Home Production and Small Open Economy Business Cycles

Chen, Kuan-Jen and Chu, Angus C. and Lai, Ching-Chong

Fu-Jen Catholic University, Fudan University, Academia Sinica

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Kuan-Jen Chen, Fu-Jen Catholic University
Angus C. Chu, Fudan University
Ching-Chong Lai, Academia Sinica

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Abstract

This paper incorporates home production into a real business cycle (RBC) model of small open economies to explain the different empirical patterns of international business cycles between developed economies and emerging markets. It is well known in the literature that in order for the RBC model to replicate quantitatively plausible empirical moments of small open economies, the model needs to feature counterfactually a small income effect on labor supply. This paper considers home production that introduces substitutability between market consumption and home consumption, which in turn generates a high volatility in market consumption in accordance with the data, even in the presence of a sizable income effect on labor supply. Furthermore, the model with estimated parameter values based on the simulated method of moments is able to match other empirical moments, such as the standard deviations of output, investment and the trade balance and the correlations between output and other macroeconomic variables. Given that home production is more prevalent in emerging markets than in developed economies, the model is able to replicate empirical differences between emerging markets and developed economies in the volatility of market consumption and the volatility/countercyclicality of the trade balance.

JEL classification: D13, E32, F41, O11

Keywords: small open economy; home production; emerging markets; business cycles.

Please send all correspondence to:

Ching-Chong Lai

Institute of Economics

Academia Sinica

Taipei, Taiwan

Email: cclai@econ.sinica.edu.tw

1 Introduction

Developed small open economies are characterized by the following stylized facts. First, consumption is less volatile than output. Second, investment is more volatile than output. Third, the trade balance-to-GDP ratio is weakly countercyclical. In their pioneering works, Mendoza (1991), Correia *et al.* (1995) and Schmitt-Grohé and Uribe (2003) develop a workhorse real business cycle (RBC) model of a small open economy to explain these stylized facts.[1] In order for the RBC model to replicate quantitatively plausible empirical moments of small open economies, the model needs to feature counterfactually a small income effect on labor supply, which is accomplished by specifying the representative household's utility function in the form proposed by Greenwood *et al.* (1988) (hereafter the GHH preference). However, Correia *et al.* (1995) find that when the income effect on labor supply is present as in the utility function proposed by King *et al.* (1988) (hereafter the KPR preference), volatilities of consumption and the trade balance-to-GDP ratio decrease significantly and the trade balance-to-GDP ratio becomes procyclical. With this understanding, we can conclude that under the KPR preference with a sizable income effect on labor supply, it is difficult for the RBC model to replicate quantitatively plausible empirical moments of developed small open economies.

The intuition behind the above result can be explained as follows. Given that the world interest rate faced by a small open economy is exogenous, the variation in the marginal utility of consumption tends to be small in response to a domestic technology shock. In the case of the KPR preference that features a sizable income effect on labor supply, consumption and leisure are complements in utility. Thus, an increase in equilibrium labor led by a positive technology shock reduces leisure and restrains the increase in consumption. As a result, consumption is not as volatile as in the data. By contrast, under the GHH preference that does not feature any income effect on labor supply, consumption and leisure are substitutes in utility. In this case, a positive technology shock reduces leisure and increases consumption significantly. As a result, consumption can be as volatile as in the data. However, empirical studies, such as Imbens *et al.* (2001), Kimball and Shapiro (2010), Khan and Tsoukalas (2011, 2012), and Dey and Tsai (2017), often find a sizable income effect on labor supply, implying that the KPR preference is the more plausible specification for the utility function.

In this study, we consider home production. Specifically, we consider two distinctive products: a home-produced product and a market-produced product. The home-produced product is not traded in the market; instead, it is consumed by the representative household for its own satisfaction. An advantage of the introduction of home production is that it allows the household to substitute between home consumption and market consumption, which in turn generates a high volatility in market consumption in accordance with the data, even in the presence of a sizable income effect on labor supply. The presence of substitutability between market consumption and home consumption is supported by Blankenau and Kose (2007).[2] Baxter and Jermann (1999) also employ the substitutability between market consumption and home consumption to explain the

[1] For seminal studies on the two-country RBC model; see, for example, Backus *et al.* (1992) and Stockman and Tesar (1995).

[2] Based on data for market variables in industrialized countries, Blankenau and Kose (2007) use the small open economy RBC model to generate simulated data of home variables. They find that market consumption is negatively correlated with home consumption, and market hours worked are negatively correlated with home hours worked.

excess sensitivity of consumption to income.

Intuitively, in the presence of home production, when the domestic economy experiences a positive technology shock in the production of market goods, it leads to a lower price of market consumption. Then the representative household increases its market consumption and substitutes away from home consumption. This substitution between market consumption and home consumption introduces a channel for an increase in the volatility of market consumption. In addition, a positive market technology shock raises the marginal product of capital. Consequently, households increase their accumulation of domestic capital and the borrowing from the world capital market. The capital inflow causes a trade deficit and reduces the trade balance-to-GDP ratio. This result implies that the trade balance-to-GDP ratio is countercyclical and more volatile in the presence of home production. Accordingly, home production is a plausible channel to explain business cycles in small open economies.

Moreover, some studies highlight the different features of business cycles between emerging markets and developed economies. In their influential articles, Neumeyer and Perri (2005) and Aguiar and Gopinath (2007) point out three important differences between these two types of economies. First, the volatility of output in emerging markets is higher than that in developed economies. Second, the volatility of output exceeds the volatility of consumption in developed economies, whereas output is less volatile than consumption in emerging markets. Third, the trade balance-to-GDP ratio is more volatile and more countercyclical in emerging markets than in developed economies. Some studies are devoted to explaining these empirical differences between emerging markets and developed economies. Neumeyer and Perri (2005) introduce a country risk shock to amplify the intertemporal substitution between current and future consumption. Aguiar and Gopinath (2007) and Boz *et al.* (2011) emphasize the importance of trend shocks to technology. This study contributes to the literature by exploring home production as a plausible explanation for the different empirical patterns of international business cycles between developed economies and emerging markets.

Parente *et al.* (2000) point out that developing economies spend more hours working in the home sector than developed economies do. Based on time-use survey data, we find that that there exists a negative correlation between the time spent on unpaid work and real GDP per capita. Therefore, we consider it to be a stylized fact that people spend more time on home production in emerging markets than in developed economies. By referring to the literature and data, we find that in emerging markets some phenomena, such as the greater strength of family ties, the lower degree of marketization, and the higher degree of labor intensity are helpful in explaining why people spend more time on home production. When home production becomes more prevalent, market consumption becomes less important in smoothing the marginal utility of aggregate consumption (aggregated over market and home consumption). The substitutability between market and home consumption can then play an important role in explaining the volatility of market consumption. To sum up, the presence of home production leads to an increase in the volatility of market consumption. Moreover, given that home production is more important in emerging markets than in developed economies, our model is able to replicate empirical differences between these two types of economies in the volatility of market consumption and the volatility/countercyclicality of the trade balance.

One related strand of the literature is the discussion regarding the informal economy and business cycles, such as the pioneering contribution of Restrepo-Echavarria (2014).

She finds some empirical evidence to support the view that there exists a positive correlation between the size of the informal economy and the relative volatility of consumption to output in the formal sector.[3] Then, she introduces an informal economy in a standard small open economy RBC model, and finds that a larger informal economy can lead to a larger degree of substitutability between formal and informal consumption, and hence amplify the relative volatility of consumption to output in the formal sector. As a consequence, home production and the informal economy share a similar mechanism to amplify the volatility of consumption. However, as mentioned by Restrepo-Echavarria (2014), the concepts and definitions of home production and the informal economy are significantly different, since the household can trade informal goods but cannot trade home production goods in the market.

Some studies also explore the implications of home production for international business cycles, but these studies mostly focus on two large countries. Canova and Ubide (1998) show that technology shocks in the home sector can generate volatile terms of trade observed in data. Karabarbounis (2014) finds that the presence of home production can generate countercyclical labor wedges, a negative correlation between relative market consumption and the terms of trade (i.e., the "Backus and Smith puzzle" pointed out by Backus and Smith (1993)), and the empirical pattern that market output correlates more than market consumption across countries (i.e., the "quantity anomaly" pointed out by Backus *et al.* (1994)). To sum up, Canova and Ubide (1998) and Karabarbounis (2014) contribute to the literature by showing that the introduction of home production to two-country RBC models is helpful in explaining international business cycles. In contrast to these studies, this paper sets up a small open economy model with home production and uses it to discuss how the presence of home production helps to explain the differences between developed economies and emerging markets in the empirical patterns of international business cycles.

The remainder of this paper proceeds as follows. Section 2 documents stylized facts of developed economies and emerging markets. Section 3 develops a small open economy RBC model with home production and characterizes the domestic economy's competitive equilibrium. Section 4 analyzes the quantitative results. Section 5 presents the concluding remarks.

2 Stylized facts

In this section, we first document stylized facts of business cycles in small open economies and update business cycle moments from previous studies. We begin by describing a data set in which the sample includes 27 small open economies. According to the classification of Morgan Stanley Capital International (MSCI), the sample countries are divided into developed economies and emerging markets. In our sample, developed economies consist of 13 countries: Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Denmark (DEN), Finland (FIN), Luxembourg (LUX), the Netherlands (NLD), New Zealand (NZL), Portugal (PRT), Spain (ESP), Sweden (SWE), and Switzerland (SWZ). Emerging markets consist of 14 countries: Argentina (ARG), Brazil (BRA), the Czech Republic

[3] Moreover, Restrepo-Echavarria (2014) estimates that the size of the informal economy is 36% of GDP in developing economies and 13% of GDP in developed economies, and finds that, compared to developed economies, the developing economies exhibit higher relative volatility of consumption to output in the formal sector.

(CZE), Estonia (EST), Hungary (HUN), Korea (KOR), Malaysia (MYS), Mexico (MEX), Poland (POL), the Slovak Republic (SVK), Slovenia (SVN), South Africa (ZAF), Thailand (THA), and Turkey (TUR).

The data that we use come from the database of the Organisation for Economic Co-operation and Development (OECD) for the available period 1976:I-2008:III.[4] For each country, there are six time series of data used in the computation of empirical moments: GDP $\hat{y}_t$, private final consumption $\hat{c}_{m,t}$, gross fixed capital formation $\hat{I}_t$, the trade balance-to-GDP ratio $\hat{b}_t$, population (defined as persons 16 years of age and older), and the GDP deflator.[5] The time series data we use are seasonally adjusted.[6] All variables except the trade balance-to-GDP ratio $\hat{b}_t$ are expressed in natural logarithms, and all variables (including $\hat{b}_t$) are de-trended by the HP-filter with the smoothing parameter set to 1,600.

Given the data, we compute the business cycle moments for each country including the standard deviation of output $std(\hat{y}_t)$, the standard deviation of market consumption $std(\hat{c}_{m,t})$, the standard deviation of investment $std(\hat{I}_t)$, the standard deviation of the trade balance-to-GDP ratio $std(\hat{b}_t)$, the correlation coefficient between consumption and output $corr(\hat{c}_{m,t}, \hat{y}_t)$, the correlation coefficient between investment and output $corr(\hat{I}_t, \hat{y}_t)$, and the correlation coefficient between the trade balance-to-GDP ratio and output $corr(\hat{b}_t, \hat{y}_t)$. The business cycle moments in developed economies and emerging markets are summarized in Table 1 and Table 2, respectively. Moreover, it should be noted that in Table 1 and Table 2, the average moments in the last row are weighted by each country's share of the group's aggregate GDP.

Table 1 shows that in developed economies the average standard deviation of output $std(\hat{y}_t)$ is 1.24, the average standard deviation of market consumption $std(\hat{c}_{m,t})$ is 1.22, the standard deviation of investment $std(\hat{I}_t)$ is 4.51, and the correlation coefficient between the trade balance-to-GDP ratio and output $corr(\hat{b}_t, \hat{y}_t)$ is -0.24. Accordingly, we can find that developed small open economies feature three stylized facts of business cycles, which have been explored by previous studies, such as Mendoza (1991), Correia et al. (1995) and Schmitt-Grohé and Uribe (2003). First, market consumption is less volatile than output. Second, investment is more volatile than output. Third, the trade balance-to-GDP ratio is weakly countercyclical.

Moreover, in view of the business cycle moments exhibited in Table 1 and Table 2, we can find three stylized facts of business cycles in developed economies and emerging markets, which are consistent with the findings in Neumeyer and Perri (2005), Aguiar and Gopinath (2007) and Ávarez-Parra *et al.* (2013). First, output is more volatile in emerging markets than in developed economies. Specifically, the average standard deviations of output $std(\hat{y}_t)$ are, respectively, 1.24 and 2.11 in developed economies and emerging markets. Second, market consumption is less volatile than output in developed economies, whereas it is more volatile than output in emerging markets. Specifically,

[4] The only exceptions are that the data on Malaysia and Thailand come from the CEIC-Asia database and the data on population in Argentina come from the International Labor Organization (ILO) database.

[5] The series of the trade balance-to-GDP ratio $\hat{b}_t$ is derived from the trade balance divided by GDP, and the trade balance is derived by subtracting imports of goods and services from exports of goods and services. In addition, given the fact that the series of the GDP deflator is derived from nominal gross domestic product divided by real gross domestic product, we can then use the GDP deflator to deflate nominal values of the relevant variables.

[6] We employ the X-12 ARIMA program provided by the U.S. Census Bureau to produce the seasonally-adjusted data.

the average ratios between the standard deviations of market consumption and output $std(\hat{c}_{m,t})/std(\hat{y}_t)$ are, respectively, 0.98 for developed economies and 1.35 for emerging markets. Third, the trade balance-to-GDP ratio is more volatile and more countercyclical in emerging markets than in developed economies. Specifically, the average standard deviations of the trade balance-to-GDP ratio $std(\hat{b}_t)$ are, respectively, 1.04 for developed economies and 1.90 for emerging markets. Furthermore, the average correlation coefficients between the trade balance-to-GDP ratio and output $corr(\hat{b}_t, \hat{y}_t)$ are, respectively, –0.24 for developed economies and –0.47 for emerging markets. With these stylized facts, we will develop a small open economy model in the next section and test the model by replicating the business-cycle features exhibited above.

Table 1: Business cycle moments in developed economies

Country	sample	$std(\hat{y}_t)$	$\frac{std(\hat{c}_{m,t})}{std(\hat{y}_t)}$	$\frac{std(\hat{I}_t)}{std(\hat{y}_t)}$	$std(\hat{b}_t)$	$corr(\hat{c}_{m,t}, \hat{y}_t)$	$corr(\hat{I}_t, \hat{y}_t)$	$corr(\hat{b}_t, \hat{y}_t)$
Australia	76:I-08:III	1.23	0.77	3.79	0.93	0.16	0.82	−0.33
Austria	76:I-08:III	1.02	1.19	2.48	0.80	0.66	0.61	−0.11
Belgium	76:I-08:III	0.99	1.02	4.09	1.01	0.69	0.73	−0.27
Canada	76:I-08:III	1.37	0.84	3.01	0.89	0.56	0.71	−0.10
Denmark	76:I-08:III	1.34	1.31	4.26	1.15	0.70	0.69	−0.36
Finland	76:I-08:III	1.90	0.63	3.62	1.46	0.55	0.85	−0.28
Luxembourg	76:I-08:III	1.76	1.28	4.34	2.52	0.37	0.31	0.22
Netherlands	76:I-08:III	1.21	1.03	3.79	1.02	0.63	0.69	−0.13
New Zealand	76:I-08:III	1.73	1.17	4.21	1.48	0.44	0.54	−0.03
Portugal	76:I-08:III	1.58	1.27	3.89	1.82	0.58	0.80	−0.48
Spain	76:I-08:III	1.01	1.19	4.16	1.09	0.71	0.73	−0.36
Sweden	76:I-08:III	1.36	1.07	3.71	1.02	0.49	0.75	−0.07
Switzerland	76:I-08:III	1.15	0.78	3.19	0.93	0.64	0.78	−0.46
Average		1.24	0.98	3.64	1.04	0.57	0.73	−0.24

Notes: For each country, the business cycle moments include the standard deviations of output $std(\hat{y}_t)$, market consumption $std(\hat{c}_{m,t})$, investment $std(\hat{I}_t)$ and the trade balance-to-GDP ratio $std(\hat{b}_t)$ and the correlation coefficients between consumption and output $corr(\hat{c}_{m,t}, \hat{y}_t)$, investment and output $corr(\hat{I}_t, \hat{y}_t)$, and the trade balance-to-GDP ratio and output $corr(\hat{b}_t, \hat{y}_t)$. All variables apart from the trade balance-to-GDP ratio $\hat{b}_t$ are in natural logarithms, and all variables (including $\hat{b}_t$) are de-trended by the HP-filter with the smoothing parameter set to 1,600. The standard deviations of output, market consumption, investment, and the trade balance-to-GDP ratios are reported in percentage terms. In addition, the average moments are weighted by each country's share of each group's GDP (in US dollars in 2005).

In the rest of this section, we document some stylized facts of the time spent on home production in developed economies and emerging markets. Our sample includes 29 countries. They are 5 large open economy countries: France (FRA), Germany (DEU), Italy (ITA), the United Kingdom (GBR), and the United States (USA) and 24 small open economy countries as in Tables 1 and 2, except for the Czech Republic, Thailand, and Portugal. The data that we obtain are from the Sustainable Development Goals (SDG) Indicators Database of the UN, except for Estonia, Korea, Luxembourg, and New Zealand.[7] Based on the database, we use the proportion of time spent on unpaid work to measure hours worked in home production.[8] Consequently, we can depict the proportion

[7] The time-use data for Estonia, Korea, Luxembourg, and New Zealand, respectively, are obtained from Statistics Estonia, Statistics Korea, the National Institute of Statistics and Economic Studies of the Grand Duchy of Luxembourg (STATEC), and Statistics New Zealand. Appendix C documents the survey year and data sources for each of the 29 countries.

[8] Based on the definition of time spent on unpaid work according to the SDG Indicators Database

of time spent on unpaid work and real GDP per capita under purchasing power parity (PPP) in 2005 in Figure 1.

Table 2: Business cycle moments in emerging market economies

Country	sample	$std(\hat{y}_t)$	$\frac{std(\hat{c}_{m,t})}{std(\hat{y}_t)}$	$\frac{std(\hat{I}_t)}{std(\hat{y}_t)}$	$std(\hat{b}_t)$	$corr(\hat{c}_{m,t}, \hat{y}_t)$	$corr(\hat{I}_t, \hat{y}_t)$	$corr(\hat{b}_t, \hat{y}_t)$
Argentina	93:I-08:III	4.10	1.36	3.18	2.81	0.93	0.92	−0.82
Brazil	96:I-08:III	1.19	1.50	3.83	0.96	0.63	0.82	−0.32
Czech Republic	95:I-08:III	1.24	1.11	3.24	1.31	0.59	0.65	−0.37
Estonia	95:I-08:III	2.37	1.22	3.63	2.51	0.80	0.88	−0.57
Hungary	95:I-08:III	0.98	2.21	2.34	1.61	0.42	0.30	−0.26
Korea	76:I-08:III	2.50	1.26	2.73	2.51	0.70	0.80	−0.39
Malaysia	91:I-08:III	2.66	1.67	4.68	4.59	0.73	0.82	−0.65
Mexico	87:I-08:III	2.13	1.29	2.93	1.36	0.75	0.86	−0.59
Poland	95:I-08:III	1.35	1.31	4.59	1.08	0.53	0.78	−0.55
Slovak Republic	93:I-08:III	1.53	1.55	6.29	4.10	0.44	0.57	−0.25
Slovenia	96:I-08:III	0.87	1.29	4.97	1.68	0.26	0.49	−0.06
South Africa	76:I-08:III	1.67	1.51	3.57	2.58	0.59	0.71	−0.50
Thailand	94:I-08:III	3.46	1.09	3.52	4.17	0.93	0.90	−0.67
Turkey	76:I-08:III	2.88	1.37	3.47	1.64	0.65	0.78	−0.50
Average		2.11	1.35	3.33	1.90	0.68	0.80	−0.47

Notes: For each country, the business cycle moments include the standard deviations of output $std(\hat{y}_t)$, market consumption $std(\hat{c}_{m,t})$, investment $std(\hat{I}_t)$ and the trade balance-to-GDP ratio $std(\hat{b}_t)$ and the correlation coefficients between consumption and output $corr(\hat{c}_{m,t}, \hat{y}_t)$, investment and output $corr(\hat{I}_t, \hat{y}_t)$, and the trade balance-to-GDP ratio and output $corr(\hat{b}_t, \hat{y}_t)$. All variables apart from the trade balance-to-GDP ratio $\hat{b}_t$ are in natural logarithms, and all variables (including $\hat{b}_t$) are de-trended by the HP-filter with the smoothing parameter set to 1,600. The standard deviations of output, market consumption, investment, and the trade balance-to-GDP ratios are reported in percentage terms. In addition, the average moments are weighted by each country's share of each group's GDP (in US dollars in 2005).

Figure 1 sheds light on the stylized fact of the time spent on unpaid work across countries. As shown in Figure 1, with the exception of Brazil, Korea, Malaysia, and South Africa, the proportion of time spent on unpaid work (home production) in emerging market countries (about 15% to 18% of a day) is higher than that in developed economy countries (about 12% to 15% of a day). As is obvious from Figure 1, the observations for Brazil and Korea seem to be outliers. Accordingly, by using a robust regression method that downweights outliers, we depict the fitted values from the regression of the proportion of time spent on unpaid work on real GDP per capita in Figure 1, and they reveal that the regression coefficient is negative and significant.[9] These results imply that

of the UN (Indicator 5.4.1), unpaid work refers to unpaid domestic and caregiving services undertaken by households for their own use. It includes food preparation, dishwashing, cleaning and upkeep of a dwelling, laundry, ironing, gardening, caring for pets, shopping, installation, servicing and repair of personal and household goods, childcare, and care of sick, elderly or disabled household members, among others.

[9] Using the robust regression method, our estimate of the regression coefficient is −0.048 with a p-value of 0.02. Another widely used method for eliminating the effects of outliers is to rule out the observations beyond the range of $[Q_1 - IQR, Q_3 + IQR]$, where Q_1 and Q_3 respectively are the lower and upper quartiles, and IQR is the interquartile range. Based on this method for detecting outliers, we can exclude the observations for Brazil and Korea from the data, and then use ordinary least squares to estimate that the regression coefficient is −0.047 with a p-value of 0.01. Therefore, the result is similar to the estimation under robust regression. However, if we consider the full set of data (including Brazil and Korea), ordinary least squares regression indicates that the regression coefficient is −0.021 with

the scale of home production is more prevalent in emerging markets than in developed economies.

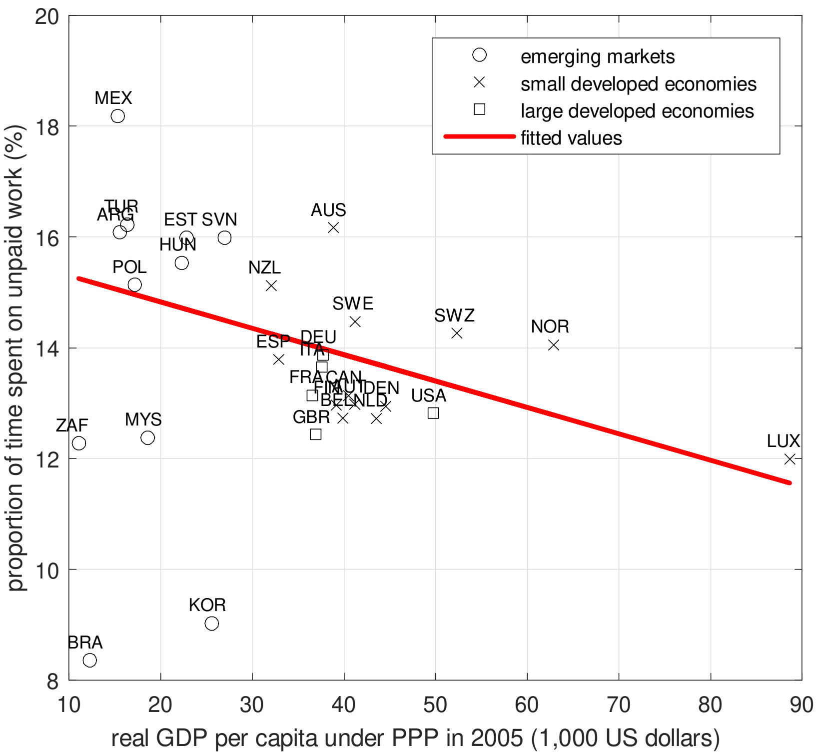

Figure 1: The proportion of time spent on unpaid work and income across countries

Notes: Following Ávarez-Parra et al. (2013) and Miyamoto and Nguyen (2017), we define large developed economies as developed economies that feature more than 2% of the world's GDP, namely, France, Germany, Italy, the United Kingdom, and the United States.

We have the following three possible explanations for the fact that people spend more time on home production in emerging markets than in developed economies. The first possible explanation relates to the different preferences for home production across countries. This point is supported by the empirical findings of Alesina and Giuliano (2010), since they find, using cross-county data, that the objective strength of family ties is positively related to family size and home hours worked. In addition, van Klaveren et al. (2008) and Bredemeier and Juessen (2013) take a similar view and propose that greater numbers of children and a larger family size can raise the utility share of home production in the home production model. Since the OECD database reveals that, during the 1970-2005 period, the average fertility rate is 1.75 in developed economies and 2.73 in emerging markets,[10] we can infer that the utility share of home production is lower in developed economies than in emerging markets. Accordingly, the fact that people spend

a p-value of 0.38. This result indicates that the effects of outliers are momentous, and can cause the negative regression coefficient to be insignificant.

[10]In the cross-country data for the fertility rate, our sample includes the 12 developed economies reported in Table 1, except for Portugal, and 11 emerging markets as reported in Table 2 except for the Czech Republic, Malaysia, and Thailand.

less (more) time on home production in developed economies (emerging markets) can be explained by their lower (higher) utility share of home production.

The second possible explanation is the different degree of "marketization" across countries, which is proposed by Freeman and Schettkat (2005), Ngai and Pissarides (2008), and Rogerson (2008). To be more specific, it refers to the phenomenon that, when the economy experiences higher growth of total factor productivity in the market sector, people will move more of their disposable working hours from the home to the market sector. On the other hand, as pointed out by Hall and Jones (1999), the empirical evidence shows the positive relationship between income and the total factor productivity in the market sector.[11] Hence, the difference in home hours worked between two groups of countries can be reflected by the fact that, compared to emerging markets, the developed economies feature a higher level of total factor productivity in the market sector.

The third possible explanation is the different degree of labor intensity in home production across countries. As pointed out by Greenwood et al. (2005) and de V. Cavalcanti and Tavares (2008), the diffusion of labor-saving household appliances in developed economies can cause females in the household to move working hours from the home to the market sector. In other words, when the developed economies experience the diffusion of labor-saving household appliances, they are associated with the lower degree of labor intensity in home production. In a recent study, Cubas (2016) shows that emerging markets exhibit less diffusion of labor-saving household appliances, and hence we can infer that they are associated with the higher degree of labor intensity in home production.[12] Accordingly, the reason why people spend less (more) time on home production in developed economies (emerging markets) can be explained on the basis that the technology they use in home production is associated with a lower (higher) degree of labor intensity.

Before ending this section, it should be noted that, to conserve space, we consider the different utility shares of home production as the main scenario in the quantitative results reported in Section 4, and then present the other two cases (i.e., different degrees of marketization and labor intensity in home production) as robustness checks.

3 A small open economy RBC model with home production

The domestic economy is inhabited by a representative household. In what follows, we describe the behavior of the representative household and characterize the competitive equilibrium of the economy.

[11] In Hall and Jones (1999), the total factor productivity is normalized to unity. Then, based on their calculation, the total factor productivities for Canada, Italy, France, and the United Kingdom in developed economies, respectively, are 1.034, 1.207, 1.126, and 1.011. In addition, the total factor productivities for Mexico and Argentina in emerging markets, respectively, are 0.926 and 0.648, which are all lower than those in developed economies.

[12] For example, based on the data in Cubas (2016), in 1990, 76% of households in the U.S. owned a washing machine, but only 24% and 36% of households in Brazil and Mexico, respectively, owned one. This reveals that there exists a slow diffusion of washing machines in emerging markets.

3.1 The representative household-producer

We follow Benhabib *et al.* (1991) and Baxter and Jermann (1999) to model home production in the RBC model. The representative household-producer derives utility from aggregate consumption C_t, which is composed of market consumption $c_{m,t}$ and home consumption $c_{h,t}$, and incurs disutility from total hours worked N_t, which is the sum of market hours worked $n_{m,t}$ and home hours worked $n_{h,t}$. In line with Jaimovich and Rebelo (2009), we propose the following utility function that nests the GHH preference and the KPR preference as special cases:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(C_t - \omega N_t^{\xi} X_t\right)^{1-\tau} - 1}{1-\tau}, \tag{1}$$

where aggregate consumption C_t, total hours worked N_t and the geometric average of current and past consumption levels X_t are defined as follows:

$$X_t = C_t^{\gamma} X_{t-1}^{1-\gamma}, \tag{2a}$$

$$C_t = \left[\theta c_{m,t}^{\phi} + (1-\theta)\, c_{h,t}^{\phi}\right]^{\frac{1}{\phi}}, \tag{2b}$$

$$N_t = n_{m,t} + n_{h,t}, \tag{2c}$$

where $\theta \in (0,1)$ denotes the utility share of market consumption, $\phi < 1$ governs the elasticity of substitution between market and home consumption (i.e., $e \equiv \frac{1}{1-\phi}$), $\tau > 0$ denotes the inverse of the intertemporal elasticity of substitution in consumption, $\xi > 0$ denotes the inverse of the Frisch labor supply elasticity, $\beta \in (0,1)$ represents the household's subjective discount factor, and $\omega > 0$ denotes the scaling disutility of labor supply. A salient feature of the Jaimovich-Rebelo preference reported in equations (1) and (2a) is that $\gamma \in [0,1]$ parameterizes the short-run income effect of labor supply. When $\gamma = 1$, the sizable income effect leads to a reduction in labor supply upon experiencing a productivity improvement, and this is associated with the KPR preference.[13] When $\gamma = 0$, the absence of the income effect leads to an increase in labor supply upon the arrival of a productivity improvement, and this is associated with the GHH preference.

Each representative household produces market output and home consumption goods according to the following Cobb-Douglas form:

$$y_t = A_{m,t} k_{m,t}^{\alpha_m} n_{m,t}^{1-\alpha_m}, \tag{3a}$$

$$c_{h,t} = A_{h,t} k_{h,t}^{\alpha_h} n_{h,t}^{1-\alpha_h}, \tag{3b}$$

where $k_{m,t}$ and $k_{h,t}$ respectively denote market capital and home capital, $\alpha_m \in (0,1)$ and $\alpha_h \in (0,1)$ respectively denote the production share of market capital and home capital, and $A_{m,t}$ and $A_{h,t}$ respectively denote the level of total factor productivity in each production sector. We assume that the natural logarithms of both total factor productivity processes are persistent, following a first-order autoregressive process:

$$\log A_{m,t} = \rho_m \log A_{m,t-1} + \varepsilon_{m,t}, \tag{4a}$$

[13] In the case of a productivity improvement, the decrease in labor supply is offset by an increase in labor demand such that the labor input increases in equilibrium.

$$\log A_{h,t} = \rho_h \log A_{h,t-1} + \varepsilon_{h,t}, \tag{4b}$$

where $\rho_m \in (0,1)$ and $\rho_h \in (0,1)$ denote persistence parameters and $\varepsilon_{m,t}$ and $\varepsilon_{h,t}$ denote exogenous innovations in the market and home production sectors, respectively. Both $\varepsilon_{m,t}$ and $\varepsilon_{h,t}$ are normally distributed with zero mean and finite variance σ_m^2 and σ_h^2.

In each period, the representative household can finance its budget deficit by borrowing from the world market, and a flow of foreign debt is linked to any difference between its expenditure and its income. Let d_t denote foreign debt measured in terms of domestic output and r_t represent the world real interest rate on foreign debt. The household's flow budget constraint can then be expressed as:

$$d_{t+1} = (1+r_t)d_t + c_{m,t} + I_{m,t}\left[1+\Psi_m\left(\frac{I_{m,t}}{k_{m,t}}\right)\right] + I_{h,t}\left[1+\Psi_h\left(\frac{I_{h,t}}{k_{h,t}}\right)\right] - y_t, \tag{5}$$

where $I_{m,t}$ and $I_{h,t}$ denote investment in market capital and home capital. The representative household installs market and home capital involving extra adjustment costs (installation costs). In line with Hayashi (1982) and Abel and Blanchard (1983), the adjustment cost functions in the two sectors are specified as follows:

$$\Psi_m\left(\frac{I_{m,t}}{k_{m,t}}\right) = \frac{\psi_m}{2}\frac{I_{m,t}}{k_{m,t}}, \tag{6a}$$

$$\Psi_h\left(\frac{I_{h,t}}{k_{h,t}}\right) = \frac{\psi_h}{2}\frac{I_{h,t}}{k_{h,t}}, \tag{6b}$$

where $\Psi_m\left(\frac{I_{m,t}}{k_{m,t}}\right)$ and $\Psi_h\left(\frac{I_{h,t}}{k_{h,t}}\right)$ reflect the adjustment costs incurred by each unit of market capital investment and home capital investment.[14] $\psi_m > 0$ and $\psi_h > 0$ denote the intensity parameters of the investment adjustment costs in the market and home sectors. As is evident in equations (6a) and (6b), the investment adjustment cost functions satisfy the following properties: $\Psi'_m(\cdot) > 0$ and $\Psi'_h(\cdot) > 0$.

Aggregate investment and the law of motion of the capital stock in each sector can be specified as follows:

$$k_{m,t+1} = (1-\delta_m)\,k_{m,t} + I_{m,t}, \tag{7a}$$

$$k_{h,t+1} = (1-\delta_h)\,k_{h,t} + I_{h,t}, \tag{7b}$$

$$I_t = I_{m,t} + I_{h,t}, \tag{7c}$$

where $\delta_m \in (0,1)$ and $\delta_h \in (0,1)$ respectively stand for the depreciation rates of market capital and home capital and I_t denotes aggregate investment.

The sequence of $\{c_{m,t}, c_{h,t}, X_t, n_{m,t}, n_{h,t}, I_{m,t}, I_{h,t}, k_{m,t+1}, k_{h,t+1}, d_{t+1}\}$ is chosen by the household to maximize lifetime utility in equation (1) subject to equations (2a)-(7c). Let g_t, μ_t, λ_t, $q'_{m,t}$ and $q'_{h,t}$ be the Lagrange multipliers associated with (2a), (3b), (5), (7a) and (7b), respectively. We define $q_{m,t} \equiv \frac{q'_{m,t}}{\lambda_t}$ and $q_{h,t} \equiv \frac{q'_{h,t}}{\lambda_t}$ such that $q_{m,t}$ and $q_{h,t}$ represent the relative prices of additional installed market and home capital in terms of the marginal utility of consumption. The optimality conditions necessary for the representative household with respect to the indicated variables are:

[14] The unit adjustment costs being a function of investment relative to the capital stock can be justified by learning-by-doing in the installation process.

$$c_{m,t}: \quad \left[\left(C_t - \omega N_t^{\xi} X_t\right)^{-\tau} + g_t \gamma \left(\frac{C_t}{X_{t-1}}\right)^{\gamma-1}\right] \theta \left(\frac{c_{m,t}}{C_t}\right)^{\phi-1} = \lambda_t, \tag{8a}$$

$$c_{h,t}: \quad \frac{\theta}{1-\theta}\left(\frac{c_{m,t}}{c_{h,t}}\right)^{\phi-1} = \frac{\lambda_t}{\mu_t}, \tag{8b}$$

$$X_t: \quad \left(C_t - \omega N_t^{\xi} X_t\right)^{-\tau} \omega N_t^{\xi} + g_t = \beta E_t \left[g_{t+1}(1-\gamma)\left(\frac{C_{t+1}}{X_t}\right)^{\gamma}\right], \tag{8c}$$

$$n_{m,t}: \quad \frac{\left(C_t - \omega N_t^{\xi} X_t\right)^{-\tau} \omega \xi N_t^{\xi-1}}{\left(C_t - \omega N_t^{\xi} X_t\right)^{-\tau} + g_t \gamma \left(\frac{C_t}{X_{t-1}}\right)^{\gamma-1}} \frac{X_t}{\theta}\left(\frac{c_{m,t}}{C_t}\right)^{1-\phi} = (1-\alpha_m)\frac{y_t}{n_{m,t}}, \tag{8d}$$

$$n_{h,t}: \frac{\mu_t}{\lambda_t} = \frac{1-\alpha_m}{1-\alpha_h}\frac{y_t/n_{m,t}}{c_{h,t}/n_{h,t}}, \tag{8e}$$

$$I_{m,t}: \quad \frac{I_{m,t}}{k_{m,t}} = \frac{q_{m,t}-1}{\psi_m}, \tag{8f}$$

$$I_{h,t}: \quad \frac{I_{h,t}}{k_{h,t}} = \frac{q_{h,t}-1}{\psi_h}, \tag{8g}$$

$$k_{m,t+1}: \; q_{m,t} = \beta E_t \left\{\frac{\lambda_{t+1}}{\lambda_t}\left[\alpha_m \frac{y_{t+1}}{k_{m,t+1}} + \frac{(q_{m,t+1}-1)^2}{2\psi_m} + (1-\delta_m) q_{m,t+1}\right]\right\}, \tag{8h}$$

$$k_{h,t+1}: \; q_{h,t} = \beta E_t \left\{\frac{\lambda_{t+1}}{\lambda_t}\left[\alpha_h \frac{\mu_{t+1}}{\lambda_{t+1}}\frac{c_{h,t+1}}{k_{h,t+1}} + \frac{(q_{h,t+1}-1)^2}{2\psi_h} + (1-\delta_h) q_{h,t+1}\right]\right\}, \tag{8i}$$

$$d_{t+1}: \; 1 = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t}(1+r_{t+1})\right]. \tag{8j}$$

Before ending this subsection, an important point should be mentioned here. The presence of home consumption allows for substitutability between home consumption and market consumption. The engine driving this substitutability is the change in the relative price between home consumption and market consumption. To shed light on the importance of home production, it is helpful to discuss how the relative price between market and home consumption $p_t (= \frac{\lambda_t}{\mu_t})$ reacts in response to technology shocks.

From equations (3a), (3b), (8b), and (8e), the relative price between market and home consumption can be expressed as:

$$p_t = \frac{\theta}{1-\theta}\left(\frac{c_{m,t}}{c_{h,t}}\right)^{\phi-1} = \frac{1-\alpha_h}{1-\alpha_m}\frac{A_{h,t} k_{h,t}^{\alpha_h} n_{h,t}^{-\alpha_h}}{A_{m,t} k_{m,t}^{\alpha_m} n_{m,t}^{-\alpha_m}}. \tag{9}$$

Equation (9) denotes the optimal allocation between market and home consumption. It states that the relative price of market consumption equals the marginal rate of substitution between market and home consumption. It also equals the ratio between the marginal product of home hours worked and the marginal product of market hours worked.[15] As is clear in equation (9), a rise in the marginal product of market hours worked leads to a lower relative price p_t, which in turn causes the household to raise market consumption and reduce home consumption.

[15] Based on equations (3a), (3b), and (8e), the household's optimal allocation between market and

3.2 Competitive equilibrium

The representative household has access to the world capital market and is able to borrow from the international market. In line with Edwards (1984), Chung and Turnovsky (2010), Li (2011) and Heer and Schubert (2012), the household faces an upward-sloping curve for debt when borrowing from abroad. More specifically, to reflect the extent of default risk in association with foreign debt, the borrowing rate charged by the foreign country on debt is specified to be positively related to the foreign debt-to-output ratio:[16]

$$r_{t+1} = R + \eta \left[\exp \left(\frac{d_{t+1}}{y_t} - \upsilon \right) - 1 \right]. \tag{10}$$

In equation (10), the parameter R denotes the exogenous component of the world interest rate and the parameter υ reflects the stationary foreign debt-to-output ratio. The parameter η reflects the borrowing premium associated with default risk and can be interpreted as the extent of the country default risk.[17] It is important to note that in this small open economy we follow the standard treatment in the literature by assuming that the representative household-producer is a price-taker in the world capital market, and he/she is unable to affect the level of the world interest rate r_{t+1}. Therefore, the representative household-producer takes r_{t+1} as given when he/she is making optimality decisions.

For ease of exposition, we use b_t to denote the trade balance-to-GDP ratio; i.e., $b_t \equiv \frac{1}{y_t}[y_t - c_{m,t} - I_{m,t}(1 + \frac{\psi_m}{2}\frac{I_{m,t}}{k_{m,t}}) - I_{h,t}(1 + \frac{\psi_h}{2}\frac{I_{h,t}}{k_{h,t}})]$. Equation (5) can be reexpressed as:

$$d_{t+1} - d_t = -\left(b_t y_t - r_t d_t \right). \tag{11}$$

Equation (11) states that the economy's net accumulation of foreign debt is equal to the negative value of the current account (the trade balance minus the net interest payment on foreign debt). The competitive equilibrium of the economy is composed of 22 equations: (2a)-(3b), (5) and (7a)-(11). The endogenous variables are the sequences of quantities $\{y_t, c_{m,t}, c_{h,t}, C_t, X_t, N_t, n_{m,t}, n_{h,t}, I_{m,t}, I_{h,t}, I_t, k_{m,t}, k_{h,t}, d_t, b_t\}$ and prices $\{r_t, g_t, \mu_t, \lambda_t, p_t, q_{m,t}, q_{h,t}\}$.

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home hours worked can be inferred as:

$$1 = \frac{\lambda_t}{\mu_t} \frac{(1-\alpha_m)A_{m,t}k_{m,t}^{\alpha_m}n_{m,t}^{-\alpha_m}}{(1-\alpha_h)A_{h,t}k_{h,t}^{\alpha_h}n_{h,t}^{-\alpha_h}}.$$

This equation indicates that the marginal rate of substitution between market and home hours worked (on the left-hand side) is equal to the marginal rate of transformation between market and home hours worked (on the right-hand side). Since $p_t = \frac{\lambda_t}{\mu_t}$ denotes the relative price of market consumption, i.e., the ratio between the marginal utilities of market and home consumption, from equations (8a) and (8b), the relative price of market consumption p_t can then be derived as the expression in equation (9).

[16] Bi *et al.* (2016) use a dynamic stochastic general equilibrium (DSGE) model to study fiscal limits in a developing economy. They find that the default probability in Argentina is an increasing function of the debt-to-output ratio. Moreover, a decrease in the revenue collection capacity of the government and a large devaluation of the real exchange rate can raise the probability of default in Argentina.

[17] Alternatively, in some of the open economy literature, the country default risk is related to either country risk shocks or productivity shocks. On the one hand, Neumeyer and Perri (2005) propose that the country default risk can be driven by country risk shocks such as foreign events, contagion, or political factors, which are independent of productivity shocks. On the other hand, in the sovereign debt model associated with endogenous default decisions, developed by Bai and Zhang (2010, 2012), the presence of negative productivity shocks would raise the possibility of sovereign default.

4 Results

We consider Canada and Mexico, respectively, as a representative developed economy and a representative emerging market. We begin by characterizing a benchmark economy, in which structural parameters are divided into two groups. Each parameter in the first group is either set to a commonly used value or calibrated to match the empirical evidence in Canada and Mexico. Each parameter in the second group is estimated by the simulated method of moments (hereafter SMM).

This section is arranged as follows. We first deal with the calibration of parameters in the first group. Next, we estimate parameters in the second group using SMM and report quantitative results to show that our theoretical model embodying home production is able to replicate standard business cycle moments in the two small open economies. In addition, we explore impulse responses in response to market-technology and home-technology shocks and explain why home production enables the model to produce empirically plausible business cycle moments in the two types of economies. Finally, we report on the sensitivity analysis.

4.1 Calibration

In the first group of parameters, we consider the following commonly used values in the literature: the discount factor $\beta = 0.98$, the production shares of market capital and home capital are set to $\alpha_m = \alpha_h = 0.33$, and the inverse of the intertemporal elasticity of substitution in consumption $\tau = 2$. Following Greenwood and Hercowitz (1991), Parente *et al.* (2000) and Karabarbounis (2014), we assume that the depreciation rates of market capital and home capital are identical; i.e., $\delta_m = \delta_h = \delta$, and following Li (2011), δ is set to 0.03. In addition, in line with Li (2011), we set the Frisch labor supply elasticity $1/(\xi - 1) = 0.69$ (i.e., $\xi = 2.44$). Given an overall non-sleeping time of 16 hours in both countries, the time-use data imply that the average proportion of time spent on paid work per day is 20.9% for Canada and 22.6% for Mexico. Then, the scaling disutility of labor supply ω is varied to match the steady-state value of market hours worked of $n_m = 0.209$ for Canada and 0.226 for Mexico.

In line with Rupert *et al.* (1995), Schmitt-Grohé (1998) and Karabarbounis (2014), we set $\phi = 0.75$ and this implies an elasticity of substitution between market and home consumption of 4.[18] In addition, we set the parameter governing the short-run income effect on labor supply as $\gamma = 1$, and hence the utility function is associated with the KPR preference.[19] The data show that the foreign debt-to-output ratio is 25% in Canada and 44% in Mexico. Hence, we set $\upsilon = 0.25$ in the developed economy and $\upsilon = 0.44$ in the emerging market. In line with Neumeyer and Perri (2005), Otsu (2008) and Jaimovich and Rebelo (2009), the parameter η reflecting the borrowing premium associated with

[18] In their pioneering studies, Benhabib *et al.* (1991) and Greenwood and Hercowitz (1991) set the elasticity of substitution between market and home consumption e equal to 5 and 3, respectively. In addition, Rupert *et al.* (1995) estimate the plausible value of e to be in the range of 0 to 5 (see Baxter and Jermann (1999, p.909)). Accordingly, the value of $e = 4$ lies within the values reported in the previous studies.

[19] This strong income effect will make it difficult for our model to match the business cycle properties of small open economies. We consider this case in order to see how robust our model with home production could be.

default risk is set to 0.00001.[20] Finally, following McGrattan *et al.* (1997), we assume that the innovations in the market and home sectors are uncorrelated in our benchmark estimation.[21] A summary of the calibrated parameter values is reported in Table 3.

Table 3: Parameter calibration

	β	α_m	α_h	τ	δ	ξ	ω	ϕ	γ	υ	η
Canada	0.98	0.33	0.33	2	0.03	2.44	varied	0.75	1	0.25	0.00001
Mexico	0.98	0.33	0.33	2	0.03	2.44	varied	0.75	1	0.44	0.00001

Notes: We vary the scaling disutility of labor supply ω to match the steady-state value of market hours worked of $n_m = 0.209$ for Canada and 0.226 for Mexico. The calibrated values of ω in response to the different scenarios are reported in the Notes of Tables 4 and 5-9, respectively.

4.2 SMM estimation and quantitative results

We now consider the second group of parameters. Due to the model's complexity, we resort to numerical methods to solve the model by linearizing the dynamic equations around the steady state.[22] We assume that the intensity parameters of investment adjustment costs in both the market and home sectors are identical (i.e., $\psi_m = \psi_h = \psi$), the persistent parameters are identical (i.e., $\rho_m = \rho_h = \rho$) and the variances of technology shocks in the market and home sectors are identical (i.e., $\sigma_m^2 = \sigma_h^2 = \sigma^2$).[23] Then, as our benchmark estimation, we employ SMM to estimate the following vector of parameters $\zeta = \{\theta, \psi, \rho, \sigma^2\}$ by minimizing the difference between the empirical and simulated moments from the model. The data that we use for Canada and Mexico come from the OECD database for the period 1976:I-2008:III and 1987:I-2008:III, respectively. We thus have a sample size of $T = 131$ for Canada and 87 for Mexico. Let m denote the vector of moments computed from actual data and m^s denote the vector of average simulated moments over N simulations from our model with the same sample size. In addition, in line with Beaudry and Portier (2004) and Karnizova (2010), we set $N = 20$. Formally, the estimator of ζ can be described as:

$$\tilde{\zeta} = \arg\min J(\zeta) = \frac{TN}{1+N}[m - m^s(\zeta)]W[m - m^s(\zeta)]', \tag{12}$$

where W denotes a positive-definite of the weighting matrix.[24]

[20] Based on Schmitt-Grohé and Uribe (2003), the presence of the parameter η reflecting the borrowing premium in association with the default risk ensures that the model is stationary. In addition, a small value of η implies that the borrowing premium in association with the default risk cannot affect the short-run dynamics of the model. Therefore, we set $\eta = 0.00001$ in the two economies to satisfy these two purposes. Moreover, we will show that the model is able to characterize business cycles in small open economies even with the strict restriction of an identical η in the two economies. Our model will have better performance to capture business cycles in small open economies when this restriction is relaxed.

[21] In the literature on home production, a positive correlation between market technology shocks and home technology shocks plays a role in explaining the synchronized relationship between market investment and home investment in the United States (see the more detailed discussion in Greenwood *et al.* (1995)). Therefore, as a robustness check in the next subsection, we show that allowing market and home technology shocks to be positively correlated does not affect our main results.

[22] The stationary expressions of variables and derivations are relegated to Appendix A.

[23] Allowing the parameters to be different would enable the model to fit the data more easily.

[24] W is computed by the Newey-West estimator.

The five target moments we select are informative for estimating SMM parameters. The reasons for choosing these target moments to estimate the vector of parameters ζ can be explained as follows. First, it is reasonable to expect that the standard deviation of output $std(\hat{y}_t)$ can provide information on the variance of technology shocks σ^2. Second, as we will show later, the standard deviation of market consumption $std(\hat{c}_{m,t})$ and the correlation coefficient between the trade balance-to-GDP ratio and output $corr(\hat{b}_t, \hat{y}_t)$ are crucially related to the utility share of market consumption θ, and hence can provide information for estimating θ. Third, the standard deviation of investment $std(\hat{I}_t)$ is informative for estimating the persistence parameter of the total factor productivity process ρ. Finally, the correlation coefficient between investment and output $corr(\hat{I}_t, \hat{y}_t)$ can provide information on the intensity parameter of investment adjustment costs ψ. A summary of the estimated parameters in the benchmark model with home production for Canada and Mexico is reported in Part A of Table 4. In addition, a summary of the targeted, selected and simulated moments for Canada and Mexico is reported in Part B of Table 4.

We first discuss the quantitative results generated from the benchmark estimation for Canada, which represents developed economies. As shown in the first row in Part A of Table 4, the utility share of market consumption θ is estimated to be equal to 0.480. The intensity parameter of investment adjustment costs ψ is estimated to be 0.196. The persistence of the total factor productivity process and the variance of technology shocks are estimated to be $\rho = 0.614$ and $\sigma^2 = 0.507$, respectively. It should be noted that the J statistic described in equation (12) is asymptotically chi-square with 1 degree of freedom (i.e., the number of over-identification restrictions). The chi-square statistic at the 95% level is $\chi^2_{0.95}(1) = 3.84$, and the test statistic $J = 1.65$ implies that the model cannot be rejected by the data. The third column in Part B of Table 4 shows that simulated moments from the benchmark model are close to empirical moments from the Canadian economy. Specifically, the benchmark model features that market consumption is less volatile than GDP (i.e., $std(\hat{c}_{m,t})/std(\hat{y}_t) = 0.87$), investment is more volatile than GDP (i.e., $std(\hat{I}_t)/std(\hat{y}_t) = 2.92$) and the trade balance-to-GDP ratio is weakly countercyclical (i.e., $corr(\hat{b}_t, \hat{y}_t) = -0.28$). Furthermore, the following simulated moments $std(\hat{b}_t) = 0.98$, $corr(\hat{c}_{m,t}, \hat{y}_t) = 0.65$ and $corr(\hat{I}_t, \hat{y}_t) = 0.77$ are close to the data.

We next focus on the quantitative results generated from the benchmark model estimated for Mexico, which represents an emerging market. As shown in the second row in Part A of Table 4, the utility share of market consumption θ is estimated to be 0.431. The intensity parameter of the investment adjustment cost ψ is estimated to be 1.028. The persistence of the total factor productivity process and the variance of technology shocks are estimated to be $\rho = 0.969$ and $\sigma^2 = 0.599$, respectively. It is useful to note that the chi-square statistic at the 95% level is $\chi^2_{0.95}(1) = 3.84$, and thus the test statistic $J = 0.27$ implies that the model cannot be rejected by the data. As reported in the fourth column in Part B of Table 4, simulated moments from the benchmark model are close to the empirical moments from Mexico. More importantly, given the estimated values of the parameters, we find that market consumption is more volatile than GDP (i.e., $std(\hat{c}_{m,t})/std(\hat{y}_t) = 1.33$) and the trade balance-to-GDP ratio is more volatile and more countercyclical (i.e., $std(\hat{b}_t) = 2.35$ and $corr(\hat{b}_t, \hat{y}_t) = -0.52$) in the emerging market. Furthermore, the following simulated moments $std(\hat{I}_t)/std(\hat{y}_t) = 2.91$, $corr(\hat{c}_{m,t}, \hat{y}_t) = 0.76$ and $corr(\hat{I}_t, \hat{y}_t) = 0.75$ are close to the data.

Table 4: SMM estimation: Benchmark model

Part A: SMM parameters

Models		θ	ψ	ρ	σ^2	J
Benchmark model	Canada	0.480 (0.004)	0.196 (0.027)	0.614 (0.051)	0.507 (0.052)	1.65
	Mexico	0.431 (0.005)	1.028 (0.131)	0.969 (0.008)	0.599 (0.049)	0.27
Sensitivity analysis	Canada	–	0.394 (0.038)	–	–	0.18
	Mexico	–	0.227 (0.036)	–	–	0.20

Part B: Targeted, selected, and simulated moments

	Data		Benchmark model		Sensitivity analysis	
Moments	Canada	Mexico	Canada	Mexico	Canada	Mexico
$std(\hat{y}_t)$	1.37	2.13	1.44	2.00	1.21	2.70
$std(\hat{c}_{m,t})$	1.15 (0.84)	2.74 (1.29)	1.26 (0.87)	2.66 (1.33)	1.12 (0.93)	2.81 (1.04)
$std(\hat{I}_t)$	4.13 (3.01)	6.25 (2.93)	4.21 (2.92)	5.80 (2.91)	3.19 (2.63)	8.49 (3.14)
$std(\hat{n}_{m,t})$	1.44 (1.05)	1.37 (0.64)	0.94 (0.65)	1.25 (0.63)	0.80 (0.66)	1.83 (0.68)
$std(\hat{b}_t)$	0.89	1.36	0.98	2.35	0.77	2.73
$corr(\hat{c}_{m,t}, \hat{y}_t)$	0.56	0.75	0.65	0.76	0.66	0.62
$corr(\hat{I}_t, \hat{y}_t)$	0.71	0.86	0.77	0.75	0.78	0.71
$corr(\hat{n}_{m,t}, \hat{y}_t)$	0.84	0.63	0.99	0.99	0.99	0.99
$corr(\hat{b}_t, \hat{y}_t)$	−0.10	−0.59	−0.28	−0.52	−0.28	−0.35

Notes: In Part A, based on the statistics of targeted moments in Part B, the reported values of SMM parameters with the standard deviations in the parentheses are computed by using 500 replications of the estimation procedure, and the variances of the aggregate factor productivity shock are reported in percentage terms. Based on the benchmark estimation, the values of ω are set to 2.60 and 1.03 for Canada and Mexico, respectively. Based on the sensitivity analysis, the values of ω are set to 2.31 and 1.40 for Canada and Mexico, respectively. In the benchmark estimation of Part B, the SMM targeted moments are: $std(\hat{y}_t)$, $std(\hat{c}_{m,t})$, $std(\hat{I}_t)$, $corr(\hat{I}_t, \hat{y}_t)$, and $corr(\hat{b}_t, \hat{y}_t)$, and the selected moments are $std(\hat{n}_{m,t})$, $std(\hat{b}_t)$, $corr(\hat{c}_{m,t}, \hat{y}_t)$, and $corr(\hat{n}_{m,t}, \hat{y}_t)$. In the sensitivity analysis of Part B, the SMM targeted moments are $corr(\hat{c}_{m,t}, \hat{y}_t)$ and $corr(\hat{I}_t, \hat{y}_t)$, and the others are the selected moments. All variables are de-trended by the HP-filter with the smoothing parameter set to 1,600. The standard deviations of output and consumption are reported in percentage terms, and the ratios of each standard deviation to the standard deviation of output are stated in the parentheses. While the sampling periods are 1976:I-2008:III for Canada and 1987:I-2008:III for Mexico, the simulated moments are the averages across 1,000 replications of 131 periods for Canada and 87 periods for Mexico.

The quantitative results imply that even in the presence of a sizable income effect on labor supply, our benchmark model with home production can capture main business cycle moments well for both developed economies and emerging markets. More importantly, it reveals that the different estimated values of parameters (i.e., $\{\theta, \psi, \rho, \sigma^2\}$) between developed economies and emerging markets can characterize the main differences in business cycles across the two countries. We now analyze the differences in the four estimated parameters across the countries as follows.

First, the utility share of market consumption θ is higher in Canada (0.480) than in Mexico (0.431). It is worth noting that θ is related to the average value of home hours worked n_h. The time-use survey data can confirm that the estimated values of θ in Canada and Mexico are plausible. Given that the overall non-sleeping time is assumed to be 16 hours per day in both countries, Table 5 summarizes the data and simulated home hours worked. As shown in Table 5, the benchmark model generates $n_h = 0.178$ in Canada and 0.340 in Mexico. These simulated values are close to the empirical values of 0.197 in Canada and 0.273 in Mexico. Therefore, the difference in the estimated values of θ across the two countries reasonably reflects the fact that people spend more time on home production in an emerging market than in a developed economy.[25] Second, we estimate that the intensity parameter of investment adjustment costs ψ is lower in Canada (0.196) than in Mexico (1.028). This result implies that the efficiency of capital allocation is higher in developed economies than in emerging markets in accordance with the empirical study of Wurgler (2000).

Table 5: Home hours worked (n_h) in Canada and Mexico

	Canada	*Mexico*
data	0.197	0.273
(1) benchmark	0.178	0.340
(2) $\psi = 0.6$	0.166	0.373
(3) $\mu > 0$	0.216	0.433

Notes: Rows (1), (2), and (3) report the average values of home hours for Canada and Mexico, which are derived from the benchmark model, the model with an identical value of ψ in the two countries (i.e., $\psi = 0.6$), and the model with a positive correlation between shocks (i.e., $\mu > 0$), respectively.

Third, the persistence of the total factor productivity process ρ is lower in Canada (0.614) than in Mexico (0.969). This result is consistent with the finding of Aguiar and Gopinath (2007), who show that permanent shocks (trend shocks) to the total factor productivity are more important for Mexico than for Canada. Fourth, the estimate for the variance of technology shocks σ^2 is lower in Canada (0.507) than in Mexico (0.599). In the real business cycle model, the variance of technology shocks is commonly used to measure the volatility of output. Therefore, it is hardly surprising that a higher variance of technology shocks will generate the higher volatility of output in Mexico.

One attractive feature is the differences in the fluctuations in labor between Canada and Mexico.[26] It should be noted that market hours worked $n_{m,t}$ is measured by total hours worked, which is approximated by multiplying the hours worked per worker by total

[25] In the benchmark model, we focus on the share of market consumption θ that reflects the scale of the market sector in explaining the major differences in business cycles between developed economies and emerging markets. A related study by Gomme and Zhao (2011) instead focuses on the long-run technology levels in the market and home sectors and the transmission of technology shocks across the market and home sectors. Specifically, they offer an explanation of the high volatility of market consumption in Mexico by proposing that the long-run technology level is lower in the market sector than in the home sector and that market technology shocks can be transmitted to the home sector. Moreover, in the present study, we use a general preference that nests the KPR and GHH preferences to discuss the major features of business cycles involving the volatility and countercyclicality of the trade balance-to-GDP ratio in emerging markets in addition to the volatility of market consumption.

[26] Another potential issue in emerging market economies relates to the business fluctuations in the interest rate. However, when we follow Schmitt-Grohé and Uribe (2003) to let the parameter η in equation (10) be a tiny value, in our model the interest rate is generated to be approximately fixed when the economy experiences technology shocks. Accordingly, similar to Schmitt-Grohé and Uribe (2003), Aguiar and Gopinath (2007), and Boz et al. (2011), among other small open RBC models, our model

employment.[27] The empirical data reveal two facts in both countries. First, the market hours worked is about as volatile as output in Canada ($std(\hat{n}_{m,t})/std(\hat{y}_t) = 1.05$), and the market hours worked is less volatile than output in Mexico ($std(\hat{n}_{m,t})/std(\hat{y}_t) = 0.64$). Second, the market hours worked is more pro-cyclical in Canada than in Mexico. However, the benchmark model can show that $std(\hat{n}_{m,t})/std(\hat{y}_t)$ is around 0.65, and $corr(\hat{n}_{m,t}, \hat{y}_t)$ is nearly close to unity in both countries. The model cannot characterize the two facts very well, since it is not able to generate the differences in the fluctuations in labor between the two countries. This is possibly because the differences in labor market frictions between the two countries are omitted in our current discussion.[28]

The results of our benchmark estimation show that the model does a good job by indicating that market consumption is more volatile and the trade balance-to-GDP ratio is more countercyclical in Mexico as the targeted moments include $std(\hat{c}_{m,t})$ and $corr(\hat{b}_t, \hat{y}_t)$. One potential concern naturally arises in our analysis: can our model still capture the differences in business cycles between Canada and Mexico, if we use the alternative targeted moments? In order to address this concern, we provide a sensitivity analysis to check whether the results of the benchmark estimation still hold under the alternative targeted moments.

We implement the sensitivity analysis by taking the following steps. First, we generate the time series of productivity in the market sector by constructing Solow residuals for both Canada and Mexico, and estimate the persistence ρ and variance σ^2 under the first-order autoregressive process reported in equation (4a).[29] With this operation, we estimate $\rho = 0.767$ and $\sigma^2 = 0.283$ in Canada and $\rho = 0.741$ and $\sigma^2 = 1.254$ in Mexico. Second, we calibrate the utility share of market consumption θ to match the realized average home hours worked of $n_h = 0.197$ for Canada and 0.273 for Mexico. As a result, θ is calibrated as 0.472 for Canada and 0.451 for Mexico.[30] Third, we use the

cannot capture the realized fluctuations in the interest rate. One possible way to explain the realized movement in the interest rate is, in line with Neumeyer and Perri (2005) and Li (2011), to incorporate the stochastic interest rate processes into the model.

[27]In line with Neumeyer and Perri (2005), Aguiar and Gopinath (2007), Li (2011), and Boz et al. (2015), we use the hours worked per worker in the manufacturing sector as a proxy for the hours worked per worker. For Canada, the data on the hours worked per worker in the manufacturing sector and total employment are all obtained from the OECD database. For Mexico, the data on the hours worked per worker in the manufacturing sector in 1994:I-2008:III and total employment in 2000:I-2008:III are retrieved from the INEGI database. Then, we use the data provided by Neumeyer and Perri (2005) to extend both series back to 1987:I. It should be noted that the series are all seasonally adjusted using the X-12 ARIMA program provided by the U.S. Census Bureau.

[28]For example, based on the OECD database, we find that the average index of strictness of employment protection from 1990-2013 is 0.92 for Canada, and 2.19 for Mexico. This can be interpreted as a signal that the degree of labor market frictions is lower in Canada than in Mexico, and thus can be treated as a plausible reason to explain why the volatility of market hours worked (relative to the volatility of output) is higher in Canada than in Mexico.

[29]We follow Aguiar and Gopinath (2007) and Li (2011) to construct Solow residuals for both Canada and Mexico, which is given by $\log A_{m,t} = \log(y_t) - \alpha \log(k_{m,t}) - (1-\alpha)\log(n_{m,t})$. We first set $\alpha = 0.33$ in the calibration of the benchmark model, and then measure y_t and $n_{m,t}$ by using real GDP and total worked hours. The stock of capital $k_{m,t}$ follows the law of motion of capital $k_{m,t+1} = (1-\delta_m)k_{m,t} + I_{m,t}$, and we can then generate $k_{m,t+1}$ by using investment $I_{m,t}$ and the initial stock of capital as δ_m is set to 0.03. Moreover, in line with Li (2011), we use the data for the investment to capital ratio provided by Nehru and Dhareshwar (1993) to construct the initial stock of capital for Canada in 1976 and for Mexico in 1987.

[30]The stationary relationship stated in equations (A3)-(A8) in Appendix A indicates that the stationary value of home hours n_h is correlated with both ψ and θ. Therefore, when we estimate ψ, the

correlation coefficients between market consumption and output as well as investment and output $\{corr(\hat{c}_{m,t}, \hat{y}_t), corr(\hat{I}_t, \hat{y}_t)\}$ as the alternative targeted moments to estimate one parameter, namely, the intensity of investment adjustment costs ψ. Finally, we report the estimation results of the sensitivity analysis in Parts A and B of Table 4.

As stated in Part A of Table 4, in the sensitivity analysis, we estimate $\psi = 0.394$ and 0.227 in Canada and Mexico, respectively. The test statistics of $J = 0.18$ in Canada and 0.20 in Mexico imply that, with the targeted moments $\{corr(\hat{c}_{m,t}, \hat{y}_t), corr(\hat{I}_t, \hat{y}_t)\}$, the model cannot be rejected by the data from these two countries as the chi-square statistic at the 95% level is $\chi^2(1) = 3.84$ with 1 degree of freedom.

In the sensitivity analysis exhibited in Part B of Table 4, the following results imply that the model is able to capture the differences in business cycles between Canada and Mexico. First, the model generates $std(\hat{c}_{m,t})/std(\hat{y}_t) = 0.93$ in Canada and 1.04 in Mexico, and this indicates the fact that market consumption is less (more) volatile than output in developed economies (emerging markets). Second, the model generates that $std(\hat{b}_t)$ is 0.77 and 2.73 in Canada and Mexico, respectively, and $corr(\hat{b}_t, \hat{y}_t)$ is -0.28 and -0.35 in the two countries, respectively. This implies the fact that the trade balance-to-GDP ratio is more volatile and more countercyclical in emerging markets than in developed economies.

4.3 Robustness

Given our basic premise that the channel of home production is crucial for understanding the different patterns of business cycles in developed economies and emerging markets, we further explore the importance of this channel. To this end, we also use SMM to estimate the model in the other four scenarios for robustness checks.

4.3.1 Calibrating using time-use survey data

We first calibrate our model to match the average values of home hours worked of $n_h = 0.197$ for Canada and 0.273 for Mexico. Then, we consider three possible circumstances to characterize the phenomenon that people engage in fewer (more) home hours worked in Canada (Mexico). It should be noted that in each circumstance, we only use a parameter to capture the difference in the home hours worked across two countries, and other calibrated parameters are kept the same as those reported in Table 3.

First, in line with Benhabib et al. (1991) and Greenwood et al. (1995), we directly calibrate the utility share of market consumption θ by using n_h, and hence we can calibrate $\theta = 0.472$ for Canada and 0.451 for Mexico.[31] In addition, we make an assumption that in the remaining two circumstances, θ is set to be identical as 0.451 in both countries. This assumption is convenient since the calibrated parameters for Mexico are all the same for the three circumstances.

Second, we calibrate the stationary value of productivity in the market sector A_m to match n_h in both countries. Given that the stationary value of TFP in the home sector

calibrated value of θ should be varied to maintain the $n_h = 0.197$ for Canada and 0.273 for Mexico. Finally, given the SMM estimation of ψ, we can calibrate $\theta = 0.472$ for Canada and 0.451 for Mexico.

[31] It should be noted that since the effect of the changes in ψ on n_h is not significant, the calibrated values of θ in this case and in the sensitivity analysis reported in sub-section 4.2 are very similar (but not exactly equivalent).

is normalized as $A_h = 1$ in the two countries, A_m is calibrated to be 1.119 and 1 for Canada and Mexico, respectively.[32] Two facts regarding this case should be mentioned. On the one hand, while A_m is greater than A_h in Canada, market goods are cheaper than home goods, and hence the household provides fewer home hours worked.[33] On the other hand, it is plausible to set A_m in Canada (1.119) as being higher than in Mexico (1), since the empirical evidence supports the view that the difference in income per capita across countries can be explained by the total factor productivity differences in the market sector (Hall and Jones, 1999; Caselli, 2005).

Third, we use n_h to calibrate the production share of labor in the home production sector α_h in both countries. Given that the countries have identical production shares of labor in the market sector $\alpha_m = 0.33$, α_h is calibrated to be 0.267 and 0.33 for Canada and Mexico, respectively.[34] This reveals the fact that home production is less labor-intensive in Canada than in Mexico. The implication for this result is consistent with the findings in Greenwood et al. (2005), de V. Cavalcanti and Tavares (2008), and Cubas (2016) that the developed economies experience a substantial diffusion of home appliances, and hence the households in these economies can save time when dealing with household chores.

A summary of three circumstances, i.e., the models associated with calibrated θ, A_m, and α_h, is reported in Part A of Table 6. In addition, a summary of the targeted, selected and simulated moments of three circumstances is reported in Part B of Table 6.

As shown in Part A of Table 6, under the first circumstance in association with the calibrated value of θ, there does not exist much of a difference in the estimated values of parameters between this circumstance and the benchmark estimation. In addition, the test statistics of $J = 2.72$ in Canada and 1.53 in Mexico imply that the model cannot be rejected by the data from the two countries as the chi-square statistic at the 95% level is $\chi^2(2) = 5.99$ with 2 degrees of freedom. Therefore, in Part B of Table 6, we can find that the simulated moments from this model are close to the actual data moments from Canada and Mexico. The result implies that even though we use n_h to calibrate θ rather than use $std(\hat{c}_{m,t})$ to estimate θ, the model can capture the major differences in business cycles between developed economies and emerging markets.

Moreover, Part A of Table 6 reports that the estimated values of the parameters are close in three circumstances where the models are associated with calibrated θ, A_m, and α_h, respectively. More importantly, just as in the model with calibrated θ, the model with calibrated A_m and α_h cannot be rejected by the data from the two countries, while the test statistics are repectively $J = 1.32$ and 2.74 in these two circumstances for Canada. Part B of Table 6 indicates that the models with calibrated A_m and α_h, respectively, can still characterize business cycles in Canada. Consequently, the results reveal an essential implication that the differences in business fluctuations between developed economies and

[32] Based on the stationary relationship stated in equations (A3)-(A8) in Appendix A, we can find that when we estimate ψ, the calibrated value of A_m should be varied to maintain $n_h = 0.197$ for Canada and 0.273 for Mexico. Finally, given the SMM estimation of ψ, we can calibrate $A_m = 1.119$ for Canada and $A_m = 1$ for Mexico.

[33] This result is supported by Cubas (2016) since he finds that the rise in the real wage driven by the rise in total factor productivity in the market sector can provide an incentive for females to increase the labor supply in the market sector and reduce the hours devoted to housework.

[34] Similar to the method used to calibrate A_m mentioned in footnote 5, when we estimate ψ, the calibrated value of α_h should be varied to maintain $n_h = 0.197$ for Canada and 0.273 for Mexico. Finally, given the SMM estimation of ψ, we can calibrate $\alpha_h = 0.267$ for Canada and $\alpha_h = 0.33$ for Mexico.

emerging markets can be explained by their differences in home hours worked, regardless of whether they are in the models with calibrated θ, A_m, and α_h, respectively.

Table 6: Robustness check: Calibrating using time-use survey data

Part A: SMM parameters

Models	ψ	ρ	σ^2	J
Canada				
Circumstance (1): Model with calibrated θ	0.225 (0.064)	0.672 (0.089)	0.423 (0.053)	2.72
Circumstance (2): Model with calibrated A_m	0.259 (0.047)	0.633 (0.091)	0.496 (0.035)	1.32
Circumstance (3): Model with calibrated α_h	0.281 (0.023)	0.748 (0.031)	0.372 (0.030)	2.74
Mexico	1.378 (0.251)	0.977 (0.012)	0.726 (0.069)	1.53

Part B: Targeted, selected, and simulated moments

	Data		Models			
Moments	Canada	Mexico	Canada			Mexico
			Circumstance (1)	*Circumstance* (2)	*Circumstance* (3)	
$std(\hat{y}_t)$	1.37	2.13	1.40	1.48	1.40	2.04
$std(\hat{c}_{m,t})$	1.15 (0.84)	2.74 (1.29)	1.28 (0.92)	1.26 (0.86)	1.28 (0.92)	2.60 (1.27)
$std(\hat{I}_t)$	4.13 (3.01)	6.25 (2.93)	4.12 (2.95)	4.15 (2.81)	4.27 (3.04)	5.82 (2.85)
$std(\hat{n}_{m,t})$	1.44 (1.05)	1.37 (0.64)	0.92 (0.66)	1.01 (0.68)	0.92 (0.66)	1.24 (0.61)
$std(\hat{b}_t)$	0.89	1.36	1.05	0.87	1.11	2.05
$corr(\hat{c}_{m,t}, \hat{y}_t)$	0.56	0.75	0.65	0.68	0.67	0.84
$corr(\hat{I}_t, \hat{y}_t)$	0.71	0.86	0.75	0.80	0.74	0.78
$corr(\hat{n}_{m,t}, \hat{y}_t)$	0.84	0.63	0.99	0.99	0.99	0.97
$corr(\hat{b}_t, \hat{y}_t)$	−0.10	−0.59	−0.31	−0.26	−0.32	−0.58

Notes: In Part A, based on the statistics of targeted moments in Part B, the reported values of SMM parameters with the standard deviations in the parentheses are computed by using 500 replications of the estimation procedure, and the variances of the aggregate factor productivity shock are reported in percentage terms. The values of ω are respectively set to 2.31, 2.35, and 2.31 for Canada in association with Circumstances (1)-(3) and 1.40 for Mexico. In Part B, the SMM targeted moments are: $std(\hat{y}_t)$, $std(\hat{c}_{m,t})$, $std(\hat{I}_t)$, $corr(\hat{I}_t, \hat{y}_t)$, and $corr(\hat{b}_t, \hat{y}_t)$, and the selected moments are $std(\hat{n}_{m,t})$, $std(\hat{b}_t)$, $corr(\hat{c}_{m,t}, \hat{y}_t)$, and $corr(\hat{n}_{m,t}, \hat{y}_t)$. All variables are de-trended by the HP-filter with the smoothing parameter set to 1,600. The standard deviations of output and consumption are reported in percentage terms, and the ratios of each standard deviation to the standard deviation of output are stated in the parentheses. While the sampling periods are 1976:I-2008:III for Canada and 1987:I-2008:III for Mexico, the simulated moments are the averages across 1,000 replications of 131 periods for Canada and 87 periods for Mexico.

4.3.2 Restricting the value of ψ to 0.6

Second, in order to show that the different values of θ are mainly driving the differences in the business cycle moments across developed economies and emerging markets, we estimate the model by restricting the value of ψ to be identical across Canada and Mexico. Specifically, we set ψ to 0.6 in both Canada and Mexico. Then, given $\psi = 0.6$, the vector of SMM parameters is $\{\theta, \rho, \sigma^2\}$. A summary of the estimated parameters in the model with an identical value of ψ across countries (i.e., $\psi = 0.6$) is reported in Part A of Table 7. In addition, a summary of the targeted, selected and simulated moments for Canada and Mexico is reported in Part B of Table 7.

Table 7: Robustness check: Restricting the value of ψ to 0.6

Part A: SMM parameters

Parameters	θ	ρ	σ^2	J
Canada	0.486 (0.040)	0.855 (0.009)	0.404 (0.036)	2.04
Mexico	0.421 (0.006)	0.934 (0.008)	0.470 (0.019)	0.91

Part B: Targeted, selected, and simulated moments

	Data		Model ($\psi = 0.6$)	
Moments	Canada	Mexico	Canada	Mexico
$std(\hat{y}_t)$	1.37	2.13	1.51	1.95
$std(\hat{c}_{m,t})$	1.15 (0.84)	2.74 (1.29)	1.30 (0.86)	2.46 (1.26)
$std(\hat{I}_t)$	4.13 (3.01)	6.25 (2.93)	4.15 (2.75)	5.73 (2.94)
$std(\hat{n}_{m,t})$	1.44 (1.05)	1.37 (0.64)	0.96 (0.64)	1.30 (0.67)
$std(\hat{b}_t)$	0.89	1.36	0.91	2.41
$corr(\hat{c}_{m,t}, \hat{y}_t)$	0.56	0.75	0.73	0.65
$corr(\hat{I}_t, \hat{y}_t)$	0.71	0.86	0.78	0.71
$corr(\hat{n}_{m,t}, \hat{y}_t)$	0.84	0.63	0.98	1.00
$corr(\hat{b}_t, \hat{y}_t)$	−0.10	−0.59	−0.29	−0.40

Notes: In Part A, based on the statistics of targeted moments in Part B, the reported values of SMM parameters with the standard deviations in the parentheses are computed by using 500 replications of the estimation procedure, and the variances of the aggregate factor productivity shock are reported in percentage terms. The values of ω are set to 2.80 and 0.89 for Canada and Mexico, respectively. In Part B, the SMM targeted moments are: $std(\hat{y}_t)$, $std(\hat{c}_{m,t})$, $std(\hat{I}_t)$, $corr(\hat{I}_t, \hat{y}_t)$, and $corr(\hat{b}_t, \hat{y}_t)$, and the selected moments are $std(\hat{n}_{m,t})$, $std(\hat{b}_t)$, $corr(\hat{c}_{m,t}, \hat{y}_t)$, and $corr(\hat{n}_{m,t}, \hat{y}_t)$. All variables are de-trended by the HP-filter with the smoothing parameter set to 1,600. The standard deviations of output and consumption are reported in percentage terms, and the ratios of each standard deviation to the standard deviation of output are stated in the parentheses. While the sampling periods are 1976:I-2008:III for Canada and 1987:I-2008:III for Mexico, the simulated moments are the averages across 1,000 replications of 131 periods for Canada and 87 periods for Mexico.

In the quantitative results of the model with an identical value of ψ across Canada and Mexico (i.e., $\psi = 0.6$), as depicted in Part A of Table 7, the estimates are similar to the estimates of the benchmark model. It should be noted that the J statistic described in equation (12) is asymptotically chi-square with 2 degrees of freedom (i.e., the number of over-identification restrictions). The chi-square statistic at the 95% level is $\chi^2_{0.95}(2) = 5.99$, and thus the test statistics of $J = 2.04$ in Canada and 0.91 in Mexico imply that the model cannot be rejected by the data from the two countries. As reported in Part B of Table 7, the simulated moments from this model are close to the empirical moments from Canada and Mexico. In addition, Table 5 shows that this model generates $n_h = 0.166$ in Canada and 0.373 in Mexico, which are close to their empirical values. Accordingly, the results of this model reveal that except for the persistent parameter ρ and the variance of technology shocks σ^2, this study only relies on the differences in the utility share of market consumption θ to capture the main differences in the features of business cycles across developed economies and emerging markets (i.e., $\theta = 0.486$ in Canada and 0.421 in Mexico).

4.3.3 Allowing for a positive correlation between shocks

Third, we estimate the model in the presence of a positive correlation between market technology shocks and home technology shocks (i.e., $corr(\varepsilon_{m,t}, \varepsilon_{h,t}) > 0$). We let $\mu \equiv corr(\varepsilon_{m,t}, \varepsilon_{h,t})$, and also set $\mu = 0.45$ under which the model generates a synchronized relationship between market investment and home investment. A summary of the estimated parameters in the model with a positive correlation between shocks (i.e., $\mu > 0$) is reported in Part A of Table 8. In addition, a summary of the targeted, selected and simulated moments for Canada and Mexico is reported in Part B of Table 8.

Table 8: Robustness check: Allowing for a positive correlation between shocks

Part A: SMM parameters

Parameters	θ	ψ	ρ	σ^2	J
Canada	0.465 (0.008)	0.466 (0.087)	0.787 (0.051)	0.450 (0.040)	1.06
Mexico	0.405 (0.006)	1.596 (0.156)	0.979 (0.003)	0.837 (0.050)	0.13

Part B: Targeted, selected, and simulated moments

	Data		Model ($\mu > 0$)	
Moments	Canada	Mexico	Canada	Mexico
$std(\hat{y}_t)$	1.37	2.13	1.47	2.05
$std(\hat{c}_{m,t})$	1.15 (0.84)	2.74 (1.29)	1.17 (0.80)	2.71 (1.32)
$std(\hat{I}_t)$	4.13 (3.01)	6.25 (2.93)	4.09 (2.78)	5.99 (2.92)
$std(\hat{n}_{m,t})$	1.44 (1.05)	1.37 (0.64)	0.91 (0.62)	1.13 (0.55)
$std(\hat{b}_t)$	0.89	1.36	0.94	2.61
$corr(\hat{c}_{m,t}, \hat{y}_t)$	0.56	0.75	0.35	0.59
$corr(\hat{I}_t, \hat{y}_t)$	0.71	0.86	0.79	0.80
$corr(\hat{n}_{m,t}, \hat{y}_t)$	0.84	0.63	0.99	0.98
$corr(\hat{b}_t, \hat{y}_t)$	−0.10	−0.59	−0.11	−0.56

Notes: In Part A, based on the statistics of targeted moments in Part B, the reported values of SMM parameters with the standard deviations in the parentheses are computed by using 500 replications of the estimation procedure, and the variances of the aggregate factor productivity shock are reported in percentage terms. The values of ω are set to 2.07 and 0.71 for Canada and Mexico, respectively. In Part B, the SMM targeted moments are: $std(\hat{y}_t)$, $std(\hat{c}_{m,t})$, $std(\hat{I}_t)$, $corr(\hat{I}_t, \hat{y}_t)$, and $corr(\hat{b}_t, \hat{y}_t)$, and the selected moments are $std(\hat{n}_{m,t})$, $std(\hat{b}_t)$, $corr(\hat{c}_{m,t}, \hat{y}_t)$, and $corr(\hat{n}_{m,t}, \hat{y}_t)$. All variables are de-trended by the HP-filter with the smoothing parameter set to 1,600. The standard deviations of output and consumption are reported in percentage terms, and the ratios of each standard deviation to the standard deviation of output are stated in the parentheses. While the sampling periods are 1976:I-2008:III for Canada and 1987:I-2008:III for Mexico, the simulated moments are the averages across 1,000 replications of 131 periods for Canada and 87 periods for Mexico.

We discuss the quantitative results of the model with a positive correlation between shocks (i.e., $\mu = corr(\varepsilon_{m,t}, \varepsilon_{h,t}) > 0$). In Part A of Table 8, we can see that the estimates are consistent with the estimates of the benchmark model. The chi-square statistic at the 95% level is $\chi^2_{0.95}(1) = 3.84$, and thus the test statistics of $J = 1.06$ in Canada and 0.13 in Mexico imply that the model cannot be rejected by the data from the two countries. As reported in Part B of Table 8, the simulated moments from this model are close to the empirical moments from Canada and Mexico. In addition, Table 5 shows that this model generates $n_h = 0.216$ in Canada and 0.433 in Mexico, which are close to their empirical values. Therefore, even in the presence of a positive correlation between technology shocks, our results are robust.

4.3.4 Removing home production

Fourth, we discuss the robustness of the model without home production by setting $\theta = 1$. In the model without home production, we include the parameter that governs the short-run income effect of labor supply γ in SMM. In other words, the vector of SMM parameters in the benchmark estimation is $\{\gamma, \psi, \rho, \sigma^2\}$ in this scenario. A summary of the estimated parameters in the model without home production (i.e., $\theta = 1$) is reported in Part A of Table 9. In addition, a summary of the targeted, selected and simulated moments for Canada and Mexico is reported in Part B of Table 9.

In the estimation of the model *without home production* (i.e., $\theta = 1$) for Canada and Mexico, as depicted in Part A of Table 9, we find that the parameter γ governing the income effect on labor supply is estimated to be close to zero. An implication is that the income effect on labor supply needs to be absent such that the utility function approximates the GHH preference. This result is consistent with previous findings in Mendoza (1991), Correia *et al.* (1995) and Schmitt-Grohé and Uribe (2003), who show that the volatility of market consumption in a small open economy under the KPR preference is too low compared to its empirical value. Hence one needs to resort to the GHH preference ($\gamma = 0$) in order to raise the volatility of market consumption to match the data.

Can the moments generated from the model *without home production* (i.e., $\theta = 1$) fit the data well? As depicted in Part B of Table 9, in the case of Canada, $std(\hat{c}_{m,t})$ and $corr(\hat{b}_t, \hat{y}_t)$, which are respectively simulated as 0.89 and 0.16, significantly differ from their empirical values (1.15 and -0.10). Therefore, given that the chi-square statistic of $\chi^2_{0.95}(1) = 3.84$ at the 95% level, the test statistic of $J = 17.96$ for Canada implies that the moments generated from this model cannot match the data very well. On the other hand, as depicted in Part B of Table 9, in the case of Mexico, when the channel of home production is absent, the ratio of the standard deviations between market consumption and GDP is simulated to be $std(\hat{c}_{m,t})/std(\hat{y}_t) = 0.59$. In other words, the model has difficulty matching an important stylized fact that the volatility of market consumption exceeds the volatility of GDP. Accordingly, these significant differences between the simulated and empirical values of $std(\hat{c}_{m,t})$ give rise to a test statistic of $J = 22.12$, implying that the model without home production is rejected by the data. By comparing this result with the estimates of the benchmark model, we can see that in the presence of an income effect on labor supply the channel of home production plays a very important role in explaining business cycles in small open economies. More importantly, home production can be viewed as a key vehicle for characterizing the main differences in business cycles between developed economies and emerging markets.

Table 9: Robustness check: Removing home production

Part A: SMM parameters

Parameters	γ	ψ	ρ	σ^2	J
Canada	0.000 (0.000)	3.903 (0.482)	0.941 (0.006)	0.745 (0.052)	17.96
Mexico	0.001 (0.003)	3.801 (0.742)	0.952 (0.012)	1.462 (0.145)	22.12

Part B: Targeted, selected, and simulated moments

	Data		Model ($\theta = 1$)	
Moments	Canada	Mexico	Canada	Mexico
$std(\hat{y}_t)$	1.37	2.13	1.58	2.21
$std(\hat{c}_{m,t})$	1.15 (0.84)	2.74 (1.29)	0.89 (0.56)	1.31 (0.59)
$std(\hat{I}_t)$	4.13 (3.01)	6.25 (2.93)	4.15 (2.63)	6.39 (2.89)
$std(\hat{n}_{m,t})$	1.44 (1.05)	1.37 (0.64)	0.65 (0.41)	0.91 (0.41)
$std(\hat{b}_t)$	0.89	1.36	0.22	0.39
$corr(\hat{c}_{m,t}, \hat{y}_t)$	0.56	0.75	1.00	1.00
$corr(\hat{I}_t, \hat{y}_t)$	0.71	0.86	0.96	0.96
$corr(\hat{n}_{m,t}, \hat{y}_t)$	0.84	0.63	1.00	1.00
$corr(\hat{b}_t, \hat{y}_t)$	−0.10	−0.59	0.16	−0.30

Notes: In Part A, based on the statistics of targeted moments in Part B, the reported values of SMM parameters with the standard deviations in the parentheses are computed by using 500 replications of the estimation procedure, and the variances of the aggregate factor productivity shock are reported in percentage terms. The values of ω are set to 15.69 and 12.77 for Canada and Mexico, respectively. In Part B, the SMM targeted moments are: $std(\hat{y}_t)$, $std(\hat{c}_{m,t})$, $std(\hat{I}_t)$, $corr(\hat{I}_t, \hat{y}_t)$, and $corr(\hat{b}_t, \hat{y}_t)$, and the selected moments are $std(\hat{n}_{m,t})$, $std(\hat{b}_t)$, $corr(\hat{c}_{m,t}, \hat{y}_t)$, and $corr(\hat{n}_{m,t}, \hat{y}_t)$. All variables are de-trended by the HP-filter with the smoothing parameter set to 1,600. The standard deviations of output and consumption are reported in percentage terms, and the ratios of each standard deviation to the standard deviation of output are stated in the parentheses. While the sampling periods are 1976:I-2008:III for Canada and 1987:I-2008:III for Mexico, the simulated moments are the averages across 1,000 replications of 131 periods for Canada and 87 periods for Mexico.

4.4 Impulse responses

We are now in a position to analyze impulse responses in association with technology shocks in the market and home sectors and provide some economic intuition to explain the fluctuations under these shocks. Based on the calibrated and estimated parameter values in the benchmark model, which are reported in Sections 4.1 and 4.2, the impulse responses to technology shocks in Canada and Mexico are depicted in Figures 2 and 3, respectively. It should be noted that the solid line and the dashed line represent the impulse responses to a 1% increase in market technology and home technology, respectively.

These fluctuations driven by market and home technology shocks can be understood by analyzing the following equations. Based on equations (9) and (11), the prices of market consumption and the social resource constraint linearized around the steady state are respectively given by:

$$\hat{p}_t = (1-\phi)(\hat{c}_{h,t} - \hat{c}_{m,t}) = (\hat{c}_{h,t} - \hat{n}_{n,t}) - (\hat{y}_t - \hat{n}_{m,t}), \tag{13a}$$

$$\hat{b}_t = \frac{(1+r)\,\hat{d}_t - \hat{d}_{t+1} + rd\hat{r}_t}{y} - \frac{rd}{y}\hat{y}_t. \tag{13b}$$

In Canada, as exhibited in Figure 2, a positive market technology shock raises market output y_t and market consumption $c_{m,t}$. It also reduces the price of market consumption p_t, home consumption $c_{h,t}$ and the trade balance-to-GDP ratio b_t. By contrast, a positive home technology shock decreases market output y_t and market consumption $c_{m,t}$. It also increases the price of market consumption p_t, home consumption $c_{h,t}$ and the trade balance-to-GDP ratio b_t.

Given $\gamma = 1$ in the benchmark estimation and equations (8a), (8c), (8d), (8i) and (9), the optimal decision regarding market consumption and the non-arbitrage condition between foreign debt and domestic capital linearized around the steady state are respectively given by:

$$\hat{c}_{m,t} = \frac{1}{\tau + (\tau-1)\Omega}\left[(\tau-1)\Omega(\hat{y}_t - \hat{n}_{m,t}) - \hat{\lambda}_t - \frac{1}{1-\phi}\frac{(\tau-1)(1+\phi\Omega)+\phi}{\frac{\theta}{1-\theta}\left(\frac{c_m}{c_h}\right)^{\phi}+1}\hat{p}_t\right],$$

$$where\ \Omega \equiv \frac{\xi\omega N^{\xi}}{(\xi-1)(1-\omega N^{\xi}) + \xi\omega N^{\xi}} \in (0,1), \tag{14a}$$

$$\eta\upsilon E_t\left(\frac{\hat{d}_{t+1}}{d} - \hat{y}_t\right) = E_t\left[\frac{\alpha_h c_h}{pq_h k_h}\left(\hat{c}_{h,t+1} - \hat{k}_{h,t+1} - \hat{p}_{t+1}\right) + \hat{q}_{h,t+1}\right] - \frac{1}{\beta}\hat{q}_{h,t}. \tag{14b}$$

From equation (14a), we find that market consumption $\hat{c}_{m,t}$ is associated with three terms. To be more precise, given that the intertemporal elasticity of substitution in consumption is in general less than unity (i.e., $\tau > 1$), market consumption is positively related to the marginal product of labor $\hat{y}_t - \hat{n}_{m,t}$ and negatively related to the shadow price of foreign debt $\hat{\lambda}_t$ and the price of market consumption $\hat{p}_t$.[35,36] In addition, equation (14b) indicates that the world interest rate (on the left-hand side) equals the capital gains from holding domestic capital (on the right-hand side).

[35] Given that most of the empirical studies support the view that the intertemporal elasticity of substitution in consumption is in general less than unity (i.e., $\tau > 1$), based on equation (14a), we can have: $\frac{\partial \hat{c}_{m,t}}{\partial(\hat{y}_t - \hat{n}_{m,t})} = \frac{\tau-1}{\tau+(\tau-1)\Omega} > 0$, $\frac{\partial \hat{c}_{m,t}}{\partial \hat{\lambda}_t} = \frac{-1}{\tau+(\tau-1)\Omega} < 0$, and $\frac{\partial \hat{c}_{m,t}}{\partial \hat{p}_t} = \frac{-1/(1-\phi)}{\tau+(\tau-1)\Omega}\frac{(\tau-1)(1+\phi\Omega)+\phi}{\frac{\theta}{1-\theta}\left(\frac{c_m}{c_h}\right)^{\phi}+1} < 0$. Moreover, a detailed derivation of equation (14a) is provided in Appendix B.

[36] We set the parameter governing the short-run income effect on labor supply as $\gamma = 1$ in the benchmark model, and hence the utility function is associated with the KPR preference. With the income effect on labor supply, it implies that market consumption is positively related to the equilibrium real wage rate. Accordingly, as shown in equation (14a), given that the real wage rate equals the marginal product of labor in equilibrium, the marginal product of labor has a positive effect on market consumption.

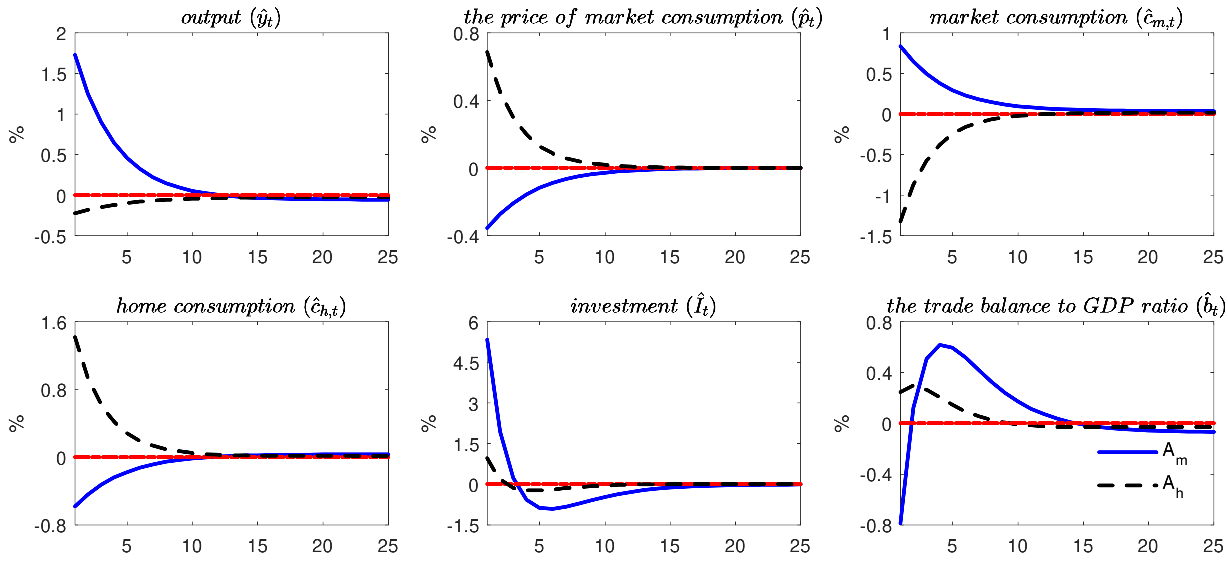

Figure 2: Impulse responses: Canada

Notes: The solid line and dashed line represent the impulse responses to a 1% increase in market technology and home technology, respectively. The values of the parameters are based on the calibration and estimation in the benchmark model.

When the economy experiences a positive market (home) technology shock, it leads to a productivity improvement in the market (home) sector. As a consequence, based on equation (13a), we find that market goods become cheaper (more expensive) than home goods, and hence it reduces (raises) the price of market consumption $\hat{p}_t$. Then from equation (14a), the household increases (decreases) its market output $\hat{y}_t$ and market consumption $\hat{c}_{m,t}$ and decreases (increases) its home consumption $\hat{c}_{h,t}$. On the other hand, based on equation (14b), a lower (higher) $\hat{p}_t$ leads to a rise (reduction) in capital gains from holding domestic capital, and thus the household borrows more (less) foreign debt $\hat{d}_{t+1}$ from the world capital market. Accordingly, equation (13b) shows that capital inflows (outflows) lead to an increase (a decrease) in the trade deficit. As a result, the trade balance-to-GDP ratio displays countercyclicality.

Figure 3 depicts impulse responses to a 1% increase in technology in Mexico. By comparing the impulse responses depicted in Figure 3 with those in Figure 2, we find that the patterns of movement in y_t, p_t, $c_{m,t}$, $c_{h,t}$, I_t, and b_t are similar to the ones in Canada. However, the adjustments of these variables are more persistent (recall that the estimated value of $\rho = 0.969$ in Mexico is higher than the corresponding $\rho = 0.614$ in Canada). As a result, the volatilities of these variables increase in response.

In addition, Figure 3 shows that the volatility of market consumption exceeds the volatility of output. A lower market consumption share θ in Mexico is a plausible explanation to demonstrate this result. Based on equation (14a), we can infer that $\frac{\partial \hat{c}_{m,t}}{\partial \hat{p}_t} < 0$ and $\partial(\frac{\partial \hat{c}_{m,t}}{\partial \hat{p}_t})/\partial\theta > 0$.[37] The former equation reflects the fact that due to the substitution effect between market and home consumption, the increases in the price of market consumption may reduce market consumption. The latter equation illustrates that the

[37] A detailed derivation is provided in Appendix B.

decreases in the market consumption share θ may reinforce this substitution effect on market consumption. Therefore, when home production is more prevalent in Mexico (i.e., a lower value of θ), market consumption becomes less important in smoothing the marginal utility of aggregate consumption. An increase in the substitutability between market and home consumption helps to increase the volatility of market consumption to match the data.

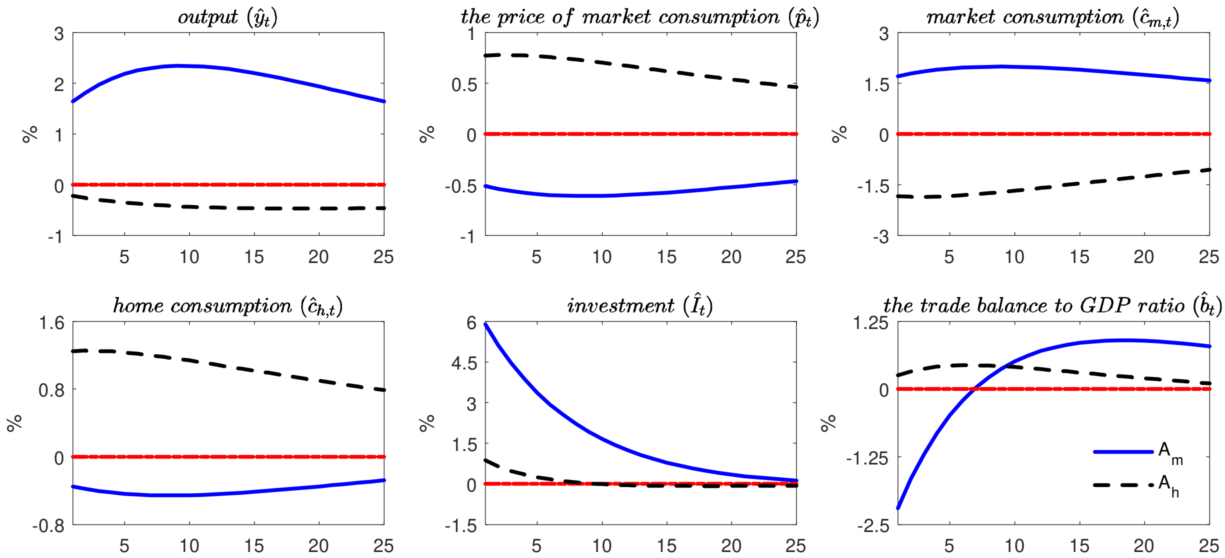

Figure 3: Impulse responses: Mexico

Notes: The solid line and dashed line represent the impulse responses to a 1% increase in market technology and home technology, respectively. The values of the parameters are based on the calibration and estimation in the benchmark model.

A lower value of θ can also explain the reason why the trade balance-to-GDP ratio $\hat{b}_t$ is more volatile and more countercyclical in Mexico. Given that a lower value of θ can raise the volatility of market consumption, equation (13a) shows that a lower value of θ can further raise the volatility of the price of market consumption. According to the previous analysis of the impulse responses of Canada, when a positive market (home) technology shock is present, a more volatile price of market consumption can amplify the decrease (increase) in the trade balance-to-GDP ratio in response. Therefore, a lower value of θ may lead to a more volatile and more countercyclical trade balance-to-GDP ratio $\hat{b}_t$ in Mexico.

4.5 Sensitivity analysis

In the previous subsection, we have provided some economic intuition to explain that a smaller market consumption share θ strengthens the substitution effect between market and home consumption. As a result, it will raise the volatilities of market consumption $\hat{c}_t$, the price of market consumption $\hat{p}_t$, and the trade balance-to-GDP ratio $\hat{b}_t$ and reinforce the countercyclicality of the trade balance-to-GDP ratio $\hat{b}_t$. In order to further clarify the relationship between the market consumption share θ and the business cycle moments, we provide a sensitivity analysis in this subsection.

Figure 4 depicts the sensitivity analysis of the following simulated moments in Canada and Mexico: $std(\hat{c}_{m,t})/std(\hat{y}_t)$, $std(\hat{b}_t)$, and $corr(\hat{b}_t, \hat{y}_t)$. The effects of the market consumption share θ on $std(\hat{c}_{m,t})/std(\hat{y}_t)$, $std(\hat{b}_t)$, and $corr(\hat{b}_t, \hat{y}_t)$ are respectively presented in Parts A, B and C. In Figure 4, the solid line and the dashed line denote the simulated moments of $std(\hat{c}_{m,t})/std(\hat{y}_t)$, $std(\hat{b}_t)$, and $corr(\hat{b}_t, \hat{y}_t)$ in Canada and Mexico, respectively. Each point is computed from the average across 1,000 replications under a value of θ. We take the estimated value of θ as our benchmark and vary its value while holding other parameter values at the same levels as the calibrated and estimated parameter values in the benchmark model, which are reported in Sections 4.1 and 4.2.

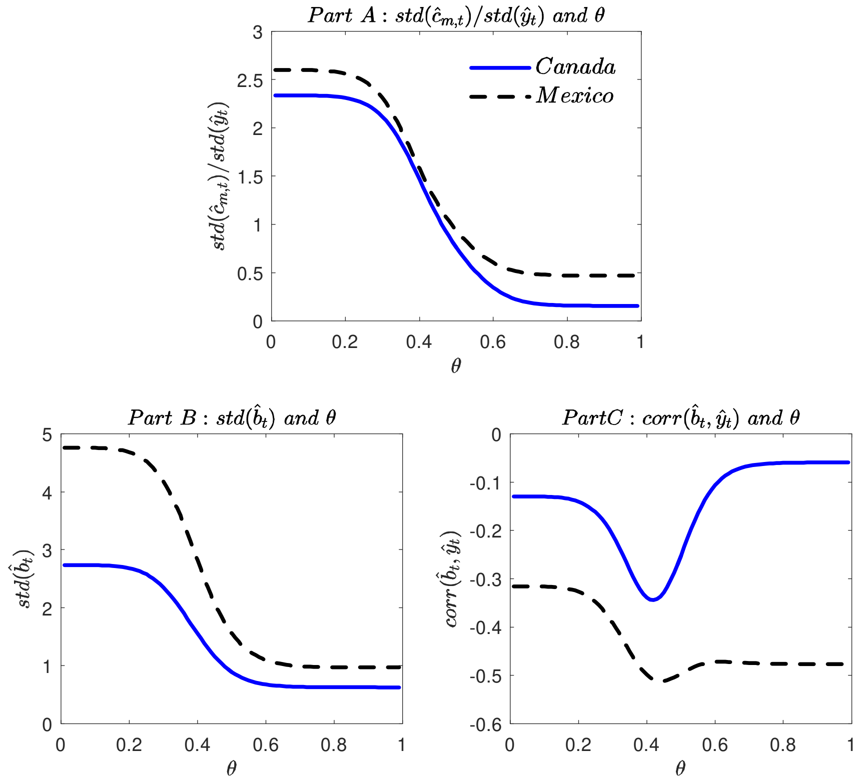

Figure 4: Sensitivity analysis

Notes: The effects of the market consumption share θ on $std(\hat{c}_{m,t})/std(\hat{y}_t)$, $std(\hat{b}_t)$, and $corr(\hat{b}_t, \hat{y}_t)$ are respectively presented in Parts A, B and C. The solid line and the dashed line denote the simulated moments of $std(\hat{c}_{m,t})/std(\hat{y}_t)$, $std(\hat{b}_t)$, and $corr(\hat{b}_t, \hat{y}_t)$ in Canada and Mexico, respectively. Each point is computed from the average across 1,000 replications under a value of θ. We take the estimated value of θ as our benchmark and vary its value while holding other parameter values constant.

In Part A of Figure 4, it can be seen that $std(\hat{c}_{m,t})/std(\hat{y}_t)$ in both countries is decreasing in the value of θ. When home production is absent (i.e., $\theta = 1$), $std(\hat{c}_{m,t})/std(\hat{y}_t)$ equals 0.15 in Canada and 0.46 in Mexico. These simulated values are significantly lower than the empirical values of 0.84 in Canada and 1.29 in Mexico. In addition, because the relative volatility between market consumption and output $std(\hat{c}_{m,t})/std(\hat{y}_t)$ is decreasing in θ, $std(\hat{c}_{m,t})/std(\hat{y}_t)$ converges to its empirical values when θ decreases toward the estimated values of 0.480 in Canada and 0.431 in Mexico. Moreover, given that the value of the income effect parameter $\gamma = 1$ in the benchmark model, we conclude that even in the presence of a significant income effect on labor supply, home production is still a useful channel for explaining business cycles in small open economies. In particular, market consumption is more volatile than output in the emerging market.

Part B of Figure 4 shows that when home production is absent (i.e., $\theta = 1$), the volatility of the trade balance-to-GDP ratio equals 0.62 in Canada and 0.97 in Mexico. These simulated values are substantially smaller than the empirical values of 0.89 in Canada and 1.36 in Mexico. We also find that the volatility of the trade balance-to-GDP ratio is decreasing in θ. When θ decreases from 1 to the estimated values of 0.480 in Canada and 0.431 in Mexico, the volatility of the trade balance-to-GDP ratio increases and becomes 0.98 in Canada and 2.35 in Mexico. These values are close to the empirical values.

Finally, we find that when home production is absent (i.e., $\theta = 1$), $corr(\hat{b}_t, \hat{y}_t) = -0.06$ in Canada. This value is slightly higher than the empirical value of -0.10 in Canada, which features a countercyclical trade balance-to-GDP ratio. As is clear from Part C of Figure 4, $corr(\hat{b}_t, \hat{y}_t)$ in Canada is increasing in θ for $\theta \geq 0.42$. We find that as home production emerges and θ converges to 0.480, $corr(\hat{b}_t, \hat{y}_t)$ equals -0.28, which is close to the empirical value for the Canadian economy. On the other hand, $corr(\hat{b}_t, \hat{y}_t)$ in Mexico is largely invariant with respect to θ for $\theta \geq 0.42$, and it is close to its empirical value of -0.59.

Before ending this subsection, we should discuss two questions related to Part C of Figure 4. First, how can the trade balance-to-GDP ratio display a high degree of countercyclicality when home production is absent in the model of Mexico (i.e., $\theta = 1$)? This is because we estimate that the technology shocks in Mexico have high persistence; i.e., $\rho = 0.969$. In this case, a positive market technology shock leads to a large increase in capital gains from holding market capital due to the forward-looking property. Therefore, on the impact of a positive market technology shock, the household accumulates more market capital and borrows more foreign debt. The increased capital inflows in the capital account lead to a larger reduction in the trade balance-to-GDP ratio $\hat{b}_t$. Thus the trade balance-to-GDP ratio displays a higher degree of countercyclicality even when home production is absent in Mexico.

Second, why does the degree of countercyclicality of the trade balance-to-GDP ratio decrease when θ is close to zero? When θ is close to zero, the level of market consumption is low, and the household only allocates its market output to the accumulation of capital. In this case, even in the presence of a positive home shock, the household has very little room to raise its investment in home capital by reducing the level of market consumption, which is low to begin with. Therefore, in order to accumulate more home capital, the household has to increase its market output. Recall that a positive home shock can increase the trade balance-to-GDP ratio. This implies that when θ is close to zero, the trade balance $\hat{b}_t$ and market output $\hat{y}_t$ have a synchronized relationship under home technology shocks. Consequently, this synchronized relationship leads to a lower degree of countercyclicality in the trade balance-to-GDP ratio.

5 Conclusion

In developed small open economies, output is more volatile than consumption but less volatile than investment, and the trade balance-to-GDP ratio is weakly countercyclical. It is commonly accepted that the presence of an income effect on labor supply would render the RBC model of a small open economy incapable of replicating these business cycle moments due to insufficient volatility of market consumption.[38] Moreover, it would cause the trade balance-to-GDP ratio to become procyclical. Given that empirical studies, such as Imbens *et al.* (2001), Kimball and Shapiro (2010) and Khan and Tsoukalas (2011, 2012), support the view that the income effect on labor supply is significant, it is necessary to find a plausible channel to explain the business cycles of developed small open economies. Furthermore, Neumeyer and Perri (2005) and Aguiar and Gopinath (2007) point out three important differences between emerging markets and developed economies. First, the volatility of output in emerging markets is higher than that in developed economies. Second, consumption is more volatile than output in emerging markets. Third, the trade balance-to-GDP ratio is more volatile and more countercyclical in emerging markets than in developed economies. In this paper, we argue that home production serves as a plausible vehicle to capture all these major features of business cycles in both developed and emerging small open economies.

Several main findings emerge from our analysis. First, we find that upon experiencing a positive technology shock in the market sector (or a negative technology shock in the home sector), the presence of home production will induce the representative household to consume more market goods and substitute away from home consumption. Therefore, this substitution effect between market and home consumption leads to a higher volatility of market consumption. Second, when a positive market technology shock increases market consumption, the household turns to borrow from the world market in order to finance the increase in aggregate investment, which in turn reduces the trade balance. This result implies that the trade balance-to-GDP ratio tends to become more volatile and more countercyclical in the presence of home production. As a result, home production is a helpful mechanism for the empirical patterns exhibited in developed economies; i.e., output is more volatile than market consumption, investment is more volatile than output, and the trade balance-to-GDP ratio is weakly countercyclical. Third, we find that the extent of substitution between market and home consumption is positively related to the scale of the home sector. Because the home sector in emerging markets is larger than that in developed economies, market consumption is more volatile in emerging markets than in developed economies. As a consequence, the larger home sector is helpful in capturing the stylized fact that the volatility of market consumption is higher than the volatility of GDP in emerging markets. Finally, the higher volatility of market consumption causes the trade balance-to-GDP ratio to be more volatile and more countercyclical in emerging markets than in developed economies. Accordingly, home production provides a plausible explanation for the empirical pattern of international business cycles in developed economies and emerging markets.

[38] See, for example, Correia *et al.* (1995) and Schmitt-Grohé and Uribe (2003).

Appendix A

This appendix provides a brief derivation of the equilibrium conditions from the non-linear form to the linearized version in terms of percentage deviations from the steady state. The full macroeconomic competitive equilibrium for the economy is composed of 21 equations: (2a)-(3b), (5), (7a)-(8j) and (10)-(11). The endogenous variables are the sequences of quantities $\{y_t, c_{m,t}, c_{h,t}, C_t, X_t, N_t, n_{m,t}, n_{h,t}, I_{m,t}, I_{h,t}, I_t, k_{m,t}, k_{h,t}, d_t, b_t\}$ and prices $\{r_t, g_t, \mu_t, \lambda_t, q_{m,t}, q_{h,t}\}$. Given $A_m = 1$ and $A_h = 1$ in the steady state, based on the full macroeconomic competitive equilibrium model, the stationary relationship can be stated as:

$$b = \frac{rd}{y}, \tag{A1}$$

$$r = \frac{1}{\beta} - 1, \tag{A2}$$

$$q_m = 1 + \psi_m \delta_m, \tag{A3}$$

$$q_h = 1 + \psi_h \delta_h, \tag{A4}$$

$$k_m = \left[\frac{\left(\frac{1}{\beta} - 1 + \delta_m\right) q_m - \frac{(q_m - 1)^2}{2\psi_m}}{\alpha_m} \right]^{\frac{1}{\alpha_m - 1}} n_m, \tag{A5}$$

$$k_h = \left[\frac{\left(\frac{1}{\beta} - 1 + \delta_h\right) q_h - \frac{(q_h - 1)^2}{2\psi_h}}{\frac{1-\alpha_m}{1-\alpha_h} \left(\frac{k_m}{n_m}\right)^{\alpha_m} \alpha_h} \right]^{-1} n_h, \tag{A6}$$

$$c_m = \left[\frac{\theta}{1-\theta} \frac{1-\alpha_m}{1-\alpha_h} \frac{(k_m/n_m)^{\alpha_m}}{(k_h/n_h)^{\alpha_h}} \right]^{\frac{1}{1-\phi}} c_h, \tag{A7}$$

$$n_m = \frac{\frac{c_m}{c_h} \left(\frac{k_h}{n_h}\right)^{\alpha_h} + \frac{q_h^2 - 1}{2\psi_h} \left(\frac{k_h}{n_h}\right)}{(1 - r\upsilon) \left(\frac{k_m}{n_m}\right)^{\alpha_m} - \frac{q_m^2 - 1}{2\psi_m} \left(\frac{k_m}{n_m}\right)} n_h, \tag{A8}$$

$$N = \left\{ \frac{\omega\xi}{1-\alpha_h} \left[\frac{\theta}{1-\theta} \left(\frac{c_m}{c_h}\right)^{\phi} + 1 \right] / \left(\frac{n_m}{n_h} + 1\right) - \frac{\omega\gamma}{\beta(1-\gamma) - 1} \right\}^{-\frac{1}{\xi}}, \tag{A9}$$

$$n_h = \frac{N}{\frac{n_m}{n_h} + 1}, \tag{A10}$$

$$c_h = A_h k_h^{\alpha_h} n_h^{1-\alpha_h}, \tag{A11}$$

$$y = A_m k_m^{\alpha_m} n_m^{1-\alpha_m}, \tag{A12}$$

$$I_m = \delta_m k_m, \tag{A13}$$

$$I_h = \delta_h k_h, \tag{A14}$$

$$I = I_m + I_h, \tag{A15}$$

$$C = \left[\theta c_m^{\phi} + (1-\theta) c_h^{\phi} \right]^{\frac{1}{\phi}}, \tag{A16}$$

$$X = C, \tag{A17}$$

$$d = vy, \tag{A18}$$

$$g = \frac{\left(C - \omega N^{\xi} C\right)^{-\tau} \omega N^{\xi}}{\beta\left(1-\gamma\right) - 1}, \tag{A19}$$

$$\lambda = \left[\left(C - \omega N^{\xi} C\right)^{-\tau} + g\gamma\right] \theta \left(\frac{c_m}{C}\right)^{\phi - 1}, \tag{A20}$$

$$\mu = \left[\left(C - \omega N^{\xi} C\right)^{-\tau} + g\gamma\right] (1-\theta) \left(\frac{c_h}{C}\right)^{\phi - 1}. \tag{A21}$$

Let $\hat{d}_t = d_t - d$ and $\hat{b}_t = b_t - b$, and $\hat{z}_t = (z_t - z)/z$, where z_t can be any endogenous variable in the model except for d_t and b_t. By log-linearizing the macroeconomic model around its steady state, we can derive the following linear expressions in terms of percentage deviations:

$$\begin{aligned} \hat{\lambda}_t &= (\phi - 1)\left(\hat{c}_{m,t} - \hat{C}_t\right) - \frac{\tau\left(C - \omega N^{\xi} C\right)^{-\tau-1} C\left[\hat{C}_t - \omega N^{\xi}\left(\xi \hat{N}_t + \hat{X}_t\right)\right]}{\left(C - \omega N^{\xi} C\right)^{-\tau} + g\gamma} \\ &\quad + \frac{g\gamma\left[\hat{g}_t + (\gamma - 1)\left(\hat{C}_t - \hat{X}_{t-1}\right)\right]}{\left(C - \omega N^{\xi} C\right)^{-\tau} + g\gamma}, \end{aligned} \tag{A22}$$

$$(\phi - 1)\left(\hat{c}_{m,t} - \hat{c}_{h,t}\right) = \hat{\lambda}_t - \hat{\mu}_t, \tag{A23}$$

$$\frac{\beta g (1-\gamma)\left[\hat{g}_{t+1} + \gamma\left(\hat{C}_{t+1} - \hat{X}_t\right)\right] - g\hat{g}_t}{\left(C - \omega N^{\xi} C\right)^{-\tau} \omega N^{\xi}} = \xi \hat{N}_t - \tau \frac{\hat{C}_t - \omega N^{\xi}\left(\xi \hat{N}_t + \hat{X}_t\right)}{1 - \omega N^{\xi}}, \tag{A24}$$

$$(\xi - 1)\hat{N}_t + \hat{X}_t - \tau \frac{\hat{C}_t - \omega N^{\xi}\left(\xi \hat{N}_t + \hat{X}_t\right)}{1 - \omega N^{\xi}} = \hat{\lambda}_t + \hat{y}_t - \hat{n}_{m,t}, \tag{A25}$$

$$\hat{\mu}_t - \hat{\lambda}_t = \hat{y}_t - \hat{n}_{m,t} - \hat{c}_{h,t} + \hat{n}_{h,t}, \tag{A26}$$

$$\hat{I}_{m,t} - \hat{k}_{m,t} = \frac{q_m}{\delta_m \psi_m} \hat{q}_{m,t}, \tag{A27}$$

$$\hat{I}_{h,t} - \hat{k}_{h,t} = \frac{q_h}{\delta_h \psi_h} \hat{q}_{h,t}, \tag{A28}$$

$$\hat{q}_{m,t} = E_t\left\{\hat{\lambda}_{t+1} - \hat{\lambda}_t + \beta\left[\frac{\alpha_m y_m}{q_m k_m}\left(\hat{y}_{m,t+1} - \hat{k}_{m,t+1}\right) + \hat{q}_{m,t+1}\right]\right\}, \tag{A29}$$

$$\hat{q}_{h,t} = E_t\left\{\hat{\lambda}_{t+1} - \hat{\lambda}_t + \beta\left[\frac{\mu \alpha_h c_h}{\lambda q_h k_h}\left(\hat{\mu}_{t+1} - \hat{\lambda}_{t+1} + \hat{c}_{h,t+1} - \hat{k}_{h,t+1}\right) + \hat{q}_{h,t+1}\right]\right\}, \tag{A30}$$

$$0 = E_t\left(\hat{\lambda}_{t+1} - \hat{\lambda}_t + \beta r \hat{r}_{t+1}\right), \tag{A31}$$

$$\begin{aligned} \hat{d}_{t+1} - (1+r)\hat{d}_t - rd\hat{r}_t &= c_m \hat{c}_{m,t} + \left(\frac{q_m^2}{\psi_m} k_m \hat{q}_{m,t} + \frac{q_m^2 - 1}{2\psi_m} k_m \hat{k}_{m,t}\right) \\ &\quad + \left(\frac{q_h^2}{\psi_h} k_h \hat{q}_{h,t} + \frac{q_h^2 - 1}{2\psi_h} k_h \hat{k}_{h,t}\right) - y\hat{y}_t, \end{aligned} \tag{A32}$$

$$\hat{X}_t = \gamma \hat{C}_t + (1-\gamma)\hat{X}_{t-1}, \tag{A33}$$

$$\hat{c}_{h,t} = \hat{A}_{h,t} + \alpha_h \hat{k}_{h,t} + (1 - \alpha_h)\,\hat{n}_{h,t}, \tag{A34}$$

$$\hat{y}_t = \hat{A}_{m,t} + \alpha_m \hat{k}_{m,t} + (1 - \alpha_m)\,\hat{n}_{m,t}, \tag{A35}$$

$$\hat{k}_{m,t+1} = (1 - \delta_m)\,\hat{k}_{m,t} + \delta_m \hat{I}_{m,t}, \tag{A36}$$

$$\hat{k}_{h,t+1} = (1 - \delta_h)\,\hat{k}_{h,t} + \delta_h \hat{I}_{h,t}, \tag{A37}$$

$$\hat{b}_t = \frac{(1+r)\,\hat{d}_t + rd\hat{r}_t - \hat{d}_{t+1}}{y} - \frac{rd}{y}\hat{y}_t \tag{A38}$$

$$\hat{r}_{t+1} = \frac{\eta\upsilon}{r}\left(\frac{\hat{d}_{t+1}}{d} - \hat{y}_t\right), \tag{A39}$$

$$\hat{C}_t = \frac{\frac{\theta}{1-\theta}\left(\frac{c_m}{c_h}\right)^{\phi}\hat{c}_{m,t} + \hat{c}_{h,t}}{\frac{\theta}{1-\theta}\left(\frac{c_m}{c_h}\right)^{\phi} + 1}, \tag{A40}$$

$$N\hat{N}_t = n_m \hat{n}_{m,t} + n_h \hat{n}_{h,t}, \tag{A41}$$

$$I\hat{I}_t = I_m \hat{I}_{m,t} + I_h \hat{I}_{h,t}. \tag{A42}$$

Appendix B

Given $\gamma = 1$ and $p_t = \frac{\lambda_t}{\mu_t}$, the linearized version of equations (2b), (8a), (8b), and (8d) can be expressed as:

$$\hat{C}_t = \frac{\frac{\theta}{1-\theta}\left(\frac{c_m}{c_h}\right)^{\phi}\hat{c}_{m,t} + \hat{c}_{h,t}}{\frac{\theta}{1-\theta}\left(\frac{c_m}{c_h}\right)^{\phi} + 1}, \tag{B1}$$

$$-(1-\tau)\frac{\xi\omega N^{\xi}}{1-\omega N^{\xi}}\hat{N}_t + (\phi - 1)\,\hat{c}_{m,t} + (1-\phi-\tau)\hat{C}_t = \hat{\lambda}_t, \tag{B2}$$

$$(\phi - 1)\,(\hat{c}_{m,t} - \hat{c}_{h,t}) = \hat{p}_t. \tag{B3}$$

$$(1-\tau)\hat{C}_t + \left(\xi - 1 + \frac{\sigma\xi\omega N^{\xi}}{1-\omega N^{\xi}}\right)\hat{N}_t = \hat{\lambda}_t + \hat{y}_t - \hat{n}_{m,t} \tag{B4}$$

Then, substituting equations (B1), (B3), and (B4) into equation (B2), we have:

$$\hat{c}_{m,t} = \frac{1}{\tau + (\tau-1)\Omega}\left[(\tau-1)\Omega(\hat{y}_t - \hat{n}_{m,t}) - \hat{\lambda}_t - \frac{1}{1-\phi}\frac{(\tau-1)(1+\phi\Omega)+\phi}{\frac{\theta}{1-\theta}\left(\frac{c_m}{c_h}\right)^{\phi}+1}\hat{p}_t\right],$$

$$where\ 0 < \Omega = \frac{\xi\omega N^{\xi}}{(\xi-1)(1-\omega N^{\xi}) + \xi\omega N^{\xi}} < 1, \tag{B5}$$

Accordingly, based on equation (B5), we can derive equation (14a) in the main text.

In addition, from equations (A2)-(A7), the ratio between market consumption and home consumption in the steady state can be expressed as:

$$\frac{c_m}{c_h} = \left[\frac{\theta}{1-\theta}\frac{1-\alpha_m}{1-\alpha_h}\frac{(k_m/n_m)^{\alpha_m}}{(k_h/n_h)^{\alpha_h}}\right]^{\frac{1}{1-\phi}},$$

$$\text{where } \frac{k_m}{n_m} = \left[\frac{\left(\frac{1}{\beta} - 1 + \delta_m\right)(1+\psi_m\delta_m) - \frac{\psi_m(\delta_m)^2}{2}}{\alpha_m}\right]^{\frac{1}{\alpha_m - 1}};$$

$$\frac{k_h}{n_h} = \frac{\frac{1-\alpha_m}{1-\alpha_h}\left(\frac{\left(\frac{1}{\beta}-1+\delta_m\right)(1+\psi_m\delta_m)-\frac{\psi_m(\delta_m)^2}{2}}{\alpha_m}\right)^{\frac{\alpha_m}{\alpha_m-1}}\alpha_h}{\left(\frac{1}{\beta} - 1 + \delta_h\right)(1+\psi_h\delta_h) - \frac{\psi_h(\delta_h)^2}{2}}. \tag{B6}$$

By substituting equation (B6) into (B5), we can have:

$$\frac{\partial\left(\frac{\partial\hat{c}_{m,t}}{\partial\hat{p}_t}\right)}{\partial\theta} = \left(\frac{1}{1-\phi}\right)^2\frac{(\tau-1)(1+\phi\Omega)+\phi}{\left[\frac{\theta}{1-\theta}\left(\frac{c_m}{c_h}\right)^{\phi}+1\right]^2}\frac{\left(\frac{c_m}{c_h}\right)^{\phi}}{(1-\theta)^2}. \tag{B7}$$

Given that most of the empirical studies support the view that the intertemporal elasticity of substitution in consumption is in general less than unity (i.e., $\tau > 1$), from equation (B7) we can then infer that $\partial(\frac{\partial \hat{c}_{m,t}}{\partial \hat{p}_t})/\partial\theta > 0$.

Appendix C

The time-use data that we use are obtained from the Sustainable Development Goals (SDG) Indicators Database of the UN, except for Estonia, Korea, Luxembourg, and New Zealand. The data for Estonia, Korea, Luxembourg, and New Zealand respectively come from Statistics Estonia, Statistics Korea, the National Institute of Statistics and Economic Studies of the Grand Duchy of Luxembourg (STATEC), and Statistics New Zealand. The survey year and data sources are summarized in Table C.1.

Table C.1: Survey year and data sources

Country	Survey Year	Data Source
Emerging markets		
Argentina (ARG)	2005 (15-74); 2010; 2013 (18 and older)	SDG Indicators
Brazil (BRA)	2012 (15 and older)	SDG Indicators
Estonia (EST)	1999; 2009 (18 and older)	Statistics Estonia
Hungary (HUN)	2000 (15-74); 2010 (20-74)	SDG Indicators
Malaysia (MYS)	2003 (15-64)	SDG Indicators
Mexico (MEX)	2009 (15 and older)	SDG Indicators
Poland (POL)	2004 (15-64); 2013 (15 and older)	SDG Indicators
Republic of Korea (KOR)	1999; 2004; 2009; 2014 (20 and older)	Statistics Korea
Slovenia (SVN)	2001 (20-74)	SDG Indicators
South Africa (ZAF)	2010 (15-64)	SDG Indicators
Turkey (TUR)	2006 (15 and older)	SDG Indicators
Small developed economies		
Australia (AUS)	2006 (15 and older)	SDG Indicators
Austria (AUT)	2009 (20-74)	SDG Indicators
Belgium (BEL)	2000; 2005 (19-65)	SDG Indicators
Canada (CAN)	2005; 2010 (15 and older)	SDG Indicators
Denmark (DEN)	2001 (16-74); 2009 (20-74)	SDG Indicators
Finland (FIN)	2000; 2010 (20-74)	SDG Indicators
Luxembourg (LUX)	2014 (20 and older)	STATEC
Netherlands (NLD)	2006; 2012 (20-74)	SDG Indicators
New Zealand (NZL)	1999; 2009 (25 and older)	Statistics New Zealand
Norway (NOR)	2001; 2011 (16-74)	SDG Indicators
Spain (ESP)	2003; 2010 (20-74)	SDG Indicators
Sweden (SWE)	2001; 2011 (20-64)	SDG Indicators
Switzerland (SWZ)	2000; 2004; 2007; 2013 (15 and older)	SDG Indicators
Large developed economies		
United States (USA)	2003-2015 (15 and older)	SDG Indicators
United Kingdom (GBR)	2001; 2005 (16 and older)	SDG Indicators
Italy (ITA)	2003; 2009 (15 and older)	SDG Indicators
France (FRA)	2010 (15 and older)	SDG Indicators
German (DEU)	2002 (20-74)	SDG Indicators

Notes: The age ranges of those people included in the respective samples in the time-use survey are stated in the parentheses.

References

[1] Abel, A. B. and Blanchard, O. J., 1983. An Intertemporal Model of Saving and Investment. *Econometrica*, 51, 673-692.

[2] Aguiar, M. and Gopinath, G., 2007. Emerging Market Business Cycles: The Cycle Is the Trend. *Journal of Political Economy*, 115, 69-102.

[3] Alesina, A. and Giuliano, P., 2010. The Power of the Family. *Journal of Economic Growth*, 15, 93-125.

[4] Ávarez-Parra, F., Brandao-Marques, L. and Toledo, M., 2013. Durable Goods, Financial Frictions, and Business Cycles in Emerging Economies. *Journal of Monetary Economics*, 60, 720-736.

[5] Backus, D. K., Kehoe, P. J. and Kydland, F. E., 1992. International Real Business Cycles. *Journal of Political Economy*, 100, 745-775.

[6] Backus, D. K., Kehoe, P. J. and Kydland, F. E., 1994. Dynamics of the Trade Balance and the Terms of Trade: The J-Curve? *American Economic Review*, 84, 84-103.

[7] Backus, D. K. and Smith, G. W., 1993. Consumption and Real Exchange Rates in Dynamic Economies with Non-Traded Goods. *Journal of International Economics*, 35, 297-316.

[8] Bai, Y. and Zhang, J., 2010. Solving the Feldstein–Horioka Puzzle with Financial Frictions. *Econometrica*, 78, 603-632.

[9] Bai, Y. and Zhang, J., 2012. Financial Integration and International Risk Sharing. *Journal of International Economics*, 86, 17-32.

[10] Baxter, M. and Jermann, U. J., 1999. Household Production and the Excess Sensitivity of Consumption to Current Income. *American Economic Review*, 89, 902-920.

[11] Beaudry, P. and Portier, F., 2004. An Exploration into Pigou's Theory of Cycles. *Journal of Monetary Economics*, 51, 1183-1216.

[12] Benhabib, J., Rogerson, R. and Wright, R., 1991. Homework in Macroeconomics: Household Production and Aggregate Fluctuations. *Journal of Political Economy*, 99, 1166-1187.

[13] Bi, H., Shen, W. and Yang, S. S., 2016. Fiscal Limits in Developing Countries: A DSGE Approach. *Journal of Macroeconomics*, 49, 119-130.

[14] Blankenau, W. and Kose, M. A., 2007. How Different is the Cyclical Behavior of Home Production Across Countries? *Macroeconomic Dynamics*, 11, 56-78.

[15] Boz, E., Daude, C. and Durdu, C. B., 2011. Emerging Market Business Cycles: Learning about the Trend. *Journal of Monetary Economics*, 58, 616-631.

[16] Boz, E., Durdu, C. and Li, N., 2015. Emerging Market Business Cycles: The Role of Labor Market Frictions. *Journal of Money, Credit and Banking*, 47, 31-72.

[17] Bredemeier, C. and Juessen, F., 2013. Assortative Mating and Female Labor Supply. *Journal of Labor Economics*, 31, 603-631.

[18] Canova, F. and Ubide, A. J., 1998. International Business Cycles, Financial Markets and Household Production. *Journal of Economic Dynamics and Control*, 22, 545-572.

[19] Caselli, F., 2005. Accounting for Cross-Country Income Differences. Handbook of Economic Growth, 1, 679-741.

[20] Chung, K. and Turnovsky, S. J., 2010. Foreign Debt Supply in an Imperfect International Capital Market: Theory and Evidence. *Journal of International Money and Finance*, 29, 201-223.

[21] Correia, I., Neves, J. C. and Rebelo, S., 1995. Business Cycles in a Small Open Economy. *European Economic Review*, 39, 1089-1113.

[22] Cubas, G., 2016. Distortions, Infrastructure, and Female Labor Supply in Developing Countries. *European Economic Review*, 87, 194-215.

[23] de V. Cavalcanti, T. V. and Tavares, J., 2008. Assessing the "Engines of Liberation": Home Appliances and Female Labor Force Participation. *Review of Economics and Statistics*, 90, 81-88.

[24] Dey, J. and Tsai, Y. C., 2017. Explaining the Durable Goods Co-Movement Puzzle: A Bayesian Approach. *Journal of Macroeconomics*, 52, 75-99.

[25] Edwards, S., 1984. LDC Foreign Borrowing and Default Risk: An Empirical Investigation, 1976-1980. *American Economic Review*, 74, 726-734.

[26] Freeman, R. B. and Schettkat, R., 2005. Marketization of Household Production and the EU-US Gap in Work. *Economic Policy*, 20, 6-50.

[27] Gomme, P. and Zhao, Y., 2011. The Volatility of Consumption and Output with Increasing Industrialization. MPRA Working Paper No. 33721.

[28] Greenwood, J., Hercowitz, Z. and Huffman, G., 1988. Investment, Capacity Utilization, and the Real Business Cycle. *American Economic Review*, 78, 402-417.

[29] Greenwood, J. and Hercowitz, Z., 1991. The Allocation of Capital and Time over the Business Cycle. *Journal of Political Economy*, 99, 1188-1214.

[30] Greenwood, J., Rogerson, R. and Wright, R., 1995. Household Production in Real Business Cycle Theory. In: Cooley, T. (Eds.), Frontiers of Business Cycle Research. Princeton University Press, Princeton, NJ.

[31] Greenwood, J., Seshadri, A. and Yorukoglu, M., 2005. Engines of Liberation. *Review of Economic Studies*, 72, 109-133.

[32] Hall, R. E. and Jones, C. I., 1999. Why Do Some Countries Produce So Much More Output Per Worker Than Others?. *Quarterly Journal of Economics*, 114, 83-116.

[33] Hayashi, F., 1982. Tobin's Marginal q and Average q: A Neoclassical Interpretation. *Econometrica*, 50, 213-224.

[34] Heer, B. and Schubert, S. F., 2012. Unemployment and Debt Dynamics in a Highly Indebted Small Open Economy. *Journal of International Money and Finance*, 31, 1392-1413.

[35] Imbens, G., Rubin, D. and Sacerdote, B., 2001. Estimating the Effect of Unearned Income on Labor Supply, Earnings, Savings and Consumption: Evidence from a Survey of Lottery Players. *American Economic Review*, 91, 778-794.

[36] Jaimovich, N. and Rebelo, S., 2009. Can News about the Future Drive the Business Cycle? *American Economic Review*, 99, 1097-1118.

[37] Karabarbounis, L., 2014. Home Production, Labor Wedges, and International Real Business Cycles. *Journal of Monetary Economics*, 64, 68-84.

[38] Karnizova, I., 2010. The Spirit of Capitalism and Expectation-Driven Business Cycles. *Journal of Monetary Economics*, 57, 739-752.

[39] Khan, H. and Tsoukalas, J., 2011. Investment Shocks and the Comovement Problem. *Journal of Economic Dynamics and Control*, 35, 115-130.

[40] Khan, H. and Tsoukalas, J., 2012. The Quantitative Importance of News Shocks in Estimated DSGE Models. *Journal of Money, Credit and Banking*, 44, 1535-1561.

[41] Kimball, M. and Shapiro, M., 2010. Labor Supply: Are the Income and Substitution Effects Both Large or Both Small? NBER Working Paper No. 14208.

[42] King, R., Plosser, C. and Rebelo, S., 1988. Production, Growth and Business Cycles: I. The Basic Neoclassical Model. *Journal of Monetary Economics*, 21, 195-232.

[43] Li, N., 2011. Cyclical Wage Movements in Emerging Markets Compared to Developed Economies: The Role of Interest Rates. *Review of Economic Dynamics*, 14. 686-704.

[44] 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, 267-290.

[45] Mendoza, E. G., 1991. Real Business Cycles in a Small Open Economy. *American Economic Review*, 81, 797-818.

[46] Miyamoto, W. and Nguyen, T. L., 2017. Business Cycles in Small Open Economies: Evidence from Panel Data Between 1900 and 2013. *International Economic Review*, 58, 1007-1044.

[47] Nehru, V. and Dhareshwar, A., 1993. A New Database on Physical Capital Stock: Sources, Methodology and Results. *Revista de Analisis Economico* 8, 37-59.

[48] Neumeyer, P. A. and Perri, F., 2005. Business Cycles in Emerging Economies: The Role of Interest Rates. *Journal of Monetary Economics*, 52, 345-380.

[49] Ngai, L. R. and Pissarides, C. A., 2008. Trends in Hours and Economic Growth. *Review of Economic Dynamics*, 11, 239-256.

[50] Otsu, K., 2008. A Neoclassical Analysis of the Korean Crisis. *Review of Economic Dynamics*, 11, 449-471.

[51] Parente, S. L., Rogerson, R. and Wright, R., 2000. Homework in Development Economics: Household Production and the Wealth of Nations. *Journal of Political Economy*, 108, 680-687.

[52] Ramey, V. A. and Francis, N., 2009. A Century of Work and Leisure. *American Economic Journal: Macroeconomics*, 1, 189-224.

[53] Restrepo-Echavarria, P., 2014. Macroeconomic Volatility: The Role of the Informal Economy. *European Economic Review*, 70, 454-469.

[54] Rogerson, R., 2008. Structural Transformation and the Deterioration of European Labor Market Outcomes. *Journal of Political Economy*, 116, 235-259.

[55] Rupert, P., Rogerson, R. and Wright, R., 1995. Estimating Substitution Elasticities in Household Production Models. *Economic Theory*, 6, 179-193.

[56] Schmitt-Grohé, S., 1998. The International Transmission of Economic Fluctuations: Effects of U.S. Business Cycles on the Canadian Economy. *Journal of International Economics*, 44, 257-287.

[57] Schmitt-Grohé, S. and Uribe, M., 2003. Closing Small Open Economy Models. *Journal of International Economics*, 61, 163-185.

[58] Stockman, A. C. and Tesar, L. L., 1995. Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements. *American Economic Review*, 85, 168-185.

[59] van Klaveren, C., van Praag, B. and van den Brink, H. M., 2008. A Public Good Version of the Collective Household Model: An Empirical Approach with an Application to British Household Data. *Review of Economics of the Household*, 6, 169-191.

[60] Wurgler, J., 2000. Financial Markets and the Allocation of Capital. *Journal of Financial Economics*, 58, 187-214.