income is calculated to be 68% from the year 1961 to 2008. Accordingly, the capital share in production, α^m, is set to be 32%. For Mexico, since there is no income based GDP data available, this number is also set as 32%. For the home sector, the data is scant for both countries. It is assumed that the home sector is more labor intensive, so labor share lies in the range $[.68, 1.00]$. In particular, the labor shares in the home sector for both countries are set as 86%, the middle value of this range, and this suggests that the capital share in home sector is 14%. This value is also adopted in Ingram et al. (2007).

Capital depreciation rates in the market sectors, δ^m, are calculated to be 2.2% for Canada (see Chapter 1), and 2% for Mexico (see Garcia-Cicco et al. (2009)). Since capital formation in the home sector comes from the market sector, it is assumed that $\delta^m = \delta^h$ for simplicity. This symmetric treatment also applies to the capital adjustment cost parameters, ϕ^m and ϕ^h, which are assumed to be equal, and their magnitude is calibrated to match with the volatility of market investment.

For the share of market sector goods in total consumption, π, and the elasticity of

[3]Data source: Statistics Canada & OECD.

substitution between the two goods, ρ, there are no available measurement. Various papers estimate that the share is around 40%, while the elasticity is 2 for the United States (Ingram et al. (2007); Blankenau and Kose (2007)). Canada and United States are both developed countries, and the two countries share many common consumption habits, therefore it is reasonable to use the same number for Canada. For Mexico, the market share in consumption is intuitively smaller. For developing countries, market goods are not prevalent, and the relative price is high. Nevertheless, it is set to be the same as in Canada for the benchmark economy, and sensitivity analysis on these two parameters will be conducted in the following section.

As in most papers in the related literature, the international real interest rate, r^*, is set to be 1 percent, suggesting that β in steady state is 0.99. The parameter ω is set at 1.6, implying that the labor supply elasticity $1/(\omega - 1) = 1.7$. The two parameters, μ and b are jointly determined to meet two ratios: the fraction of time spent working, and the trade balance to GDP. For time spent working, this is set as 61%, the same for both countries, in which 33% goes to the market sector and 28% is spent in the home sector (see Benhabib et al. (1991)). For the trade balance ratio, the number is calculated to be 1.6% for Canada and 1.25% for Mexico. The risk aversion parameter, γ, is widely regarded to lie in the range of 1 to 2, and it is set to be 1.5, the middle value of this range.

For τ, the financial friction parameter, this is chosen so that the marginal cost τtb is 0.58 percent of GDP as in Backus et al. (1992). This implies that $\tau = \frac{0.58\%}{tb/GDP}$. As mentioned earlier, since this parameter represents one key difference across countries, a reasonable guess is that it indeed varies from country to country.

To estimate the matrix V describing the technological process, the first step is to find the Solow residuals in the two sectors. Solow residuals in the market sectors can be obtained with the available series of output, capital and hours worked. The Solow residual in the home sector, however, is virtually impossible to compute for lack of data, especially for home hours. Three approaches have been proposed to overcome this problem. The

first is to estimate the parameters in an $AR(1)$ process of the Solow residuals by maximum likelihood to match with moments in the data as proposed by McGrattan et al. (1997). The second is to recover output, the capital stock and hours worked in the home sector from the first order conditions of the model, and then compute the Solow residual, as was originated by Ingram et al. (2007). The third approach is to assume the shock in the home sector has the same process as that of the market sector as in Gomme et al. (2001). For simplicity, this paper adopts the third approach. Thus, the diagonal elements in matrix V are identical, $\rho_{mm} = \rho_{hh}$.

For the off-diagonal elements, ρ_{mh} and ρ_{hm}, it is assumed that the technology spill over effect is asymmetric: technology can only spill from more advanced sectors to less advanced sectors. The market sector is relatively efficient by assumption, and therefore there is no spill over from home sector, implying that $\rho_{mh} = 0$. In contrast, ρ_{hm} represents the spill over effect from the market sector to the home sector, and is assumed to be positive. It is further assumed that spill overs are only partial, implying that ρ_{hm} is within the range $[0, 1.0]$. The value of this parameter is to set to match with the consumption volatility ratio in the market sector. For Mexico, this value is 0.90, and for Canada it is 0.52. It is worth noting that the spill over effect may vary across countries. It is easier for technology to spill to sectors with similar levels of development, or TFP. In particular, if the gap between the market sector and the home sector is big, this effect will be limited. Another reason for the stronger transmission effect in emerging countries is the lack of patent protection. Therefore in emerging economies, it is less costly to adopt the new technology, which typically developed in the advanced sector. [4] For this reason, ρ_{hm} is of particular interest in the sensitivity analysis. $\xi = corr(\epsilon^m, \epsilon^h)$, and its value is set at 0.6, as suggested by Blankenau and Kose (2007).

The last parameter to be set is the technology level in both sectors, $\bar{z}^m$, and $\bar{z}^h$. By

[4]The transmission effect discussed here should be described as *effective transmission* rather than *potential transmission*. When the technology discrepancy is big, the available transmission may be potentially large but the effect is limited because it may need adjustment for other production factors such as capital and labor. That is, it is easier for a sector to assimilate technology from similar sectors.

normalizing $\bar{z}^h = 1$, $\bar{z}^m$ represents the relative technology advantage in the market sector. The relative technology advantage varies across countries. For extremely underdeveloped economies, where family workshops are being transformed to factories in the early stage of industrialization, it is expected that relative technology is just above unity. With the development of technology and the expansion of markets, which are characteristic of further industrialization, established factories or firms may have additional economies of scale and the technology advantage will grow. Therefore, it seems plausible that the relative technology advantage is bigger in developed economies. [5] Although it is not possible to obtain an exact value to conduct the simulation in the benchmark model, the market sector is set to be three times as productive as the home sector for Canada, and 1.5 times for Mexico. These values imply that $\bar{z_m} = 1.1$ for Canada and $\bar{z_m} = 0.4$ for Mexico. The relative technology advantage is perceived to represent one of the major differences between developed and developing countries, and so it is necessary to perform sensitivity analysis in the following section.

Table 1: Relative Volatility

Country	Data: $\frac{\sigma_{cm}}{\sigma_{ym}}$	Model: $\frac{\sigma_{cm}}{\sigma_{ym}}$	Model: $\frac{\sigma_c}{\sigma_y}$
Canada	0.67	0.67	0.59
Mexico	1.21	1.21	0.97

The parameter values are summarized in Table 2. With the parameters set in the benchmark economy, the ratio of market consumption volatility to market output volatility, $\frac{\sigma_c}{\sigma_{ym}}$ is 0.53 for Canada, less than the corresponding ratio in the data which is 0.67. For Mexico, this ratio is 0.803, which is also less than in the data at 1.21, as shown in Table 1. Nevertheless, the benchmark model generates higher relative volatility in market

[5] Gollin et al. (2002) examined data for the 1960-90 period for 62 countries and found that the share of employment in agriculture is negatively correlated with the relative technology advantage. The share of agriculture employment in Mexico is bigger than that in Canada. Agriculture is an analogue to home sector at the start of industrialization, thus Gollin et al. (2002)'s result support the claim that $\bar{z_m}$ is greater in Canada.

consumption in Mexico, which suggests that adding home sector in the model is in the right direction to explain the puzzle. It is worthy noting that the *aggregate consumption* is less volatile than *aggregate output* in the model, although the market consumption is more volatile than market output in the data.

Table 2: Calibration Summary

Parameter	Description	Canada	Mexico
ω	labor supply elasticity	1.60	1.60
μ	adjustment parameter of labor supply	0.99	0.99
γ	measure of risk aversion	1.5	1.5
$r^\star$	risk free international interest rate	0.01	0.01
π	share of market goods in consumption	0.40	0.40
ρ	elasticity of substitution between c^m and c^h	2	2
α^m	capital share in market production	0.32	0.32
α^h	capital share in home production	0.14	0.14
δ^m, δ^h	capital depreciation	0.02	0.02
τ	Financial friction parameter	0.36	0.46
ν	matrix of technological spill over	$\begin{bmatrix} 0.97 & 0.00 \\ 0.00 & 0.97 \end{bmatrix}$	$\begin{bmatrix} 0.95 & 0.00 \\ 0.50 & 0.95 \end{bmatrix}$
ξ	correlation coefficient of technology shocks	0.6	0.6
$\bar{z}^m$	relative technology advantage of the market sector	1.10	0.40
σ^m, σ^h	standard deviation of technology shock	0.0063	0.0073

4 Further Discussion

4.1 Sensitivity analysis

As shown in the calibration there is some uncertainty concerning the values of some parameters either because of a lack of data or of related empirical studies. Notwithstanding this uncertainty, these parameters were set to some particular ad hoc values for simulation purposes. The ranges for most of these parameters, however, can be determined from economic theory or stylized facts. Performing a sensitivity analysis gives some feel for how the results vary with these parameters.

More importantly, some of the parameters vary across countries, and represent some of the key differences between developed countries and developing countries. As discussed earlier, the methodology of this paper is to identify these differences and see which of them contributes to the excessive consumption volatility in developing countries. Therefore, performing sensitivity analysis is essential to determine the factors which contribute to the difference in consumption volatility between developed and developing economies.

Developing countries differ from developed countries in many aspects including preferences, production and international linkages. The difference in preference is represented by the share of market consumption, π, and the elasticity of substitution, ψ. The difference in international linkages is embodied in τ, the ease of access to foreign financial markets. As for different levels of production, this is indicated by ρ_{hm}, the technology transmission from the market sector to the home sector, and $\bar{z}^m$, the relative technology advantage in the market sector.

The share parameter of market consumption is set at 40 percent for both Mexico and Canada in the benchmark economy. The home-sector produced goods (and services) in emerging countries, however, are considered to have a bigger share in total consumption. The main reason is that when the market sector is not prevalent, the price of market

goods is high. For example, professional day care and old care institutions in some developing countries are rare, and these services are mostly offered at home. π is within $[0.0, 1.0]$, and the binary relationship between $\frac{\sigma_{cm}}{\sigma_{ym}}$ and π is plotted as Figure 1, with all other parameters fixed in the benchmark model for Mexico. Figure 1 indicates that as the share of market consumption increases, its volatility first increases and then decreases. Specifically, market consumption becomes volatile when this share is around half.

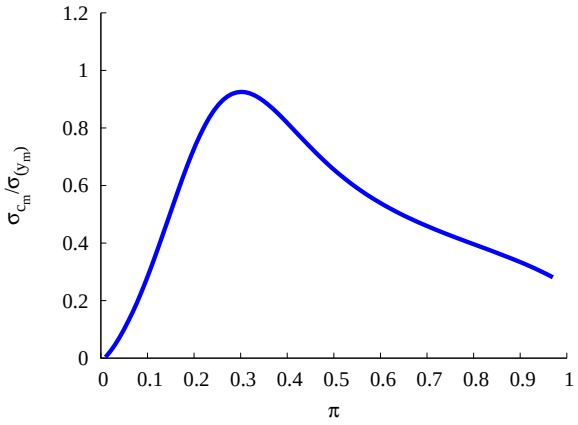


Figure 1: π and $\frac{\sigma_{cm}}{\sigma_{ym}}$

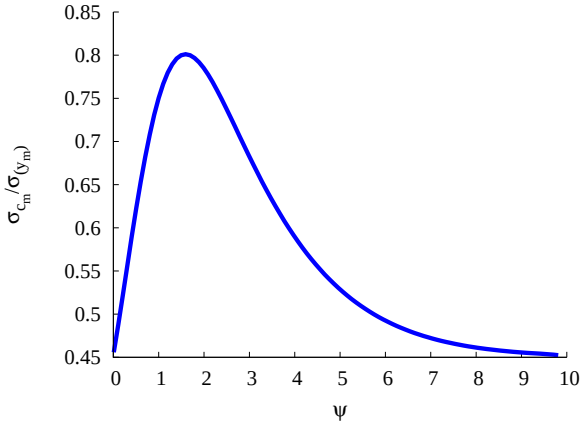


Figure 2: ψ and $\frac{\sigma_{cm}}{\sigma_{ym}}$

Another factor that represents the difference in preferences is the elasticity of substitution, ψ. The simulation results are presented in Figure 2, which also suggests that the relationship between $\frac{\sigma_{cm}}{\sigma_{ym}}$ and ψ is nonlinear, with a peak around $\psi = 2$. Careful exam-

ination of Figures 1 and 2 reveals that the maximum consumption volatility $\frac{\sigma_{cm}}{\sigma_{ym}}$ is less than unity, suggesting that the difference in preference is not the main cause for excessive consumption volatility in developing countries.

τ is the parameter that represents ease of international asset adjustment. Developed countries can access the international finance markets more easily owing to their more transparent financial system and sound financial position. Developing countries, on the other hand, may have to pay an extra cost to enter into the foreign capital market when lending or borrowing, particular during a financial crisis. Figure 3 illustrates that the relative volatility of market consumption increases with the financial friction parameter τ. However, the effect of financial friction is limited: when τ varies from 0 to 45, 100 times as the benchmark value, $\frac{\sigma_{cm}}{\sigma_{ym}}$ changes less then 10 percent.

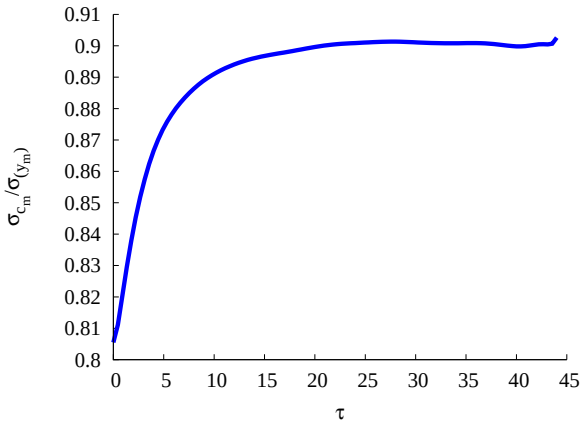


Figure 3: τ and $\frac{\sigma_{cm}}{\sigma_{ym}}$

The sensitivity analysis on differences in production is presented in Figure 4 and 5. Figure 4 indicates that when the transmission effect gets stronger, volatility of market consumption becomes larger. As discussed earlier, the transmission effect (from the market sector to the home sector) is bigger when the productivity gap between sectors is closer, as it is in developing countries.

The productivity gap between the two sectors is indicated by $\bar{z}^m$, and Figure 5 suggests that a more productive market sector leads to smoother market consumption. Further

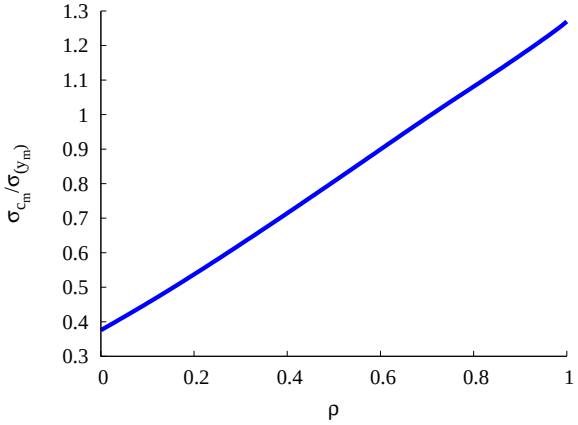


Figure 4: ρ_{hm} and $\frac{\sigma_{cm}}{\sigma_{ym}}$

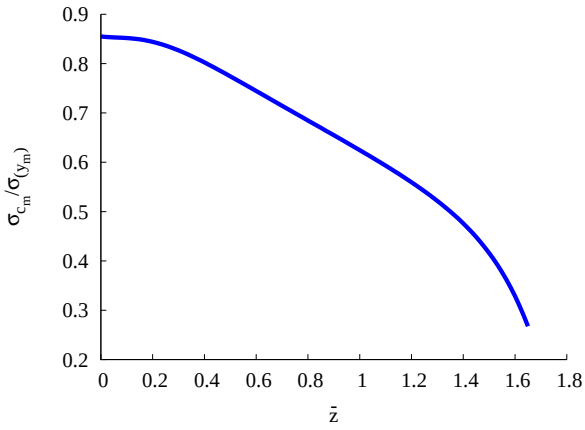


Figure 5: $\bar{z}^m$ and $\frac{\sigma_{cm}}{\sigma_{ym}}$

investigation reveals that the maximum volatility exceeds unity in Figure 4, and $\frac{\sigma_{cm}}{\sigma_{ym}}$ varies more than in Figure 1, 2 and 3, implying that a difference in technology is the main cause for excess consumption volatility in developing countries.

4.2 Benchmark discussion

In Canada, the relative volatility of market consumption is lower because its market sector is much more important, or dominant. This dominance results from the relative technology advantage in the market sector. Market sector's status calls for particular consumption smoothing incentives for market consumption. [6]

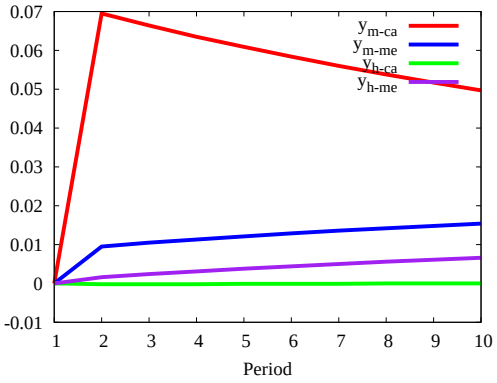
In Mexico, the market sector is not dominant. The main reason for this is the relative small technology level difference across sectors, i.e., market sector in Mexico has not developed enough to make home sector trivial. As a result, the market sector consumption is not smoothed as in Canada.

The impulse responses suggest that, for one shock that hits the market sector in Canada, the market sector expands and the home sector shrinks in that $y_h(c_h)$ decreases. In contrast, for the same shock in Mexico, because of the stronger technology transmission effect, both sectors expands. Actually, the home sector in Mexico changes more than 20 times in absolute value of the change in Canada.

Also, because of the stronger transmission effect, consumption in Mexico increases to a greater extent because the agent knows that the positive shock is more persistent. The consumption change in Canada is small relative to output, reflecting that consumption smoothing is strong with the expectation the shock is more transitory.

[6] In the extreme case where home sector is nil, the two-sector model reduces to a standard one-sector model with $\frac{\sigma_c}{\sigma_{ym}} < 1$.

6(a): output



6(b): consumption

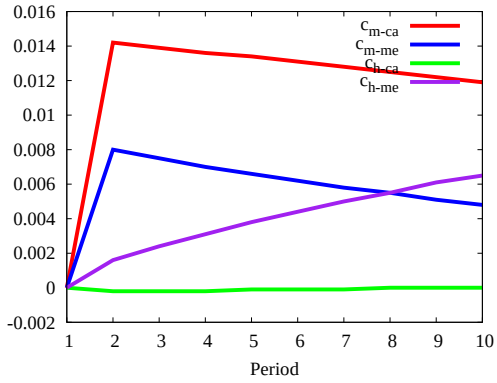


Figure 6: Shock to z_m: Output and Consumption

5 Conclusion

This paper offers an explanation for why consumption is generally less volatile than output in developed countries, while it tends to be more volatile than output in developed countries. By constructing a two sector small open economy model, this paper proposes for the first time that a relatively large home sector, characteristically found in developing countries, can explain this phenomenon.

The methodology of the paper has been to extract different factors across countries and examine which of them generates excessive volatility of market consumption relative to market output under reasonable conditions. These factors include differences in preferences, technology and international linkages.

For differences in preferences, the simulation results suggests that their effect on the relative volatility of consumption is ambiguous. For both the share of consumption and the elasticity of substitution, the volatility of consumption first increases and then decreases, implying that market consumption tends to be most volatile when preferences for market and home goods are relatively moderate.

For differences in international linkages, this paper refers to frictions in international financial transactions, which is modeled as an adjustment cost on foreign assets. The

results suggests that financial openness helps to smooth market consumption. This effect, however, is limited in that the variation in consumption volatility is relatively small.

As to the differences in technology, these are embodied in two factors: one is the market sector's relative productivity and the other is the technology transmission effect across sectors. The sensitivity analysis indicates that the more advanced is a market sector, or the less effective the transmission effect, both of which correspond to the group of developing countries, the smoother will be market consumption. The volatility of consumption exceeds that of output when technology varies, and it is more sensitive to changes in technology, suggesting that differences in technology are the main cause for excessive volatility in consumption in some countries.

The conclusion that technology is the driving force for the relative volatility of consumption predicts that volatile market consumption is almost inevitable at the start of industrialization, when the technology level in the market sector is just above that of the home sector. With the advancement of the market sector, its consumption will become less volatile. For this reason, relative volatility of market consumption could be regarded as an indicator to assess a country's stage of economic development.

Since excessive volatility leads to a welfare loss, the paper has significant implications. First, it is implied that the international financial integration helps to smooth consumption. Second and more important, it is also implied that technology enhancement is vital to reduce the excessive volatility in consumption. Therefore, investment in R&D may be an effective way to gain smoother consumption.

References

Aguiar, M. and Gopinath, G. (2007). Emerging market business cycles: The cycle is the trend. *The Journal of Political Economy*, 115(1):69–102.

Backus, D. K., Kehoe, P. J., and Kydland, F. E. (1992). International real business cycles. *The Journal of Political Economy*, 100:745–775.

Baxter, M. and Crucini, M. J. (1995). Business cycles and the asset structure of foreign trade. *International Economic Review*, 36(4):821–854.

Benhabib, J., Rogerson, R., and Wright, R. (1991). Homework in macroeconomics: Household production and aggregate fluctuations. *The Journal of Political Economy*, 99(6):1166–1187.

Blankenau, W. and Kose, M. A. (2007). How different is the cyclical behavior of home production across countries? *Macroeconomic Dynamics*, 11:56–78.

Eisner, R. (1988). Extended accounts for national income and product. *Journal of Economic Literature*, 26(4):1611–1684.

Garcia-Cicco, J., Pancrazi, R., and Uribe, M. (2009). Real business cycles in emerging countries. *Working paper*.

Gavin, M., Hausmann, R., Perotti, R., and Talvi, E. (1996). Managing fiscal policy in latin america and the caribbean:volatility, procyclicality, and limited credit worthiness. *I-ADB working paper*.

Gollin, D., Parente, S., and Rogerson, R. (2002). The role of agriculture in development. *The American Economic Review*, 92(2):160–164.

Gomme, P., Kydland, F. E., and Rupert, P. (2001). Home production meets time to build. *The Journal of Political Economy*, 109(5):1115–1131.

Gomme, P. and Rupert, P. (2007). Theory,measurement and calibration of macroeconomic

models. *Journal of Monetary Economics*, 54:460–497.

Greenwood, J., Hercowitz, Z., and Huffman, G. W. (1988). Investment, capacity utilization, and the real business cycle. *American Economic Review*, 78:402–417.

Ingram, B. F., Kocherlakota, N. R., and Savin, N. (2007). Using theory for measurement: An analysis of the cyclical behavior of home production. *Journal of Monetary Economics*, 40:435–456.

McGrattan, E. R., Rogerson, R., and Wright, R. (1997). An equilibrium model of the business cycle with household production and fiscal policy. *International Economic Review*, 38(2):267–290.

Mendoza, E. G. (1991). Real business cycles in a small open economy. *The American Economic Review*, 81:797–818.

Mendoza, E. G. (1994). *Capital Mobility: The Impact on Consumption, Investment, and Growt*, chapter 4. Cambridge University Press.

Schmitt-Grohe, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61:163–185.