# TWO ESSAYS ON MACRO ECONOMIC IMPLICATIONS FOR GOVERNMENT SPENDING EFFECTS

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TWO ESSAYS ON MACRO ECONOMIC IMPLICATIONS FOR GOVERNMENT SPENDING EFFECTS

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Abstract: My dissertation comprises two chapters. The first chapter is an empirical study of government spending effects in both developed and developing countries. Based on the panel structural VAR analysis and the sign-restriction method for identifying the government spending shock, I find that private consumption increases in response to a positive government spending shock in both groups, yet such consumption effect is greater in developing than industrial countries; the response of real effective exchange rate to the government spending shock varies across groups: it depreciates in developed countries and appreciates in developing countries.

The second chapter investigates the transmission mechanism underlying the empirical findings of the first chapter. I set up a New Keynesian small open economy model, augmented with hand-to-mouth consumers, non-separable preferences between public and private consumptions, and government spending reversals to well replicate the responses of private consumption and the real exchange rate in the first chapter. The large fraction of hand-to-mouth consumers and high complementarity between public and private consumption contribute to the greater positive response of private consumption in developing countries; when introducing spending reversals to the model in the context of developed countries, it magnifies the positive response of private consumption by mitigating the negative wealth effect resulting from a fiscal expansion, moreover, it induces the real exchange rate to become depreciated after several quarters.

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# CHAPTER I

# THE EFFECTS OF GOVERNMENT SPENDING ON CONSUMPTION AND THE REAL EXCHANGE RATE: A COMPARISON BETWEEN DEVELOPED AND DEVELOPING COUNTRIES

## 1. Introduction

In recent years, there has been a resurgence of interest in the role of fiscal policy in stabilizing the economy due to the less effectiveness of monetary policy after 2008 financial crisis, as nominal interest rate has reached zero bound in major developed countries. Regarding the consequences of fiscal policy in open economies, a body of studies based on structural vector autoregression (VAR) have generated a lively debate. As discussed in Ilzetzki *et al.* (2013), the key issue in the debate is that there is no consensus on the approach to identify the fiscal shock, even in the context of a structural VAR analysis. The short-run restriction method, firstly introduced in Blanchard and Perotti (2002) by assuming that changes in government consumption require at least one quarter to respond to innovations in other macroeconomic variables so as to identify the structure shock, is largely employed in the following relevant VAR literature. For example, Ravn *et al.* (2012) apply a panel structural VAR to four industrialized countries and document the empirical evidence of an increased private consumption and a real depreciation after the positive government spending shock.

Consistent results are shown in Corsetti *et al.* (2012)'s paper, who use the same Blanchard-Perotti identification scheme as Ravn *et al.* (2012) to U.S. data. Another approach called sign-restriction is developed in Uhlig (2005). In this identification method, sign restrictions are imposed on the impulse response functions of certain variables. Sign-restriction method gains more attention in identifying the monetary policy, yet recently researchers have extended the sign-restriction scheme to identify the fiscal shocks and provided complementary VAR evidence to the ongoing debate. A negative response of consumption accompanied by a depreciation of real exchange rate to a fiscal shock is found in Enders *et al.* (2011), which is based on an alternative sign-restrictions identification method and analysis of U.S. time series data. Following the signs of several impulse responses formally derived by Enders *et al.* (2011), Iwata (2013) uses the sign-restrictions scheme to identify the government spending shock in context of Japan data and shows that private consumption goes up and real exchange rate depreciates in response to a fiscal expansion.[1]

Theoretical studies have suggested that dynamics of real exchange rate and private consumption are related in an open economy setting under the assumption of complete assets market. After a positive government spending shock, a positive (negative) consumption is associated with a real depreciation (appreciation) via the international risk sharing condition. On the other hand, differences across countries play a crucial role in evaluating the impacts of fiscal policy, which is shown in relevant literature such as Kim (2015) and Ilzetzki *et al.* (2013). However, previous studies have mostly investigated into consumption and(or) real exchange rate in the context of advanced countries data, paying less attention to the development variation across countries in the models. To shed light on this issue, this paper conducts an empirical investigation into the impact of government spending shocks on consumption, trade balance and real exchange rate in both developed and developing countries. Specifically, I apply a panel structural VAR model to a group of 10 developed countries and a group of 14 developing countries with

[1]According to the definition of the real effective exchange rate (REER) discussed in Section 3, an increase indicates a depreciation of the economy's currency against its trade partner.

quarterly time-series data and identify government spending shocks by imposing robust restrictions on the signs of several impulse responses of the model, following Uhlig (2005) and Mountford and Uhlig (2009). This paper attempts to answer the following two questions: First, what are the empirical impacts of fiscal policy on private consumption and on real exchange rate in both developing and developed countries? Second, does there exist cross-country differences on the impacts of government spending shocks on private consumption and real exchange rate? If yes, what are the differences?

The main results of the empirical analysis can be summarized as follows: in both groups private consumption shows a positive response to the government spending shock and the consumption impact is smaller yet more persistent in developed countries; a fiscal expansion tends to induce a real exchange rate appreciation in developing countries and a real depreciation in developed countries; the trade balance goes into surplus after an exogenous increase in government spending in all countries. These results deliver several important implications. Although a crowding-in of consumption is triggered by government spending shocks in all countries, consistent with several VAR analysis, the response of consumption in developing countries displays a different pattern where the effect is lager on impact and far more transient (dying out after about eight quarters). The effect of government spending shocks on real exchange rate varies across countries. A real depreciation in developed countries is consistent with the findings of recent related VAR literature. However, a real appreciation in developing countries provides support for the theoretical prediction of either traditional Mundell-Fleming IS-LM models, standard international real business cycle models or the basic new open economy macroeconomics models, in stark contrast with relevant studies mentioned above. Further, in developed countries, the increased private consumption and the real exchange rate depreciation reveal a positive correlation between the two variables, which implies that the assumption of complete asset markets works well as the basis of dynamics of real exchange rate and private consumption in developed countries. With complete asset markets, the ratio of the marginal utilities of consumption across countries is tied to the real exchange rate,

which implies that a rise in consumption is associated with an equilibrium depreciation of real exchange rate. Yet, this assumption does not hold in developing countries where a positive private consumption is accompanied by a real appreciation. All in all the degree of development matters in assessing the effects of fiscal policy and the failure or success of theoretical models.

This paper attempts to contribute to the following issues: first, the empirical literature studying the link between fiscal policy and the private consumption and(or) the real exchange rate has paid less attention on developing countries. It is, however, worth exploring the effects of fiscal expansion in the context of developing countries. Although Ilzetzki *et al.* (2013) find that after a government spending shock, the real exchange rate depreciates in the long run in developed countries while appreciates on impact in developing countries, indicating the response of the real exchange rate tends to be affected by the degree of development across countries. Private consumption is not included in VAR model of Ilzetzki *et al.* (2013)'s paper. As mentioned before, the dynamics of private consumption is tied closely to the dynamics of the real exchange rate, given international risk-sharing under complete asset market consumption. Therefore, this paper provides a complement to relevant studies with respect to the response of private consumption, the response of the real exchange rate, and the consumption-real exchange rate relationship in developing country fiscal policy. Second, this paper employs sign-restrictions scheme to identify the government spending innovations other than the standard approaches such as recursive Cholesky decomposition, short-run or long-run zero restrictions. Sign-restrictions scheme is more agnostic than the standard approaches because it imposes no restrictions on the impulse responses of variables of interest and just let the data decide. Another advantage of sign-restrictions is its close link to theoretical models. Since it identifies the structural inference in VAR models on basis of prior beliefs about the signs of the impact of certain shocks, which can be derived from a large number of dynamic stochastic general equilibrium (DSGE) models. It is hard for these models to produce any zero restrictions or recursive structures. The value-added of this paper

can be evaluated in the context of two closely related studies, namely Enders *et al.* (2011) and Ilzetzki *et al.* (2013). Although Enders *et al.* (2011) formally derive the sign and time horizon of the identification based on a quantitative general equilibrium model, they then estimate VAR model on an individual country data[2]. In contrast, this paper employs panel VAR on data of 24 countries to reveal evidence of the private consumption and the real exchange rate impact to fiscal shocks in the open markets. Ilzetzki *et al.* (2013) estimate the effects of government spending on both developed and developing countries, that paper, nevertheless, focuses on fiscal multipliers and estimates VAR model using standard approaches, that is, short-rum restrictions and a recursive Cholesky decomposition to identify government spending shock[3]. This paper focuses on the responses of private consumption and real exchange rate to a government spending shock, employing alternative identification scheme, sign restrictions to identify the shocks.

The remainder of the paper is organized as follows. Section 2 describes identification strategy. Section 3 estimates VAR model and compares the empirical results. Section 4 shows results for sensitivity analysis. Section 5 concludes.

## 2. Panel VAR and Identification

### 2.1. Panel VAR

A reduced form panel VAR with country fixed effect is conducted and estimated to illustrate the macroeconomic effects of a government spending shock

$$\mathbf{Y}_t^s = \mathbf{D}^s + \mathbf{B}(\mathbf{L})\mathbf{Y}_{t-1}^s + \boldsymbol{\epsilon}_t^s \tag{1}$$

where $s = 1, 2$ denotes two groups of countries with 1 as developing-country group and 2 as developed-country group; $\mathbf{D}^s$ is a vector of country dummies; $\mathbf{Y}_t^s$ is a vector of endogenous variables; The factor $\mathbf{B}(\mathbf{L})$ is a finite-order vector polynomial with the lag operator $\mathbf{L}$; and $\boldsymbol{\epsilon}_t^s$ is a vector of mean-zero, serially uncorrelated shocks with diagonal

[2]They use U.S. time series relative to an aggregate of industrialized countries.

[3]They also provide some evidence of a real exchange rate depreciation (appreciation) to a fiscal expansion in industrialized (developing) countries.

variance-covariance matrix $\mathbf{\Sigma}$. The matrices of coefficients $\mathbf{B}$ is of size 9 by 9, given nine endogenous variables.

The vector of endogenous variables, $\mathbf{Y}_t$ in model (1), consists of the following: real per capita government spending (government consumption only) deflated by the GDP deflator, real per capita Gross Domestic Product(GDP), real per capita private consumption, real per capita private investment, primary government budget balance-to-GDP ratio, net export-to GDP ratio, real effective exchange rate defined as the ratio of a trade-weighted average of exchange-rate-adjusted foreign CPIs to the domestic CPI, inflation rate calculated by GDP deflator, and the domestic nominal 90-day interest rate. Each variable is measured in logarithm, except for government budget balance-to-GDP ratio, net export-to GDP ratio, and interest rate. The choice of these variables is largely determined by the chosen identification method. GDP, private consumption, real effective exchange rate and net exports are included as the focus of interest. Government budget balance is there to identify fiscal policy shocks while interest rate and inflation rate are included to identify monetary policy shocks. To maintain comparability with the related literature, four lags of endogenous variables are included in the VAR model.[4]

### 2.2. Identification

To solve the identification problem of reduced VAR model, additional restrictions are required. In this paper, sign-restriction scheme is used. That is, imposing certain signs on the impulse responses of chosen variables to a fiscal expansion so as to make sure the signs are consistent with the predictions of theoretical models. Specifically, researchers need to find a matrix $\mathbf{A}$ such that $\boldsymbol{\epsilon}_t = \mathbf{A}\upsilon_t$, where $\upsilon_t$ denotes the vector of structural shocks, following the common assumption in VAR literature that $\mathbf{E}[\upsilon_t\upsilon_t'] = \boldsymbol{I}_l$. To identify structural shocks, first imposing sign restrictions on impulse responses of selected variables for a certain period and then consider various matrices $\mathbf{A}$ and check, for each

[4]Ravn *et al.* (2012) argues that the choice of lags in SVAR is guided by a likelihood ratio test which rejects the hypothesis of one or two lags in favor of a longer lag length. The choice of lags is also dictated by sample length, e.g. three lags are used in Iwata (2013) due to a relative short sample period. In this paper, three-lag and four-lag specification yield virtually identical impulse response functions and error bands.

case, whether the sign restrictions are fulfilled and dismiss the matrix if this is not the case.

As mentioned above, several approaches are used to identify fiscal shocks. For example, narrative approach proposed by Ramey and Shapiro (1998), yet it is relatively hard to motivate in the context of a panel of countries where similar narrative data are not available. Short-run zero restrictions by assuming the sluggish reaction of some variables to fiscal policy shocks or by using additional detailed information about the tax system, zero constraints on impact responses albeit justify in some cases, they are inconsistent with most theoretical models.(Canova and Pina, 2005). This paper prefers to the third alternative identification scheme: sign restrictions developed by Uhlig (2005). One reason is that it is more agnostic than other identification methods. Another reason is that the aim of this paper is to find dynamic properties of the time-series data and assess empirical responses to government spending shocks in developed and developing countries based on panel VAR analysis, sign-restrictions method allows to rely on time series data as well as a priori theorizing to achieve the fiscal shock without additional informations or assumptions required in other identification approaches.

Some recent literature have applied sign-restrictions approach to identify fiscal shocks.[5] Enders *et al.* (2011) formally derive the sign and time horizon of the identification based on a quantitative general equilibrium business cycle model and provide evidence of a real depreciation for U.S. data. Iwata (2013) follows the restrictions of sign in Enders *et al.* (2011) and provides consistent evidence of a real depreciation for Japan data. In this paper, I impose restrictions along the lines of Enders *et al.* (2011). Table 1 shows the set of sign restrictions used. The response of private consumption and the real exchange rate to a fiscal expansion are of interest, which thus remain unrestricted. The sign of net exports is also unrestricted because its response would vary due to different specifications of the model.[6] The sign of private investment is restricted in Enders *et al.*

[5]See Mountford and Uhlig (2009); Pappa (2009); Enders *et al.* (2011); Iwata (2013).

[6]Müller (2008) argues that the response of net exports to government spending shocks is determined by the trade price elasticity: A high (low) trade price elasticity tend to cause a negative (positive) response.

(2011)'s paper, and left unrestricted in Iwata (2013). However, the positive response of private investment shown in VAR model is not consistent with the response produced by the theoretical model proposed in Iwata (2013). In this paper, I follow theoretical prediction that investment falls because current and expected future rental costs and the real interest rate rise in response to a fiscal expansion. Output, inflation and interest rate are supposed to arise as they respond to a government spending shock, in line with what a large class of DSGE models predict. That a decline in budget balance in response to the increased government spending is the key identifying strategy to distinguish a government spending shock from other shocks, such as business cycle shock, or monetary policy shocks. And the sign restrictions are imposed for a year after the shock, following Mountford and Uhlig (2009).

## 3. Time Series Evidence

### 3.1. Data

I estimate the panel structural VAR model (1) on quarterly time series data. Previous literature such as Perotti (2004) and Ilzetzki *et al.* (2013), argue that the quarterly data on government spending are interpolated in some countries, especially in developing counties. To avoid the bias in estimation, it is necessary to use non-interpolated data. Here, I use data sources documented in Ilzetzki *et al.* (2013) to obtain non-interpolated data on government spending. The sample includes developed and developing economies that have at least 15 years of quarterly data. Specifically, I follow the World Bank's 2017 classification of middle high-income and high-income countries to identify developing and developed economies, respectively.[7] The choice of countries in each group is guided by the availability of sufficient and reliable quarterly data on public consumption and government budget balance. The sample periods are from 1999Q1 to 2015Q4 for developed countries, and 2000Q1 to 2015Q4 for developing countries. A more detailed description

[7]Exceptions are Israel and South Korea, which are categorized as emerging markets in J.P. Morgan Index, but are denoted as high-income countries in the World Bank's 2017 classification. In this paper, they are grouped into developing countries.

can be found in Appendix .4.

A selected de-seasonalization method, X-13 algorithm, was used to remove the strong seasonal patterns of the data. To ensure all variables in the VAR model are stationary, I follow Ilzetzki *et al.* (2013) to detrend government expenditure and GDP data, as well as inflation rate by regressing them on a quadratic trend.[8] The policy interest rate, primary government budget balance-to-GDP ratio, net export-to GDP ratio were included in levels and real effective exchange rate was included in first differences.

Table 2 provides summary statistics for the main nine variables of all countries included in the analysis. For the (detrended) government spending, the greatest standard deviation is UK (0.7) in developed countries and Argentina (0.13) in developing countries, respectively. An obvious difference between developed and developing countries is the standard deviation of nominal interest rate. Compared to developed-country group (1.87), developing-country group has much larger standard deviation (10.62).

Table 3 reports summary statistics for quarterly government spending: the ratio of government spending to GDP, the autocorrelation of (detrended) government spending, and the variance of (detrended) government spending relative to the variance of (detrended) GDP. These statistics are firstly calculated for each country and then for the two groups respectively by averaging the countries' statistics within each group. In developed countries, government spending accounts for 15.29% of GDP in US, yet 25.38% in Denmark. In developing counties, the proportion varies from 7.46% in Mexico to 23.76% in Israel. Hence, the developed-country group has larger government size (19.67%) than the developing-country group does (14.81%). The persistence of government spending also shows a different pattern over the two groups. Autocorrelation coefficient varies from 0.8 to 0.97 in developed countries and from 0.12 to 0.94 in developing countries, reflecting that government spending is more persistent (with average coefficient of 0.9) in developed countries and more transitory (0.6) in developing countries. Besides, the developing-country group displays a greater volatility than the developed-country does,

[8] A linear trend yielded similar results.

although government spending is more volatile than GDP in both groups.

### 3.2. VAR Evidence

The median, as well as the 16% and 84%, of the posterior distribution of impulse responses to the identified government spending shock are displayed in Figure 1 and Figure 2 for developing and developed countries, respectively. Evidence of developing economy shows that private consumption ascends on impact, yet only approximately 8 quarters after the impact does it fall below trend. Increased consumption contributes to the output rise, which displays a similar pattern and the response is in a statistical significant way. The real exchange rate appreciates slightly after the shock. Besides, the positive response of private consumption and the negative response of real exchange rate show that co-movement between the two variables after a government innovation does not exist in the emerging market. Government spending, displayed in the upper left panel, rises persistently and significantly. The improvement of net exports on impact then gradually fades away in the following years due to the appreciation of real exchange rate. Budget balance deteriorates persistently during the limited periods. Private investment shows an significant decline after the shock and lasts about 5 years to go back its preshock trend. Inflation increases on impact, and interest rates go up immediately after the shock given non-negative response restriction, as well.

Compared to that of developing countries, in rich countries it takes about 20 quarters for increased consumption to decline to its preshock trend, although the positive effect on consumption is smaller in quantitative term. The real exchange rate depreciates on impact and its response is mildly hump shaped and peaks at about 2 quarters after the shock. Moreover, private consumption and real exchange rate show a positive relationship which is consistent with the complete assets market assumption. The trade balance improves after the shock, which may appear surprising because a strand of studies has documented a positive correlation between fiscal and trade deficits and consistent results of a trade balance deterioration are also shown in Corsetti and Müller (2006), Monacelli

and Perotti (2006), and Ravn *et al.* (2012). However, Kim and Roubini (2008) finds that fiscal expansions cause a significant and large improvement in current account. Müller (2008) theoretically proves that the response of net exports would be positive if there is home bias in private consumption. Except for private consumption, real exchange rate and trade balance, the responses of which are of interest, other variables present some discrepancies between developing and developed countries' evidence, as well. In quantitative term, the negative impact of a fiscal expansion on private investment is larger while the positive impact on interest rate is smaller in developed than in developing countries.

The stimulative effects of a fiscal expansion are generally framed in terms of multipliers. One measure is the impact multiplier and the other is the cumulative multiplier. Here I follow the definitions of fiscal multipliers proposed in Ilzetzki *et al.* (2013) to compute the corresponding fiscal multipliers for output and private consumption, respectively, given the impulse responses depicted in Figure 1 and Figure 2. Results are shown in Figure 3. For developing countries, the impact multiplier for output is 1.07 and the impact multiplier for consumption is 0.25. The positive response of private consumption accounts for the larger output multiplier. Since in standard models, the negative wealth effect on consumption would mitigate the rise in output induced by a fiscal expansion. For developed countries, the impact multiplier for output is 1.32 and the impact multiplier for consumption is slightly negative at -0.11. Cumulative multiplier captures the cumulative effects of the fiscal shocks along the entire path up to a given period. For developing countries, up to 20 quarters after the shock, the cumulative multiplier for output drops to 0.85 and the cumulative multiplier for consumption declines below 0 at -0.11, which implies that private consumption contributes to some crowding out of output by government spending. For developed countries, the cumulative multiplier for output drops to 1.22 and the cumulative multiplier for consumption rises to 0.17.

### 3.3. Transmission Mechanism

In this section I turn to discuss the possible channels through which positive government spending shocks affect the dynamics of private consumption, the real exchange rate and trade balance. In the baseline model, a positive private consumption in response to a fiscal expansion provides supportive evidence to the textbook IS-LM model's prediction of a crowding-in consumption, yet contradicts with the basic real business cycle model's prediction of a crowding-out consumption. So far, a class of DSGE models has been built up to reconcile the contradiction between empirical findings and theoretical predictions, for example, non-Ricardian households, the complementary between public and private consumption, "deep habits", etc. See Galí *et al.* (2007), Bouakez and Rebei (2007), and Ravn *et al.* (2012). Empirical evidence also shows that the positive consumption response is larger in developing than in developed countries. One potential explanation is that, in most developing countries, there are a large number of hand-to-mouth consumers, who simply consume their current income, which in turn reflects an inability to trade in asset markets due to infinite transactions costs. In this case, the fiscal expansion has a greater stimulating effect on private consumption.

The response of the real exchange rate to a positive government spending shock appreciates in developing countries, which is opposite to the real exchange rate response in developed countries. One possible explanation of the obvious discrepancy between the two groups of countries might be that households in developed countries have quite different preferences, compared to those in developing countries.[9] Another possible explanation is that public consumption is mainly in the form of non-tradables, so a fiscal expansion tends to push up the price of non-tradable goods. In developing countries, fluctuations in the relative price of non-tradable goods to tradable goods contributes to the real exchange rate movements, and thus an increase in the relative price of non-tradables to tradables in turn appreciates real exchange rate. However, real exchange

[9]Ravn *et al.* (2012) documents a real exchange rate depreciation in response to government spending innovations and introduces a model with non-standard preference to get this result.

rate movements in developed countries reflect mainly the relative price of tradables, and thus the relatively lower price of tradable goods tends to depreciate real exchange rate.[10]

Müller (2008) provides a theoretical explanation to the surprising finding of trade balance improvement in both developing and developed countries after the fiscal shock. He argues that the response of net exports to government spending shocks is determined by trade price elasticity. That is, net exports is likely to rise if private consumption in domestic country is relatively lower than that in foreign country and if there exists limited substitution from home to foreign goods, given certain degree of home bias in private consumption. In this case, resources transfer from domestic country to foreign country.

## 4. Further Sensitivity Analysis

I check the robustness of the results in several ways. Firstly, I investigate whether results are sensitive to the alternative identification scheme: a conventional short-run zero restrictions method, proposed by Blanchard and Perotti (2002) and then employed by Ravn *et al.* (2012) in a panel VAR model. Five variables including government spending, output, private consumption, net exports and real effective exchange rate are used. Government spending shocks are identified by the assumption that it requires at least a one quarter lag for government spending to respond to structural innovations except for government spending innovations. Figure 4 and Figure 5 show the results. After a positive government spending shock, private consumption increases in both developed and developing countries, while the real exchange rate appreciates in emerging markets and depreciates in rich countries. These results are well in line with those obtained by the baseline model. One difference exists in the response of net exports, which is positive in the baseline model but negative in short-run restrictions. Another is that the positive effect of a fiscal expansion on private consumption is larger in developed than in de-

[10]Engel (1999) shows that almost all of the variance in the bilateral real exchange rates between U.S. and a number of other high-income countries is attributable to fluctuations in the real exchange rates of traded goods, which is inconsistent with the implications of traditional real exchange rate theory: all movements in the bilateral real exchange rate between two countries are due to fluctuations in the bilateral relative price of non-traded to traded goods.

veloping countries in short-run restrictions, which is contrary to that of baseline model. Fiscal multipliers for developed and developing countries are calculated as well, based on the impulse responses obtained in short-run restrictions. Results are shown in Figure 6. The impact multiplier for output is larger in developed (>0.5) than in developing (<0.5) countries. The cumulative multiplier for output declines to -0.5 in developed countries and rises to 0.6 in developing countries in the long run(20 quarters after the shock). The impact multiplier for consumption is also larger in developed (>0.4) than in developing (<0.4) countries. The cumulative multiplier for consumption declines to 0.25 in developed countries and rises to about 0.4 in developing countries in the long run. Compared to results of the baseline model, fiscal multipliers differ not only in pattern but also in quantitative terms. One possible reason is the different response of net exports in the two models. In the model with short-run restrictions, the negative response of net exports largely crowd out the rise in output in response to a positive government spending shock, leading to output multipliers less than 1. Another reason could be that in the baseline model, interest rate and inflation are included to capture the monetary policy shock, while they are not considered in the model with short-run restrictions. The interaction between monetary and fiscal policy is a critical role of determining the magnitude of fiscal multipliers across countries.

Secondly, after 2008 financial crisis nominal interest rate hits the zero lower bound in major industrialized countries as I mentioned before. The effectiveness of a fiscal expansion could be affected in the zero-lower-bound regime. So the robustness of the results is then checked by estimating the effects of fiscal policy in selected subsample periods covering 1999q1 to 2007q4 in developed-country group. Figure 7 shows the results. After a positive government spending shock, the real exchange rate tends to depreciate and trade balance improves, showing a strong robustness. Private consumption decreases. The positive impact on output is larger in the subsample than in the baseline model, which is inconsistent with previous studies arguing that the size of the fiscal multiplier

can be larger when nominal interest rate are near zero.[11]

Thirdly, a big concern about panel data is the consistency. Estimates of the parameters are inconsistent and structural inference is biased if heterogeneity is neglected in the dynamics.To check the robustness, I investigate the implications in a subsample consists of 6 countries which are members of G7. Figure 8 shows the results. Private consumption drops only briefly on impact and then begins to rise in response to a fiscal expansion. The real exchange rate depreciates and trade balance improves during the following two years after the shock, which are consistent with the baseline results.

## 5. Conclusion

This paper has tried to empirically establish and assess the dynamic effects of an exogenous increase in government spending on private consumption and the real exchange rate in both developed and developing countries. Specifically, by fitting a panel VAR model to time series data from a group of 14 developing countries for the period from 2000Q1 to 2015Q4 and a group of 10 developed countries for the period from 1999Q1 to 2015Q4, this paper shows that private consumption rises in response to a fiscal expansion in both groups and a greater consumption response in developing than developed countries. The impact of a positive government spending shock on real exchange rate differs largely within the two groups. After the shock, the real exchange rate appreciates in developing countries, while a real depreciation is suggested in developed countries, which is consistent with the findings of Ilzetzki *et al.* (2013). Trade balance moves into surplus after the positive government spending shock in both groups, in stark contrast with findings suggested in Monacelli and Perotti (2010) and Ravn *et al.* (2012). Yet Kim and Roubini (2008) documents consistent evidence of a positive relationship between fiscal deficit and current account surplus.

Empirical evidence in the baseline model also indicates that the positive correlation

[11] In recent years significant attention has been paid to the effectiveness of a fiscal expansion under the circumstance as nominal interest rate hits zero lower bound. see Cogan *et al.* (2010), Christiano *et al.* (2005), Coenen and Straub (2005), Davig and Leeper (2011).

between private consumption and the real exchange rate implied by international risk-sharing condition via complete assets market assumption does not exist in developing countries. Although an increased consumption and a real depreciation in developed countries suggest the positive relationship between the two, they are opposite with the theoretical prediction of a negative consumption and a real appreciation after government spending shocks. All of these findings call for further theoretical explorations to reveal the mechanism that dominates the underlying transmission, given the failure of standard models to fully explain these empirical patterns.

From a policy perspective, the results of this study could provide some important policy implications. A expansionary fiscal policy would stimulate output and private consumption in both developed and developing countries, but the stimulative effect on output is larger and more persistent in developed than in developing countries while the stimulative effect on consumption is smaller and more persistent in developed than in developing countries. A positive government spending shock tends to depress private investment and induce a larger drop in developed than in developing countries although nominal interest rates increase less. The open economy effects of fiscal policy vary across groups. In developing countries, trade balance goes into surplus as the real exchange rate appreciates in response to a fiscal expansion, showing a strong evidence for the traditional Mundell-Fleming channel. In developed countries, after a positive government spending shock, the real exchange rate depreciates, which dose not induce a deterioration in trade balance. The positive correlation between fiscal deficit and trade balance surplus suggested in this paper supports the finding of "two divergence" in Kim and Roubini (2008), which is inconsistent with a conventional argument that a fiscal deficit is associated with a deterioration in trade balance.

# CHAPTER II

# FISCAL POLICY, CONSUMPTION AND THE REAL EXCHANGE RATE IN DEVELOPED AND DEVELOPING COUNTRIES: A COMPARISON

## 1. Introduction

The theoretical analysis concerning relationships between fiscal policy, private consumption, and the real exchange rate has made substantial progress since 2008 financial recession, as fiscal stimulus packages play an important role in both advanced and emerging markets.

Despite the debates on dynamic effects of government spending on economic activities, several recent studies based on standard vector autoregression (VAR) models tend to find consistent evidence that private consumption rises (see Fatás and Mihov (2001), Blanchard and Perotti (2002)) and(or) real exchange rate depreciates after the positive government spending shock in advanced economies (see Corsetti (2012); Ravn *et al.* (2012); Iwata (2013); Kim and Roubini (2008); Monacelli and Perotti (2010))[12]. Ilzetzki *et al.* (2013), yet find that in developing countries a fiscal expansion causes a real exchange rate appreciation. Empirical findings documented in Li (2017) imply that there is a discrepancy of the fiscal effects in the context of developed and developing countries. Private consumption rises after a fiscal shock across the two groups of countries yet it raises by a larger amount in developing than advanced countries. The real exchange rate depreciates in developed countries while it

[12]One exception is Enders *et al.* (2011), who provide evidence of nonincrease in consumption after a fiscal expansion using U.S. data.

appreciates in developing countries, in response to a fiscal expansion.[13]

Discrepancies in the empirical evidences of advanced and developing markets call for theoretical models that can capture different characteristics across two groups of countries, since the differences in key features between developed and developing countries would affect government spending effects. Note that the composition of households shows a different pattern between developed and developing countries. The World Bank's Global Financial Inclusion database[14] document that account ownership is nearly universal in high-income countries where the fraction of adults who have an account has reached as high as 94% in 2017. With less developed financial environment and a relatively great share of low-income people, only about 63% of adults in developing countries have an account, much lower than that of developed countries. This indicates that the share of savers in high-income economies is roughly twice greater than that in developing countries.[15] The existence of a great share of hand-to-mouth consumers (or, non-savers) in developing countries may lead to upward pressure on private consumption, since hand-to-mouth consumers, or non-Ricardian households are assumed to be liquidity constrained and therefore cannot smooth consumption intertemporally. Unlike Ricardians' decision behaviors, they are less affected by the negative wealth effect after a fiscal expansion.[16]

Another difference between the two country groups is the degree of complementarity between public and private consumption. Most recent studies have found that public and private consumption are complements.[17] Karras (1994) investigates the relationship between private consumption and public spending and finds that they are more complementary than substitutable. Based on the estimates in 30 countries, we can see that overall the degree of complementarity between public and private consumption is rel-

[13]There are also other empirical evidence based approaches other than VAR, for example, Ramey and Shapiro (1998) use a narrative approach to investigate U.S. data and suggest that private consumption slightly decreases after a fiscal shock.

[14]URL:https://globalfindex.worldbank.org

[15]Empirically, there is barely direct measurement of the share of hand-to-mouth consumers, hence we resort to people who are unbanked as a proxy.

[16]Galí *et al.* (2007) first introduce the non-Ricardian households to a simple DSGE model which produces the crowding-in effect on consumption.

[17]Aschauer (1985) find substitutability between private consumpiton and overall government spending. About the relationship between private and public consumptions, see more detailed dicussions in Karras (1994), Ni (1995), Turnovsky and Fisher (1995) and Fiorito and Kollintzas (2004).

atively higher in developing than developed countries. The average value of estimates in sixteen high-income countries is -0.58 while the average value of estimates in five developing countries is -2.6. Bouakez and Rebei (2007) argue that when a strong complementarity exists between public and private consumption, higher government spending tends to increase marginal utility of households' consumption, stimulating households to work more, which in turn offsets the negative wealth effect induced by an increase in government spending. Higher complementarity in developing countries would cause a stronger increase in marginal utility, inducing a stronger crowding-in effect of private consumption.

Note that government financing schemes have an impact on fiscal policy effectiveness, as well. Corsetti (2012) provides empirical evidence that a higher public debt is followed by a drop of government spending below trend after a fiscal expansion based on a VAR model on U.S. time series, which is then named as "spending reversals". They state that the effect of fiscal policy is affected not only by current tax rules and spending choices but also by anticipation of future policy adjustments.[18] However, for developing countries, such "spending reversals"feedback is barely observed, and most developing countries have a great reliance on tax revenue to finance their debt. Hence, in this paper, government spending responds endogenously to the state of economy in the context of developed countries, in addition to distortionary taxation which works as the debt stabilization tool in both developed and developing countries.

The purpose of this paper is to build up a theoretical model to account for the discrepancies in empirical evidences of the responses of private consumption and the real exchange rate to a positive government innovation. Following Shen *et al.* (2018), we use a small open economy dynamic stochastic general equilibrium (DSGE) model, augmented with two modifications, such as a share of hand-to-mouth consumers, direct interaction between public and private purchase via preferences, where prices are adjusted infre-

[18]Baxter and King (1993), Leeper and Yang (2008) study how the changes in tax system affect the effects of fiscal policy. Shen *et al.* (2018) analyze that the dependence on external financing in low-income countries contributes to the short-run effects of government spending, as well.

quently in a forward looking manner, to reveal the transmission mechanisms underlying the dynamic effects of government spending shocks on private consumption and the real exchange rate within developed and developing countries.

Several findings are shown. First, by capturing country characteristics across developed and developing countries, such as a much lower fraction of savers, a relatively higher degree of complementarity between public and private consumption in developing than developed countries, the baseline model successfully generates the positive response of private consumption to a fiscal expansion in context of both developed and developing countries and a higher level of the positive response in developing than developed countries, as well. Including the share of hand-to-mouth consumers or(and) allowing public purchase into households' utility function directly is helpful to explain the empirical finding that the positive effect on private consumption is greater in developing than developed countries. The negative wealth effect induced by a higher government purchase would be offset either by a sufficient share of hand-to-mouth consumers who would spend all of their increased income or by public consumption working as a complement to private consumption which result in higher total private consumption and output.

Second, the baseline model generates an immediate real exchange rate appreciation in context of developing countries which is consistent with the empirical evidence. For developed countries, the real exchange rate tends to become depreciated gradually due to "spending reversals". The relatively higher degree of home bias in public spending contributes to the immediate real appreciation within developed and developing countries.

Third, combining "spending reversals" with hand-to-mouth consumers or non-separable preferences in context of developed countries would enhance the positive effect of government spending on private consumption, since "spending reversals" would mitigate the negative wealth effect induced by the positive government spending shock. Besides, anticipated spending reversals together with monetary policy tend to cause the immediate real appreciation in response to a fiscal expansion in developed countries to depreciate after several quarters, since the households expect public expenditure contraction in the

future to reduce inflation and the real short-term interest rate, which, in turn, is associated with lower current long-term interest rate. Lower long-term rates then reflect a real depreciation.

The rest of this paper is organized as follows. Section 2 is literature review. Section 3 develops the theoretical model. Section 4 describes calibrations and solutions. Section 5 discusses the model's implications. Section 6 shows some sensitivity analysis. Section 7 concludes.

## 2. Literature Review

Theoretically, the effect of a fiscal expansion on private consumption can be of both signs, which are called "crowding-in" (a rise in consumption) and "crowding-out"(a decline in consumption) effect on consumption. The textbook IS-LM model predicts that private consumption rises after a positive government spending shock, because increases in government spending trigger a rise of aggregate demand, prompting producers to increase their production to meet this new demand, which benefits labor market and thus raises households' income, which in turn increases private consumption. In contrast, the Real Business Cycle (RBC) model predicts a decline in domestic private consumption in response to an increase of government spending, as a fiscal expansion lowers present value of after-tax income and thus causes a negative wealth effect on consumption, assuming consumers behave in a Ricardian fashion. Unlike private consumption, both theories predict that real effective exchange rate appreciates after a positive government spending shock hits the economy. The IS-LM model claims that the rise in aggregate demand that accompanies an increased government spending shock needs a nominal exchange rate appreciation to clear the goods market, and thus entails a real exchange rate appreciation with the assumption of sticky prices. The RBC model predicts that a crowding-out private consumption induced by a fiscal expansion would lead to a real exchange rate appreciation with the assumption of international consumption risk sharing.

To reconcile the contradiction between empirical evidence and theoretical predictions,

researchers have proposed different modifications to the standard model. A strand of theoretical literature has devoted to generate nonnegative private consumption and (or) a real exchange rate depreciation after a positive government spending shock. Some of them has focused on the positive impact on private consumption after a fiscal expansion in a closed economy (Galí *et al.*, 2007; Bouakez and Rebei, 2007; Linnemann, 2006; Bilbiie, 2011, 2009). They augment some modifications such as non-Ricardian households, non-separable preferences over consumption and leisure or productive public capital to the standard model to generate positive consumption response. Some literature is interested in the dynamics of the real exchange rate in response to a positive government spending shock in an open economy, see Kim and Roubini (2008); Monacelli and Perotti (2010). Few literature has investigated the two effects simultaneously, except for Ravn *et al.* (2012), Corsetti (2012) and Iwata (2013). Ravn *et al.* (2012) argue that positive response of consumption and a real depreciation can be achieved if firm markups of prices are countercyclical with the economy. Corsetti (2012), yet resort to spending reversals to alter the short-run impact of fiscal policy in a new Keynesian model. They argue that after a positive government spending innovation, households expect a tight fiscal policy in future, which, in turn lowers future inflation and policy rates, combined with the reaction of monetary policy. This, then induces a fall in long-term real interest rates, stimulating current consumption since consumption is negatively correlated with all future interest rates in their theoretical model. A real exchange rate depreciation accompanies the lower long-term real interest rates, as well. Iwata (2013) documents that a DSGE model augmented with Edgeworth complementarity between private and public consumption, productive public capital works well to replicate the empirical evidence of a positive consumption response, in addition, if combined with home bias and incomplete asset market, the real exchange rate depreciation would appear based on Japan data.

# 3. The Model

This section describes the models in which transmission mechanisms underlying the effects of the government spending shocks. There are three types of agents included in the model: households, firms and policy authorities. (1) A continuum of infinitely-lived households optimize their utility function in which leisure and private consumption are valued. Additionally public consumption enters utility function in some models. Householdes are also separated into two groups, one can save ("saver") and the other is constrained to consume their income each period ("non-savers"). (2) Two production sectors for nontradables and tradables (denoted by $N$ and $T$) seek to achieve profit optimization by allocating capital and labor inputs. The nontraded sector is monopolistically competitive and the traded sector is perfectly competitive. There are nominal price rigidities in the nontraded sector. (3) Fiscal and monetary authorities set their instruments using simple feedback rules. Same assumptions regarding investment adjustment costs and labor mobility friction are made.

## 3.1. Households

The economy is populated by a continuum of households in which a fraction $F$ are savers (denoted by $s$) and a fraction $1-F$ are non-savers (denoted by $ns$).

### 3.1.1. Savers

A representative saver chooses ($c_t^s$), labor ($l_t^s$), investment, and capital ($i_t^{N,s}, i_t^{T,s}, k_t^{N,s}, k_t^{T,s}$) to maximize the expected utility over an infinite horizon

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{(c_t^{s*})^{1-\sigma}}{1-\sigma} - \mathfrak{a} \frac{(l_t^s)^{1+\psi}}{1+\psi} \right] \tag{2}$$

where $\beta \in (0,1)$ is the discount factor, $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution, $c_t^{s*}$ is composite consumption defined as in Leeper *et al.* (2015) $c_t^{s*} = c_t^s + U^g g_t$, where $g_t$ is government consumption. Negative [positive] $U^g$ denotes

complementarity[substitutability] between $c_t^s$ and $g_t$. And $\mathfrak{a} > 0$ is a labor disutility weight, $\psi \geq 0$ is the inverse of the Frisch labor elasticity.

The household's budget constraint is

$$c_t^s + i_t^{N,s} + i_t^{T,s} + b_t^{d,s} + ac_t^{i,s} = (1-\tau_t)\left(w_t l_t^s + r_t^N k_{t-1}^{N,s} + r_t^T k_{t-1}^{T,s}\right) + \frac{R_{t-1} b_{t-1}^{d,s}}{\pi_t} + z_t^s + \Omega_t^s \quad (3)$$

Savers can purchase domestic government bond $b_t^{d,s}$ at period $t$ and pay a nominal rate of $R_t$ at $t+1$. $w_t = \frac{W_t}{P_t}$ is the real wage rate, $P_t$ is the price of consumption, $\pi_t = \frac{P_t}{P_{t-1}}$ is the inflation rate, $z_t^s$ is government transfers, and $\Omega_t^s$ is profits from firms in the traded and non-traded good sectors.

Capital is assumed to be sector-specific and subject to adjustment costs

$$ac_t^{i,s} \equiv \frac{\kappa}{2}\left[\left(\frac{i_t^{N,s}}{k_{t-1}^{N,s}} - \delta\right)^2 k_{t-1}^{N,s} + \left(\frac{i_t^{T,s}}{k_{t-1}^{T,s}} - \delta\right)^2 k_{t-1}^{T,s}\right]$$

$r_t^N$ and $r_t^T$ are returns to capital in non-traded and traded good sectors, respectively. The law of motion for capital is:

$$k_t^{j,s} = (1-\delta)k_{t-1}^{j,s} + i_t^{j,s} \quad j \in (N,T) \quad (4)$$

where $\delta$ is the depreciation rate and $i_t^{j,s}$ is investment. Aggregate investment by savers is $i_t^s = i_t^{N,s} + i_t^{T,s}$.

Private consumption and investment are CES aggregates of nontradables and tradables with the intra-temporal elasticity of substitution $\chi > 0$ and the degree of home bias $\varphi \in (0,1)$ which measures the share of private spending on non-traded goods. Thus,

$$x_t = \left[\varphi^{\frac{1}{\chi}}\left(x_t^N\right)^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}}\left(x_t^T\right)^{\frac{\chi-1}{\chi}}\right]^{\frac{\chi}{\chi-1}}, \quad x_t \in \{c_t^s, i_t^s\}. \quad (5)$$

The corresponding demand functions are

$$c_t^{N,s} = \varphi(p_t^N)^{-\chi} c_t^s \qquad \text{and} \qquad c_t^{T,s} = (1-\varphi)(s_t)^{-\chi} c_t^s \quad (6)$$

and the price for composite consumption $c_t^s, P_t$, satisfies

$$1 = (\frac{P_t}{P_t})^{1-\chi} = \varphi(p_t^N)^{1-\chi} + (1-\varphi)(s_t)^{1-\chi} \tag{7}$$

where $s_t = \frac{S_t}{P_t}$ and $p_t^N = \frac{P_t^N}{P_t}$ are the relative prices of traded and non-traded goods, and $S_t$ and $P_t^N$ are their nominal prices, respectively. We normalize the price of composite consumption (or local goods) to 1.

Households supply labor to both sectors. Aggregate labor is

$$l_t = \left[ (\varphi^l)^{-\frac{1}{\chi^l}} \left(l_t^N\right)^{\frac{1+\chi^l}{\chi^l}} + (1-\varphi^l)^{-\frac{1}{\chi^l}} \left(l_t^T\right)^{\frac{1+\chi^l}{\chi^l}} \right]^{\frac{\chi^l}{1+\chi^l}}, \tag{8}$$

where $0 < \varphi^l < 1$ is the steady-state share of labor in the non-traded good sector. While capital is specific to each sector, we allow some labor mobility across sectors, and $\chi^l > 0$ is the elasticity of substitution between sectors. Therefore, the labor mobility is not perfect. A smaller $\chi^l$ implies more friction in labor mobility. From the cost minimization problem, the aggregate wage index can be derived as $w_t = \left[\varphi^l \left(w_t^N\right)^{1+\chi^l} + (1-\varphi^l)\left(w_t^T\right)^{1+\chi^l}\right]^{\frac{1}{1+\chi^l}}$, where $w_t^N$ and $w_t^T$ are the real wage rates of each sector.

#### 3.1.2. Non-savers

Non-savers have the same preferences as savers. Non-savers are hand-to-mouth agents, they receive after-tax labor income and lump-sum transfers $z_t^{ns}$ from the government and consume their entire disposable income every period. Non-savers have an inelastic labor supply ($l_t^{ns} = l^{ns} \forall t$) and the budget constraint is

$$c_t^{ns} = (1-\tau_t) w_t l^{ns} + z_t^{ns}. \tag{9}$$

### 3.2. Firms and Price Setting

The production sector consists of non-traded and traded goods producing firms. Non-traded goods firms are monopolistic competitors and prices are flexible. Nominal price

rigidities are also introduced in the non-traded goods sector.

#### 3.2.1. Nontraded Good Sector

The nontraded goods producer $i \in [0,1]$ has access to the technology

$$y_t^N(i) = z^N [k_{t-1}^N(i)]^{1-\alpha^N} [l_t^N(i)]^{\alpha^N} (k_{t-1}^G)^{\alpha^G} \tag{10}$$

where $z^N$ is the sector-specific total factor productivity and $k_{t-1}^G$ is public capital with an output elasticity of $\alpha^G$. Aggregating all nontraded goods $y_t^N = \left[\int_0^1 y_t^N(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$ and solving the profit maximization problem yield the demand function for good $i$,

$$y_t^N(i) = \left[\frac{P_t^N(i)}{P_t^N}\right]^{-\theta} y_t^N \tag{11}$$

A nontraded good firm $i$ chooses the nominal price $P_t^N(i)$, labor $l_t^N(i)$ and capital $k_{t-1}^N(i)$ to maximize its net present value profits,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \underbrace{\left[p_t^N(i) y_t^N(i) - ac_t^p(i) - w_t^N l_t^N(i) - r_t^N k_{t-1}^N(i)\right]}_{\equiv \Omega_t^N(i), dividends}$$

subject to the production function (10) and demand function (11), $\lambda_t$ is the marginal consumption utility of savers, $p_t^N(i) = \frac{P_t^N(i)}{P_t^N}$. Following Rotemberg (1982), each nontraded goods-producing firm is assumed to have a quadratic cost when it changes the nominal price of the variety it produces. Hence, nominal price rigidities are introduced in the form of price adjustment costs, which are given by $ac_t^p(i) \equiv \frac{\zeta}{2}\left[\frac{\pi_t^N(i)}{\pi_{t-1}^N} - 1\right]^2 p_t^N y_t^N$, where $\zeta \geq 0$, $\pi_t^N(i) = \frac{P_t^N(i)}{P_{t-1}^N(i)}$ and $\pi_t^N$ is the steady state level of gross inflation in nontraded sector. Total price adjustment costs correspond to $ac_t^p \equiv \int_0^1 ac_t^p(i) di$. Similarly, total output nontraded and dividends are defined as $y_t^N \equiv \int_0^1 y_t^N(i) di$, and $\Omega_t^N \equiv \int_0^1 \Omega_t^N(i) di$.

#### 3.2.2. Traded Good Sector

A representative traded good firm chooses labor and capital to maximize periodic profits

$$\Omega_t^T \equiv s_t \left[ z^T (k_{t-1}^T)^{1-\alpha^T} (l_t^T)^{\alpha^T} (k_{t-1}^G)^{\alpha^G} \right] - w_t^T l_t^T - r_t^T k_{t-1}^T$$

Total dividends from firms are $\Omega_t = \Omega_t^N + \Omega_t^T$, and total real output produced is $y_t = p_t^N y_t^N + s_t y_t^T$.

### 3.3. Monetary and Fiscal Policy

The monetary authority follows a Taylor-type rule, in which the nominal interest rate $R_t$ responds to current output and the current inflation rate,

$$R_t = R^* + \phi_\pi(\pi_t - \pi^*) + \phi_y(y_t - y^*) \tag{12}$$

where the variable with an asterisk denotes its steady state value.

The government receives taxes from capital and labor, and issues domestic bond, $b_t^d$, to finance its interest payments and expenditures at each period. Total expenditures include government purchases ($g_t^C$), public investment ($g_t^I$), transfers to households and debt services. The flow budget constraint is

$$tax_t + b_t^d = p_t^{GC} g_t^C + p_t^{GI} g_t^I + z_t + \frac{R_{t-1} b_{t-1}^d}{\pi_t} \tag{13}$$

where $tax_t = \tau_t(w_t^T l_t^T + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T)$. Lump-sum transfers are assumed to be identical across households, so that $z_t = \int_0^1 z_t(i)di = z_t^s = z_t^{ns}$.

Government spending and public investment are CES aggregates of traded and non-traded goods

$$G_t = \left[ (\varphi^G)^{\frac{1}{\chi}} \left(G_t^N\right)^{\frac{\chi-1}{\chi}} + (1-\varphi^G)^{\frac{1}{\chi}} \left(G_t^T\right)^{\frac{\chi-1}{\chi}} \right]^{\frac{\chi}{\chi-1}}, \quad G_t \in \left\{ g_t^C, g_t^I \right\}. \tag{14}$$

with the same intratemporal elasticity $\chi$ as in (5) and a share of public spending on non-

traded goods $0 \leq \varphi^G \leq 1$ which is assumed to be different from the home bias parameter $\varphi$ in the private sector.

The relative price is

$$p_t^j \equiv \frac{P_t^j}{P_t} = \left[\varphi^G (p_t^N)^{1-\chi} + (1-\varphi^G) s_t^{1-\chi}\right]^{\frac{1}{1-\chi}}, \quad j \in [GC, GI] \tag{15}$$

where $P_t^{GC}$, $P_t^{GI}$ are the nominal prices of $g_t^{GC}$ and $g_t^{GI}$, respectively.

Fiscal rules are described by the log-linear feedback forms below:

$$\log \frac{g_t^j}{g^j} = \rho_G \log \frac{g_{t-1}^j}{g^j} - \gamma_G \log \frac{s_{t-1}^b}{s_b} + \varepsilon_t^j, \quad j \in [GC, GI]. \tag{16}$$

$$\log \frac{\tau_t}{\tau} = \rho_\tau \log \frac{\tau_{t-1}}{\tau} + \gamma_\tau \log \frac{s_{t-1}^b}{s_b}, \tag{17}$$

where $s_{t-1}^b = \frac{b_{t-1}^d}{y_{t-1}}$ and the shocks $\varepsilon_t^j$ are assumed to be i.i.d.-normal. The tax rate is assumed to adjust to maintain debt sustainability, hence $\gamma_\tau \geq 0$. Note that if $\gamma_G < 0$, government consumption and investment follow a debt-stabilizing spending rule named "spending reversal" (Corsetti, 2012).

### 3.4. Aggregation and Market Clearing

Given two type of households, aggregate consumption and labor are calculated as

$$v_t = f v_t^a + (1-f) v_t^h, \quad v \in (c, c^N, c^T, l, l^N, l^T) \tag{18}$$

Note that only savers have access to asset and capital markets, therefore investment, capital, debt and dividends are calculated as

$$v_t = f v_t^a, \quad v \in (i, i^N, i^T, k^N, k^T, b^d, \Omega, ac^i) \tag{19}$$

The market clearing condition for nontradables is

$$y_t^N = (p_t^N)^{-\chi} D_t^N \tag{20}$$

where $D_t^N = \varphi\left(c_t + i_t + ac_t^i + ac_t^p\right) + \varphi^G\left[\left(p_t^{GC}\right)^\chi g_t^C + \left(p_t^{GI}\right)^\chi g_t^I\right]$.

Finally, the balance-of-payment condition is

$$c_t + i_t + p_t^G(g_t^C + g_t^I) + ac_t^i + ac_t^p = y_t \tag{21}$$

## 4. Solution and Calibration

Sims (2001) algorithm is used to solve the log-linearized equilibrium equations of the model which is calibrated at a quarterly frequency. To show how our framework can be used to assess the differences in the responses of private consumption and real exchange rate to a government spending shock in developed and developing countries, the model is calibrated to the recent economic conditions of Canada and Mexico, respectively. We use the quarterly data from 1998Q1 to 2017Q4 to calibrate the steady-state values of private consumption, public investment, and government debt as a share of output, and the income tax rate. Compared to Canada with a consumption to output ratio of roughly 55.89%, the ratio is relatively higher in Mexico, which is about 66.93%. The ratio of public investment to output in Mexico is about 4.09% on average and this ratio is set to 3.79% for developed countries.[19] The government debt-to-annual output ratio $sb$, is 0.299 for developed countries and 0.491 for developing countries.[20] The tax rate $\tau$, measured by the ratio of tax revenues (including social security taxes) to GDP, is 0.13 for developed countries and 0.143 for developing countries, and government transfers are kept constant throughout the analysis and is calibrated to close the government budget in the steady state.[21] Tables 5 and 6 contain these calibrated steady-state values and the values of parameter calibration.

For the following variable parameters, we use the common values in the general DSGE literature for both developed and developing countries. One reason is that some estimates

[19] Due to lack of gross fixed capital formation for private sector for Canada, here we use time series data of United States.

[20] For developed countries, time series data of government debt to output ratio is not available in Canada so we resort to data of Australia from 1998 to 2016, while for developing countries, data in Mexico is very short and thus we use data in Malaysia from 2002 to 2016.

[21] The tax rate calibration in developing countries is based on data of Brazil, due to the lack of sufficient tax rate data in Mexico.

for developing countries are hard to be located due to data unavailability. Another reason is that we need to focus on the key variable parameters in the model so as to keep all else equal across two groups of countries. The discount factor, $\beta$, is set to equal 0.99, which implies an annual steady state interest rate of 4%. The depreciation rate, $\delta$, is set to 0.025, consistent with the annual steady state depreciation rate 10% commonly used in relevant studies.[22] Quarterly CPI inflation rate is set to 1. For the intertemporal substitution elasticity for consumption, $1/\sigma$, we follow Ogaki *et al.* (1996) estimate for developing and high-income countries. For developing countries, we are interested in upper middle-income countries which has the point estimate of 0.605 while the estimate is 0.631 for high-income countries. This shows that little difference of intertemporal factors in consumption and saving decisions exists across developing and developed countries. Hence, $\sigma = 1/0.6$. For the labor Frisch elasticity, the elasticity of hand-to-mouth consumers is zero and savers' Frisch elasticity, $1/\psi$, is set to 0.5, following the value for developed countries, since there is lack of empirical support for developing countries. Home bias in private sector $\varphi$ is set to be 0.5, in line with the value used in many theoretical papers. Burstein *et al.* (2005) also give some empirical supports by estimating the tradable share in the private consumer price index in five developing countries Argentina, Brazil, Korea, Mexico and Thailand, which are 0.53, 0.593, 0.48, 0.535, and 0.433, respectively and thus the average value is 0.514. Home bias in public sector is higher than that in private sector due to some explicit or(and) implicit discriminatory government procurement policies. Gourdon and Messent (2017) estimate the ratio of import share in public sector to that in private sector and thus, home bias in government consumption is set to 0.72. Based on the the estimate of four Latin American countries in Ostry and Reinhart (1992), the intratemporal elasticity of substitution between tradables and nontradables, $\chi$ is set to 0.44. Based on Buffie *et al.* (2012), labor income shares in non-traded and traded good sectors are set to 0.45 and 0.6, respectively. Based on Gupta *et al.* (2014), the output

[22]Following García-Cicco *et al.* (2010), the discount factor, $\beta$, is set to 0.981 and the depreciation rate, $\delta$, is set to 0.03, based on quarterly time series data of Argentina. The results for developing countries, yet are quite similar to the baseline calibration.

elasticity with respect to public capital $\alpha^G$ is 0.11.[23] The intratemproal elasticity of substitution between non-traded good varieties is 8, matching the estimate in Pappa (2009). As for the price adjustment cost parameter $\zeta$, Shen *et al.* (2018) argues that it should be set to match the stickiness length of price stickiness to be 4-11 months, in consistent with the evidence showed in Nakamura and Steinsson (2008). For fiscal rules, parameters $\rho_g$, $\rho_\tau$ and $\rho_z$ are set to be 0.9, capturing the persistence for government spending deviations from trend stated in many related studies.

Some key variable parameters are set in the context of developed and developing countries' economic conditions, respectively.

For the share of savers, $F$, we resort to the World Bank's Global Financial Inclusion Database, which shows that 99.7% of adults have bank accounts in Canada while the fraction is 36.9% in Mexico in 2017. We can then calculate that about 83.72% of Canadians have bank accounts yet Mexico only has a much lower share of about 27.06%, showing that more than two thirds Mexicans are unbanked.[24]

For the substitutability of private and public consumption, $U^g$, we follow the estimations in Karras (1994) showing that private and public consumption has a complementary rather than a substitutable pattern in most of their samples. Hence, we calculate the mean value of the estimates to calibrate the parameter. We set $U^g = -0.58$ for developed countries and $U^g = -2.6$ for developing countries.[25]

For the sector elasticity substitution for labor, we set $\chi^l = 1$ for developed countries, in line with the estimate in Horvath (2000) using US data. There is a little direct empirical support for the estimate in developing countries, yet Artuc *et al.* (2015) provides the estimates of the labor mobility for 56 countries showing that in general mobility costs in developing countries are higher than that in developed countries. On average, the

[23] We take the average of outupt growth and the average of public capital stock growth for middle-income countries in 1990-2000 and 2000-2009 to calculate output elasticity of public capital.

[24] Estimate here is consistent with the value based on calculation in Klaehn *et al.* (2006) and Skelton *et al.* (2008) that less than 25 percent of Mexicans have bank accounts.

[25] According to Table 3 in Karras (1994)'s paper, we select estimates of sixteen high-income countries to get the mean value of -0.58 and of five upper middle income countries to get the value of -2.58. We notice that the variation is wide within each group, for example, among high-income countries, Japan has a estimate of -2.79 while United Kingdom has an estimate of 0.05. The same pattern also shows in developing countries, where Venezuela has an estimate of -3.18 while Thailand has an estimate of -2.18. In general, the country is less developed, public and private consumption gets more complementary.

labor mobility costs are 3.71 times the annual wage and 2.76 times the annual wage in developing and developed countries, respectively. Hence, we set $\chi^l = 0.7$ for developing countries, reflecting more labor mobility frictions in developing than in developed countries.

We consider "spending reversals" in developed countries following Corsetti (2012), hence set $\gamma_G = 0.04$ and a relatively less reliance on tax, hence set $\gamma_\tau = 0.01$. For developing countries, government is largely dependent on the taxation to stabilize debt, hence set $\gamma_\tau = 0.02$.

## 5. Results

Our baseline model is a new Keynesian model incorporated with price stickiness, non-saving hand-to-mouth consumers, non-separable preference between public and private consumption, and allows "spending reversal", as well. Figure 9 shows that after a positive government spending shock, private consumption rises on impact in both developed and developing countries, in addition, the positive response is greater in developing than developed countries. Both savers and hand-to-mouth consumers contribute to the increase in private consumption. A positive government spending shock leads to a rise in aggregate demand, which in turn induces the production to expand and thus wage rate goes up. And then hand-to-mouth consumers would raise their consumption with rising wages. This is because hand-to-mouth consumers are not affected by the negative wealth effect of future increased taxes since they have to consume all of their current disposable income to meet living needs. Given the share of hand-to-mouth consumers is relatively larger in developing than developed countries, the figure shows that consumption of hand-to-mouth consumers goes up in all countries yet it increases more in developing than developed countries. Based on the assumption of rational expectations, savers tend to lower their current consumption to smooth consumption in case of the future tax increase, given a fiscal expansion today. In the baseline model, however, consumption of savers rises on impact and gradually drops below its preshock level. The

transmission mechanism behind this is that public consumption works as a complementarity to private consumption in the model, hence, the increased public consumption causes marginal utility of savers to increase and thus private consumption raises. The real exchange rate appreciates immediately in both developed and developing countries, yet it then climbs to its preshock level and becomes depreciated gradually in developed countries. The relatively higher degree of home bias in public expenditure contributes to the immediate real exchange rate appreciation. The figure shows that non-traded output outperforms traded output, which is consistent with findings in Shen *et al.* (2018) where under a lower degree of home bias, higher government demand causes a rise in traded output, which, in turn, induces a real exchange rate depreciation, without external debt financing. "Spending reversals" contributes to the improvement of the real exchange rate in developed countries, which is consistent with Corsetti *et al.* (2010) who argue that a decline in the long-term interest rate would cause the real exchange rate to become depreciated.

In the following sections, we would examine how do hand-to-mouth consumers, public consumption entering households' utility function directly, and "spending reversals" contribute to the results of baseline model, respectively.

### 5.1. Hand-to-mouth Consumers

We first turn to the model including hand-to-mouth consumers solely ($U^g = 0$). Figure 10 shows that the model could successfully generate an increase of private consumption in response to a positive government spending innovation as long as the fraction of hand-to-mouth consumers is sufficiently large in the economy, which is consistent with Galí *et al.* (2007) and Colciago (2011). After a shock, private consumption in developing countries ascends on impact while it declines in developed countries. It is obvious that the positive private consumption response in developing countries depends greatly on the increased current consumption of hand-to-mouth consumers, which is large enough to offset the decline in savers' current consumption. For developed countries, although hand-to-mouth

consumers enhance their current consumption after a fiscal expansion, yet, the majority of the economy is savers, who tend to lower their current consumption. Therefore, the decline of savers' consumption dominates the pattern of consumption response. The model with hand-to-mouth consumers helps to explain the greater positive response of private consumption in developing countries than in developed countries, because compared to developed countries, developing countries have a relatively bigger share of non-savers. The real exchange rate appreciates after the shock in both developed and developing countries. This is because with a larger share of hand-to-mouth consumers, private consumption increases more after the shock, due to home bias in private consumption, the increased demand for domestically produced goods raises and thus pushes up the relative price of domestic goods to foreign goods, that is, the foreign economy is less expensive than domestic economy, hence an appreciation occurs.

### 5.2. Government Spending in Utility Function

We then examine the model only augmented with government spending entering the utility function directly ($F = 1$). When government spending is non-separable in households' utility and works as a complement to private consumption, private consumption goes up in response to a positive government spending shock. This is because increased public purchases raise output and consumption. In figure 11 we can see that since developing countries have a relatively higher complementarity between public and private consumption, the immediate positive response of private consumption to a government shock in developing countries is almost as much as 5 times than that in developed countries. Non-traded and traded output ascend by a higher level, which leads to total output raise more in developing than developed countries. Although trade output increases in both developed and developing countries, non-traded output rises by a higher level given a relatively higher degree of home bias in public purchase, therefore, the real exchange rate appreciates across countries.

### 5.3. "Spending Reversals"

As we mentioned before, "spending reversals" is hardly to observe in developing countries. Hence, we examine the model with "spending reversals" in the context of developed countries. Figure 12 shows that when we set a higher value to parameter $\gamma_G$, which implies that government spending is restrained more strongly in response to higher outstanding debt, the decline of private consumption in response to a fiscal expansion is lower and the real exchange rate becomes depreciated in a shorter time path. The reason is that higher inflation rate after the shock induces a rise of real interest rate, given Taylor rule. This anticipated increase in future short-run rate is then reflected in current long-term rate, which in turn is associated with a real exchange rate appreciation immediately. However, after a few quarters, government spending restraint would lead inflation rate to drop and then the process is reversed, which causes the real exchange rate to depreciate gradually. Higher feedback effect of "spending reversals" is associated with a stronger depreciation in a few quarters and more mitigation in negative wealth effect, implying a smaller amount of the declined private consumption on impact.

"Spending reversals" by itself is hard to generate a positive response of private consumption, nevertheless, it combines with hand-to-mouth consumers or non-separable preference would boost the rise of private consumption in response to a fiscal shock in the context of developed countries. Figure 13 displays that the model with hand-to-mouth consumers alone cannot generate positive consumption response at any horizon, since the share of hand-to-mouth consumers is much small, but combined with "spending reversals", private consumption tends to increase after about two years. The main contribution comes from the rise of savers' consumption, which results from the mitigation induced by "spending reversal" on negative wealth effect. Due to the mitigation, labor and output increase by a lower amount. Figure 14 shows that "Spending reversal" together with non-separable preference enhance the positive response of private consumption to a fiscal expansion, as well, but output multiplier becomes smaller given the lower rise of

labor in response to the offset caused by anticipated spending reversal. A similar pattern as in figure 13.

## 6. Sensitivity Analysis

In this section we examine several other factors displaying some discrepancies between developed and developing countries that might influence the effects of government spending. The degree of home bias in private consumption (investment) plays an important role in determining the response of the real exchange rate. A country with more home bias in the private sector, that is, lower trade openness, tends to experience a substantial real exchange rate appreciation after a positive government spending shock. The reason is that government spending mostly falls into domestic goods, which pushes up the relative price of home-produced to foreign-produced goods, hence, domestic economy becomes relatively more expensive than the foreign economy, which means that a real exchange rate appreciation appears. In the baseline model, to focus on the factors of interest, we set the same value for the degree of home bias in private sector across developed and developing countries. Empirical evidence suggests that more home bias exists in developing than developed countries in general, due to less developed economic environment and market conditions (Bekaert and Wang (2009)). Figure 15 displays the short-run effects across the two groups of countries. We set $\varphi = 0.72$ for developing countries and $\varphi = 0.4$ for developed countries, with all else equal to their settings in the baseline model. To compare figure 15 with figure 9, we can see that for developed countries, with lower degree of home bias, the real exchange rate tends to become depreciated on impact, as traded output outperforms non-traded output. For developing countries, with higher degree of home bias, non-traded goods shoot up on impact while traded goods decrease, the relative higher price of domestic-based good leading to a substantial appreciation, which is consistent with the statement of Ilzetzki *et al.* (2013) that the volatility of real exchange rate in developed countries are more associated with the volatility in traded goods while the volatility of real exchange rate in developing countries mainly reflects

the fluctuations in non-traded goods.

Another factor we need to consider is the differences in fiscal rules between developed and developing countries. Government spending is founded to be procyclical in developing countries (e.g., Gavin and Perotti (1997), Kaminski *et al.* (2004), and Alesina *et al.* (2008)). In the baseline model, we do not model the procyclical response in developing countries. Now we let government spending responds to output with a one-quarter delay ($y_{t-1}$), which is specified as

$$\log \frac{g_t^j}{g^j} = \rho_G \log \frac{g_{t-1}^j}{g^j} - \gamma_G \log \frac{s_{t-1}^b}{s_b} + \eta_G log \frac{y_{t-1}^b}{y} + \varepsilon_t^j, \quad j \in [GC, GI].$$

Following Bi *et al.* (2014), we set $\eta_G = 0.1$. Figure 16 shows the results. Comparing with figure 9, little obvious changes suggest that the weakly procyclical response of government spending to output in developing countries has less impact on the short-run effects of government spending, or precisely, if there is, comparing to other factors included in the baseline model, the influence is tiny.

## 7. Conclusion

This paper is a complement to the theoretical analysis on the effects of government spending. The majority of existing related papers have studied fiscal policy issues in developed countries. However, empirical evidence based on VAR model suggests that in developed countries private consumption increases and the real exchange rate depreciates in response to a fiscal expansion, while in developing countries, private consumption shares a similar pattern but the crowding-in effect is stronger and the real exchange rate appreciates in response to a fiscal expansion. This paper attempts to propose a explanation for the discrepancies of empirical findings between developed and developing countries.

The features in different countries such as the composition of households, complementarity between public and private consumption, government financing strategies, are identified to influence the effects of fiscal policy. Empirical studies show that developed

and developing countries vary greatly in terms to theses features. This paper contributes to the literature by estimating a two-sector dynamic new Keynesian model introducing nominal price rigidities, hand-to-mouth consumers, and non-separable preferences between public and private consumptions to study the effects of government spending on private consumption and the real exchange rate in the context of both developed and developing countries.

The estimated model delivers a crowding-in consumption in the two groups of countries and such positive response is larger in developing than developed countries. For the real exchange rate, the model produces an immediate appreciation in developed and developing countries, but the real exchange rate tends to become depreciated after several quarters in developed countries. The larger share of hand-to-mouth consumers and the higher complementarity between public and private consumptions work well in generating a stronger positive consumption response to a fiscal expansion in developing countries. Although anticipated spending reversal in developed countries tends to significantly magnify consumption multiplier effect on impact, it mainly works to cause the real exchange rate depreciation later, due to its close link to monetary policy under the logic of rational expectation hypothesis.

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Galí, J., López-Salido, J. D. and Vallés, J. (2007). Understanding the effects of government spending on consumption. *Journal of the European Economic Association*, **5** (1), 227–270.

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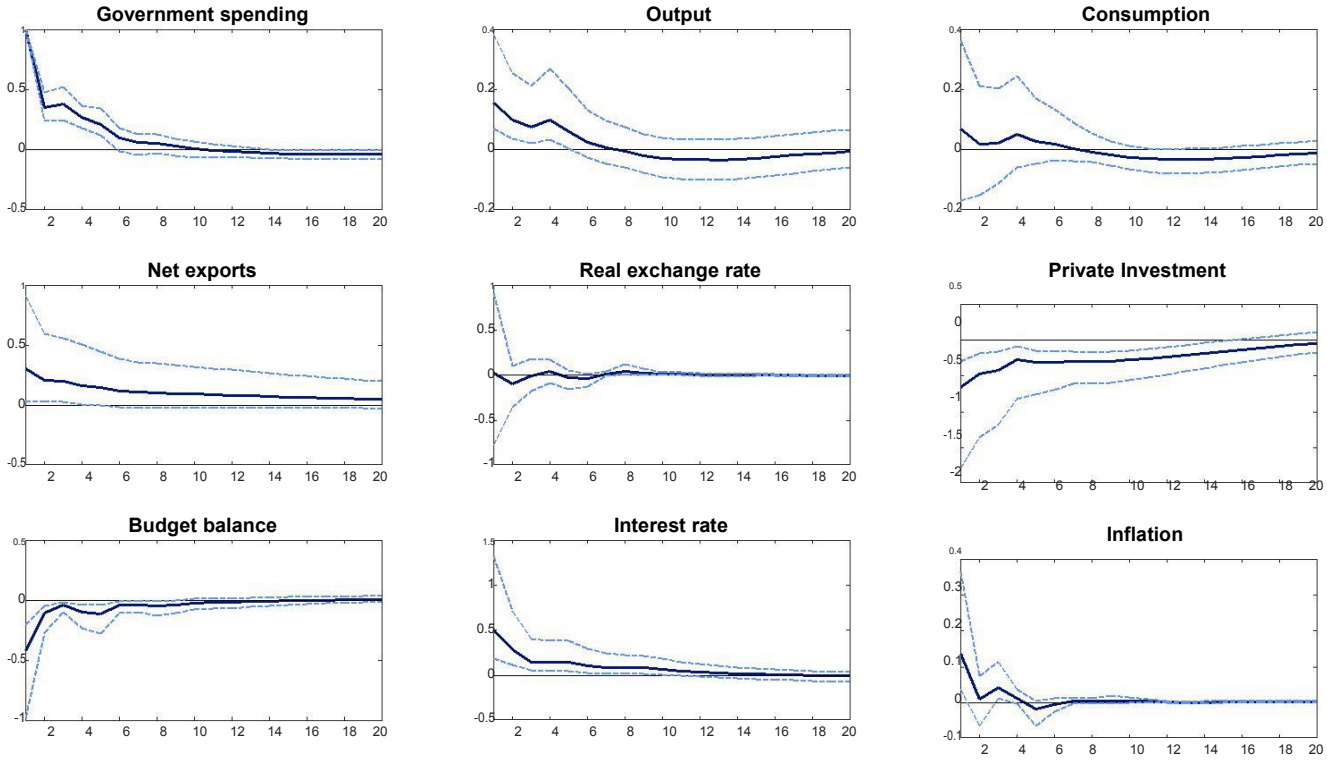
# APPENDICES

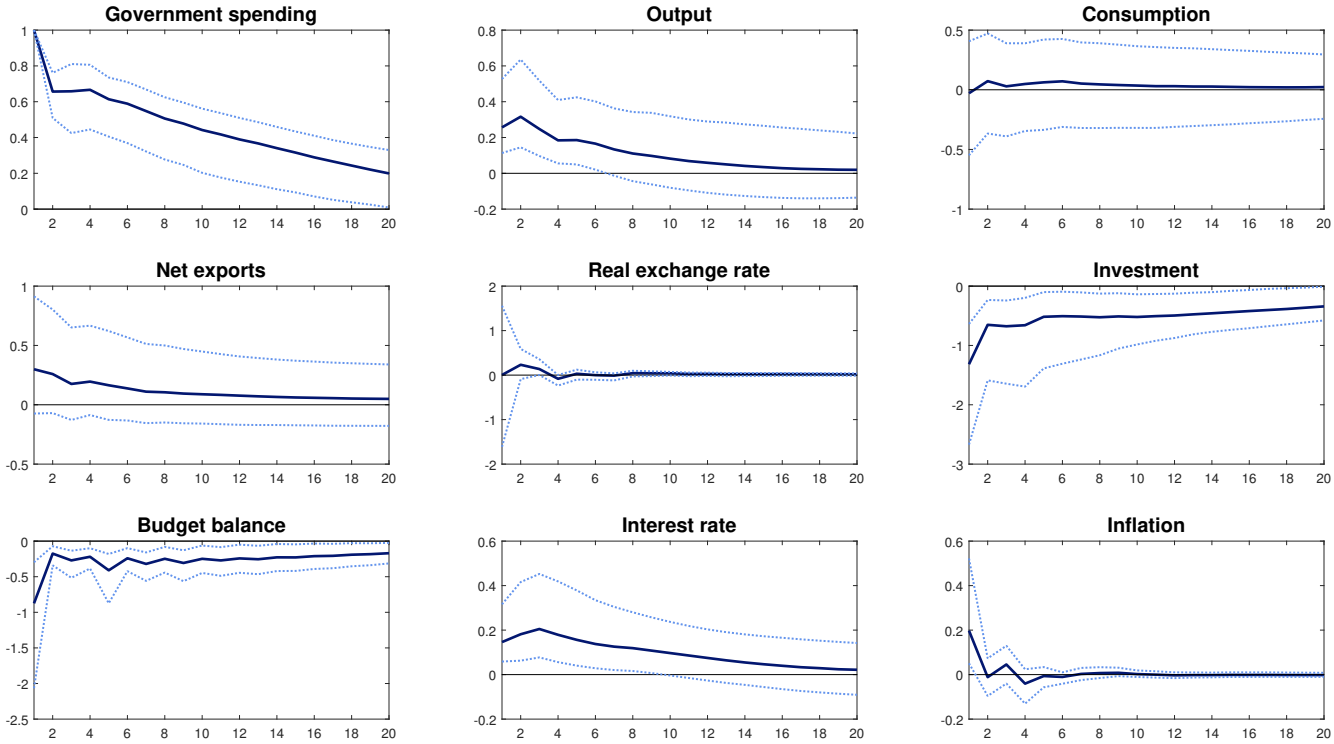
## APPENDIX A: Figures

Figure 1: Impulse Responses of Developing Countries: Baseline Model



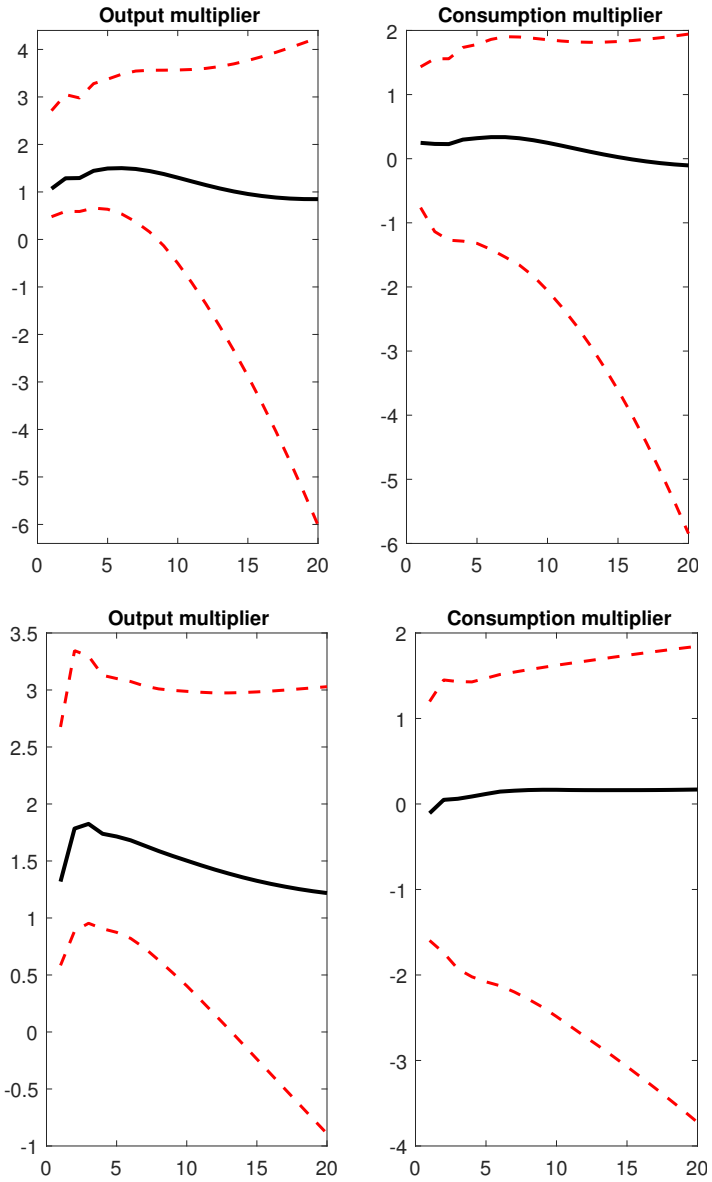

Impulse responses to a 1% government spending shock in developing countries. The median responses and the 16 and 84% quantiles are depicted.

Figure 2: Impulse Responses of Developed Countries: Baseline Model



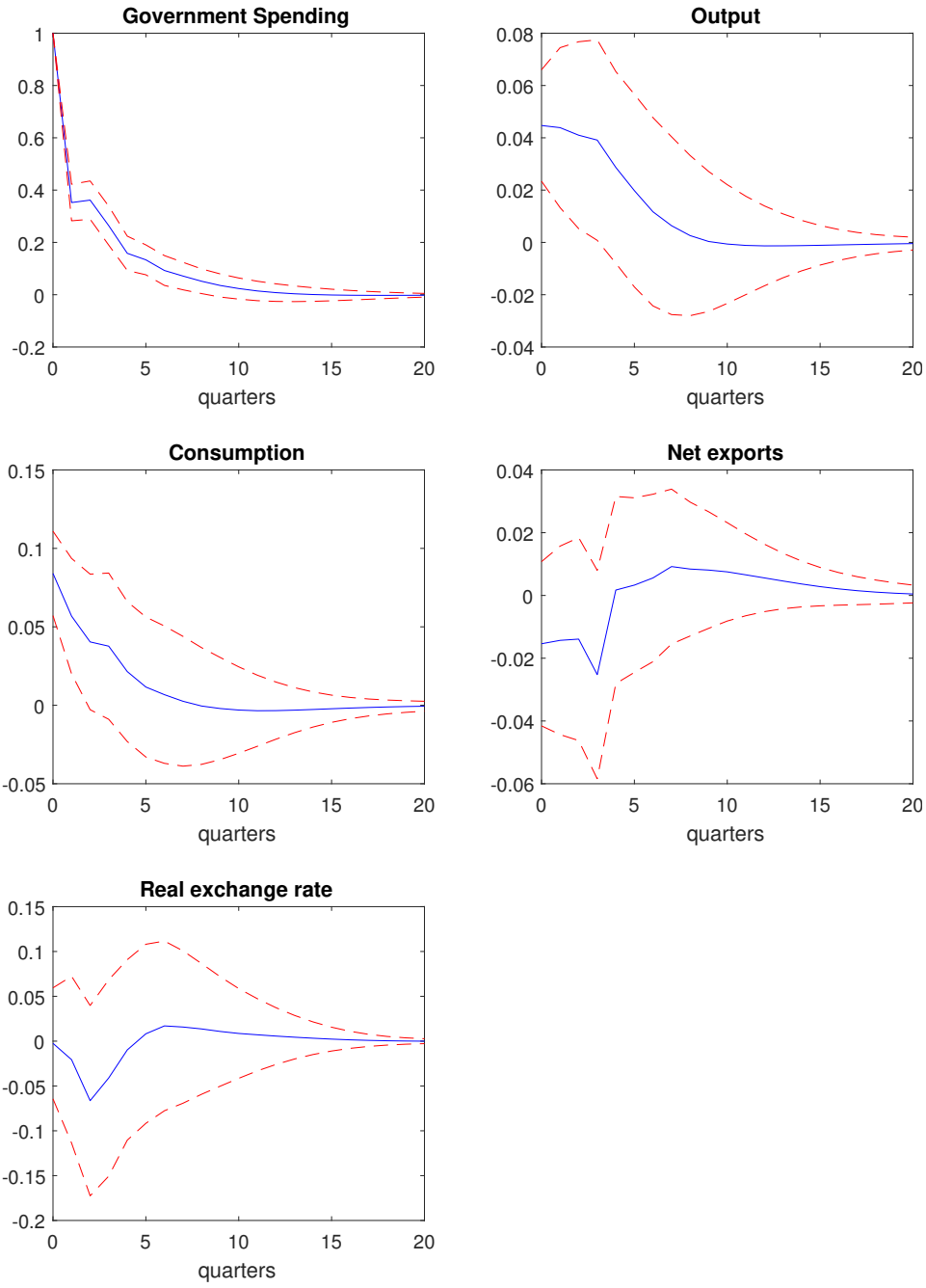

Impulse responses to a 1% government spending shock in developed countries. The median responses and the 16 and 84% quantiles are depicted.

Figure 3: Cumulative Multipliers: Baseline Model



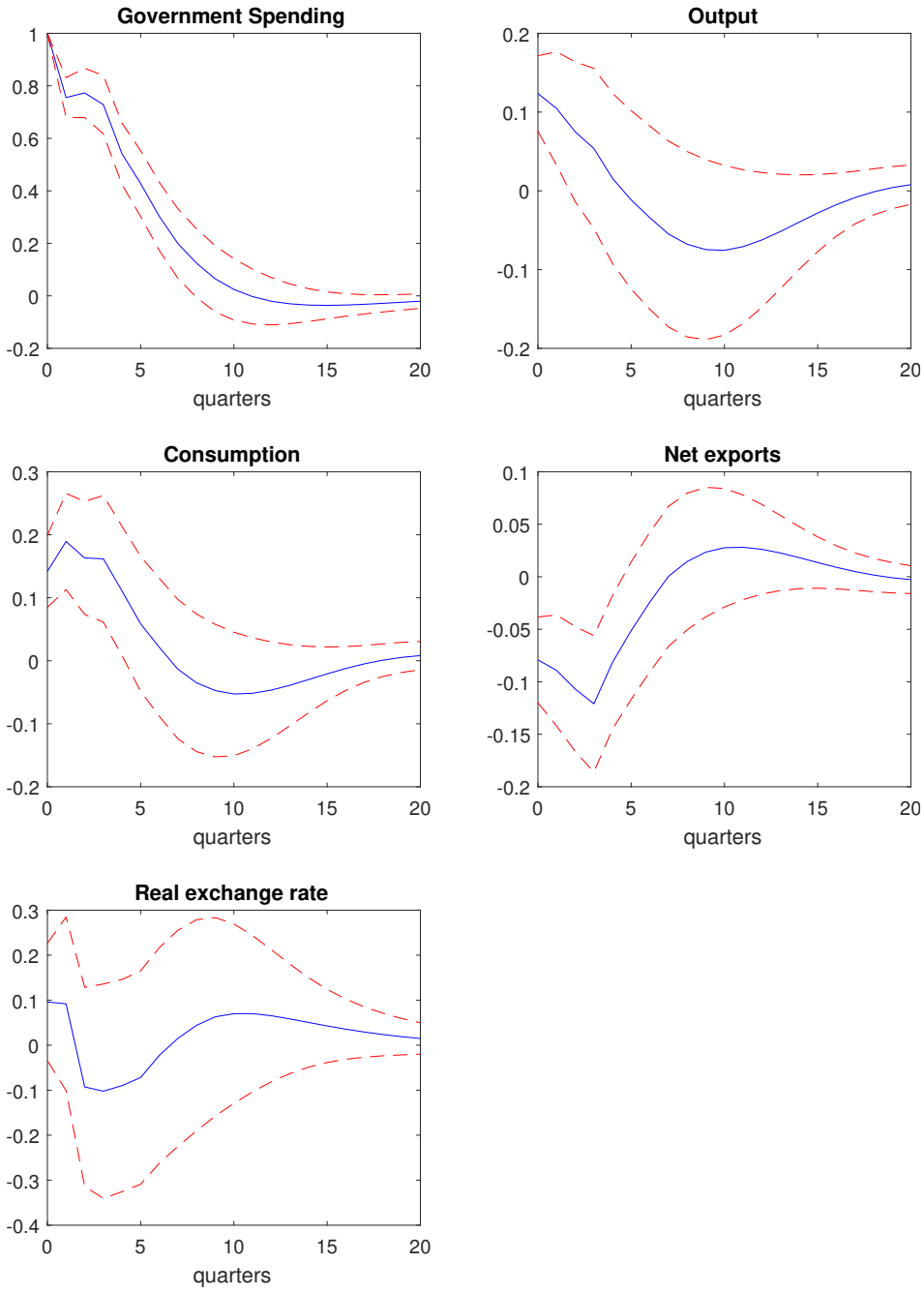

Cumulative multipliers of developing (upper panel) and developed (lower panel) countries. Output multiplier is the ratio of the cumulative increase in the net present value of GDP to the cumulative increase in the net present value of government consumption. Consumption multiplier is the ratio of the cumulative increase in the net present value of private consumption to the cumulative increase in the net present value of government consumption. Multipliers are calculated on the basis of impulse response functions obtained in baseline model.Dotted lines represent 90% confidence intervals based on Monte Carlo simulation.

Figure 4: Impulse Responses of Developing Countries: Short-run Restrictions



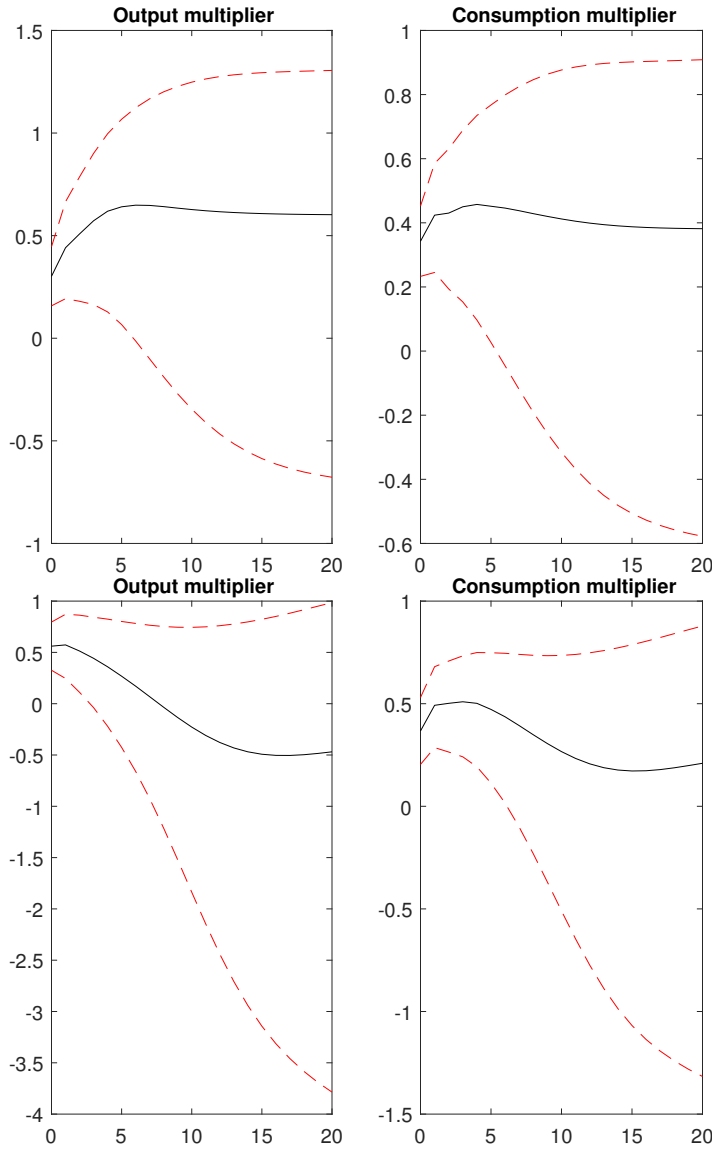

Impulse responses to a 1% government spending shock.(Short-run Restrictions_Developing Countries)

Figure 5: Impulse Responses of Developed countries: Short-run Restrictions



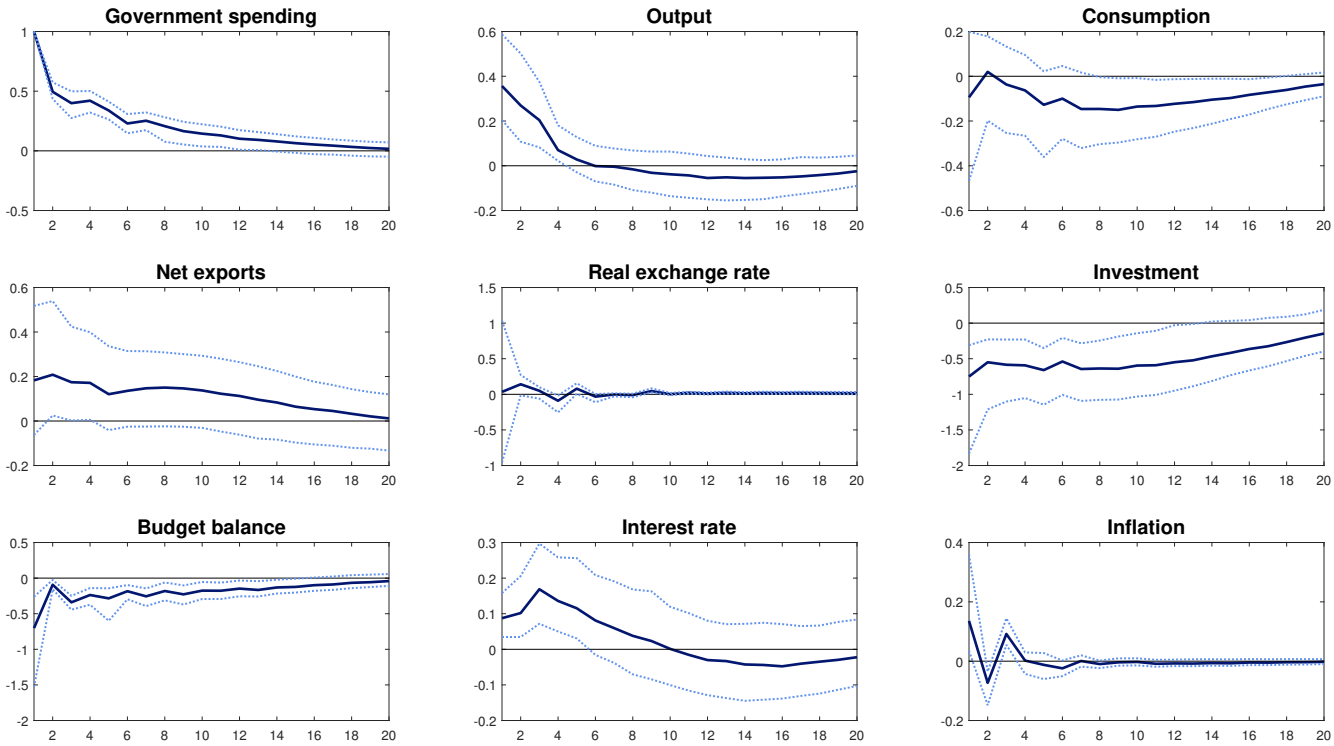

Impulse responses to a 1% government spending shock.(Short-run Restrictions_Developed Countries)

Figure 6: Cumulative Multipliers: Short-run Restrictions



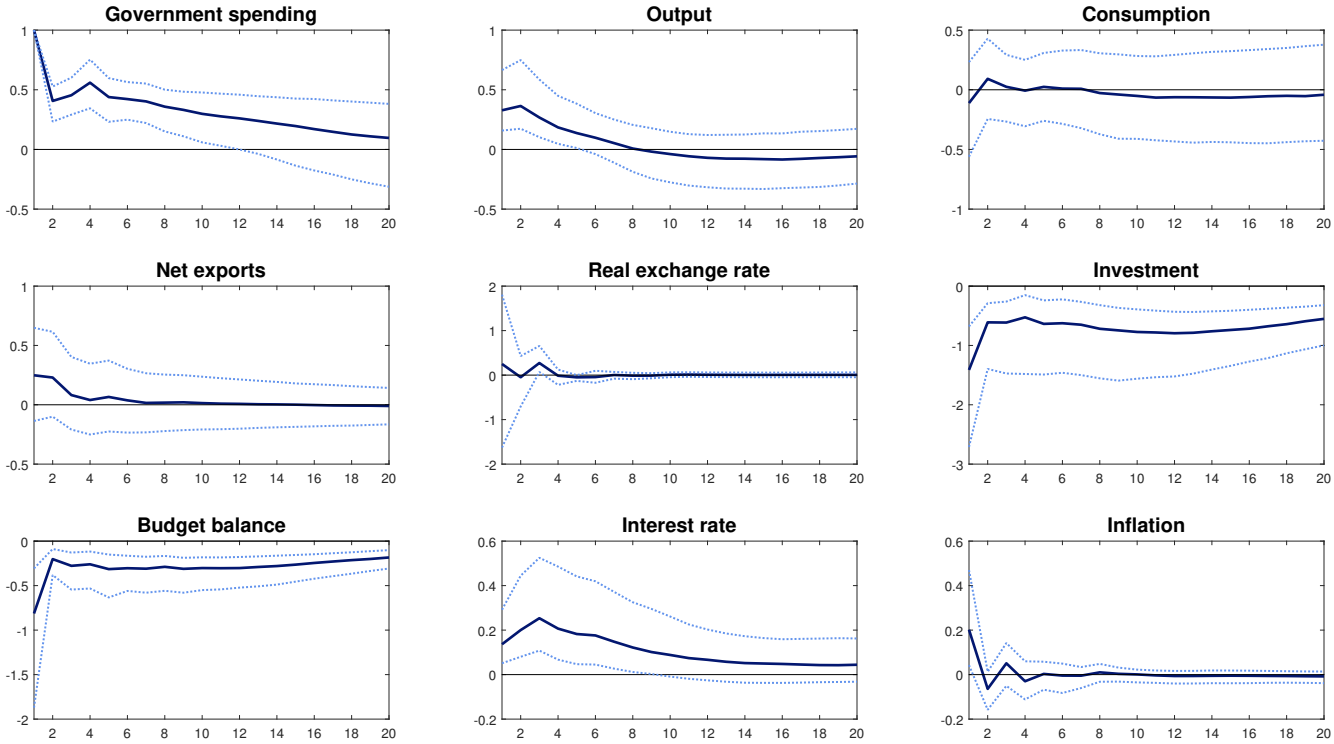

Cumulative multipliers of developing (upper panel) and developed (lower panel) countries. Output multiplier is the ratio of the cumulative increase in the net present value of GDP to the cumulative increase in the net present value of government consumption. Consumption multiplier is the ratio of the cumulative increase in the net present value of private consumption to the cumulative increase in the net present value of government consumption. Multipliers are calculated on the basis of impulse response functions obtained in the model using short-run restriction to identify the government spending shock. Dotted lines represent 90% confidence intervals based on Monte Carlo simulation.

Figure 7: Impulse Responses of Developed Countries: Subsample Periods



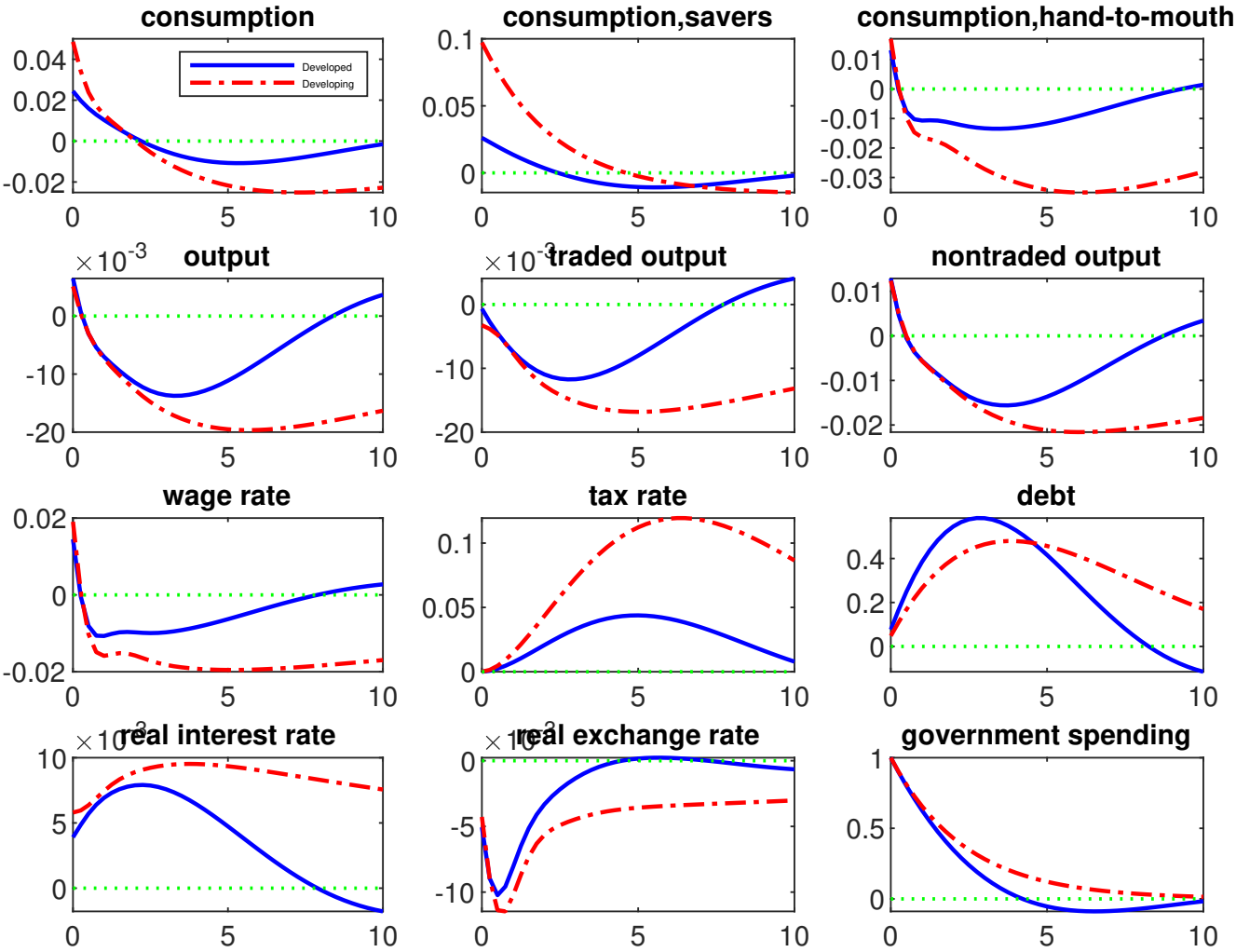

Impulse responses to a 1% government spending shock. (Subsample periods:1999q1-2007q4)

Figure 8: Impulse Responses of Developed Countries: Subsample Countries



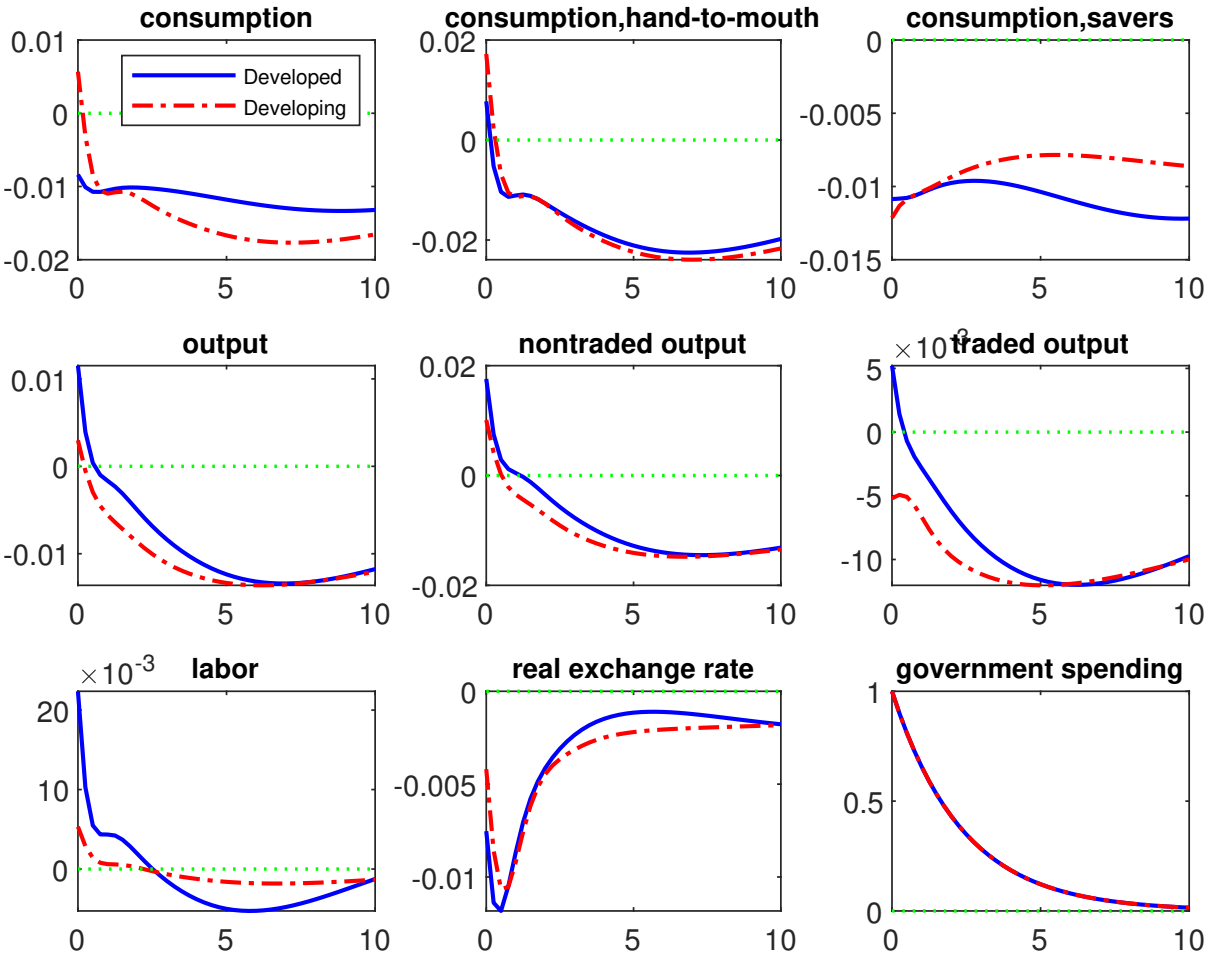

Impulse responses to a 1% government spending shock. (Subsample countries: G7_exclude Japan)

Figure 9: Effects of a Government Spending Shock: Baseline Specification



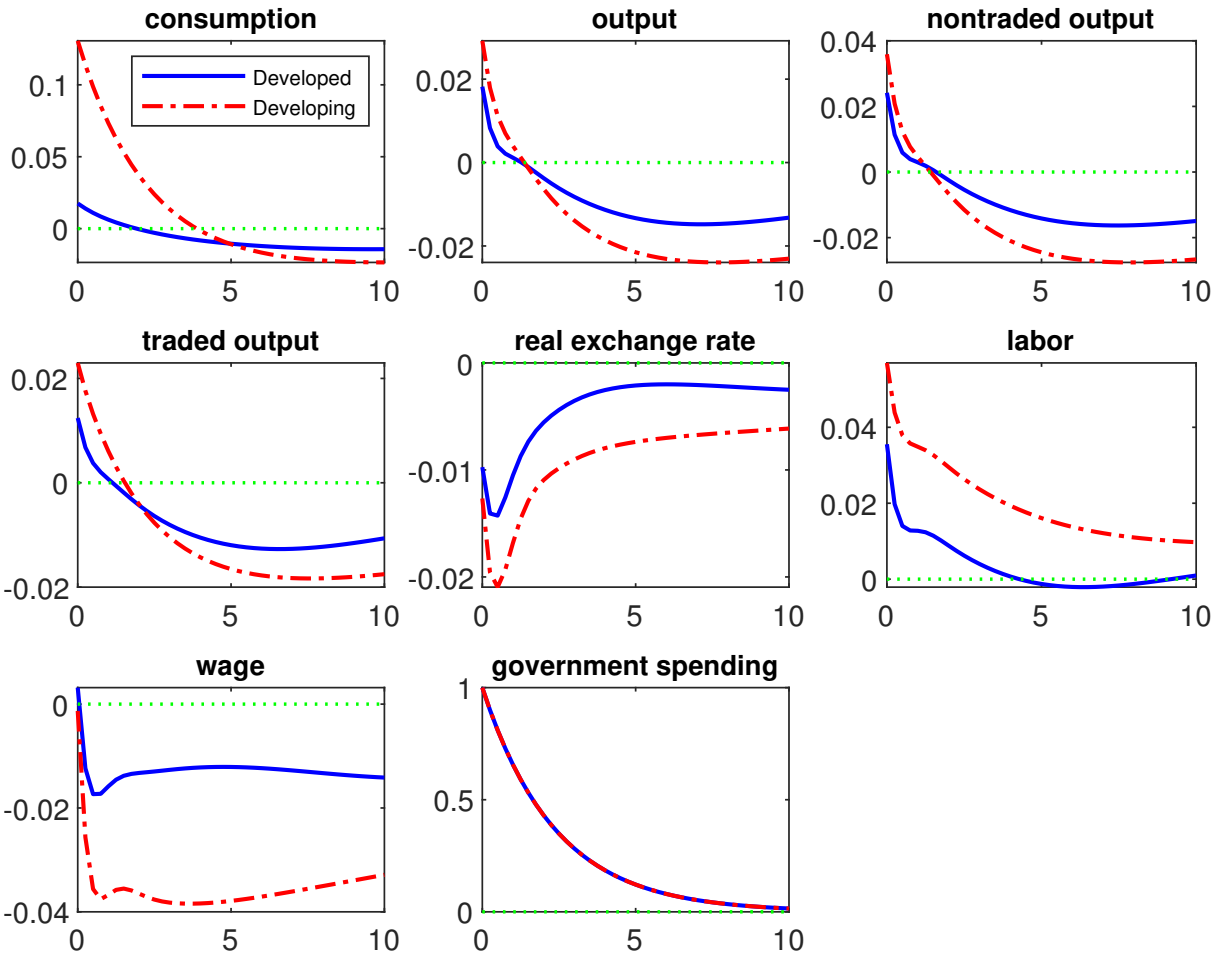

The solid lines are the responses of developed countries, and the dotted lines are the responses of developing countries.

Figure 10: Effects of a Government Spending Shock: Hand-to-mouth Consumers



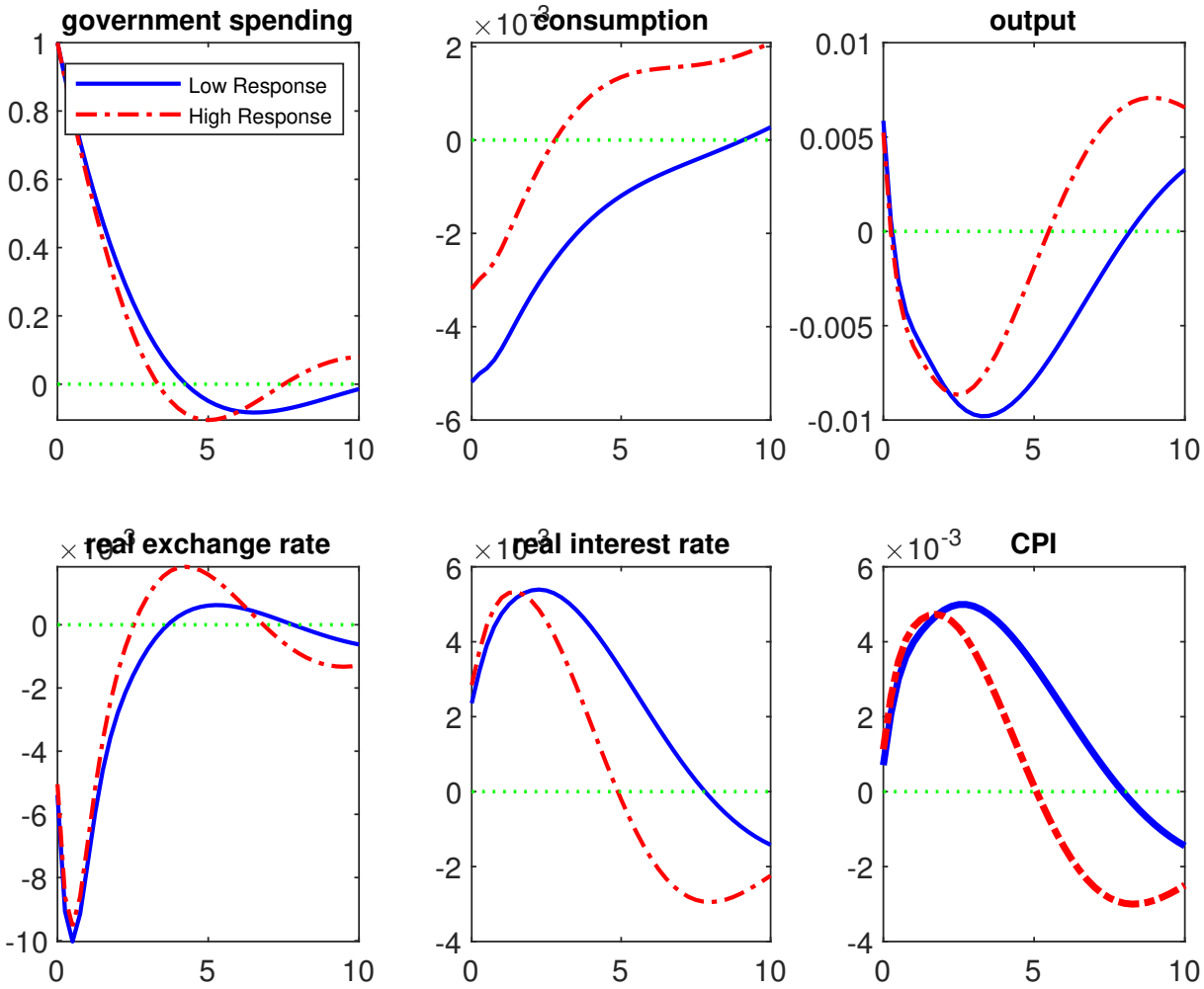

The solid lines are the responses of developed countries, and the dotted lines are the responses of developing countries.

Figure 11: Effects of a Government Spending shock: g in Utility



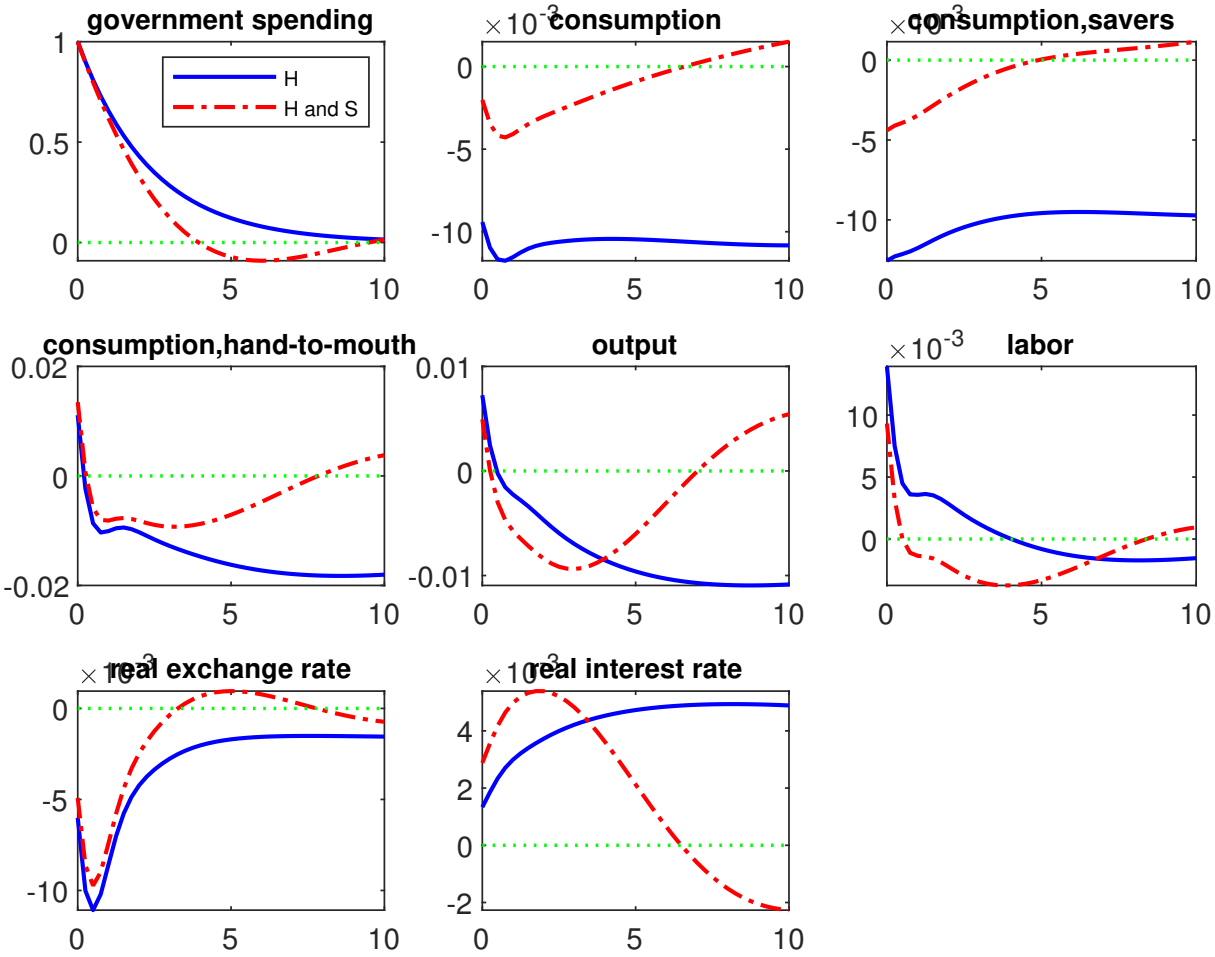

The solid lines are the responses of developed countries, and the dotted lines are the responses of developing countries.

Figure 12: Effects of a Government Spending Shock in Developed Countries: "Spending Reversal"



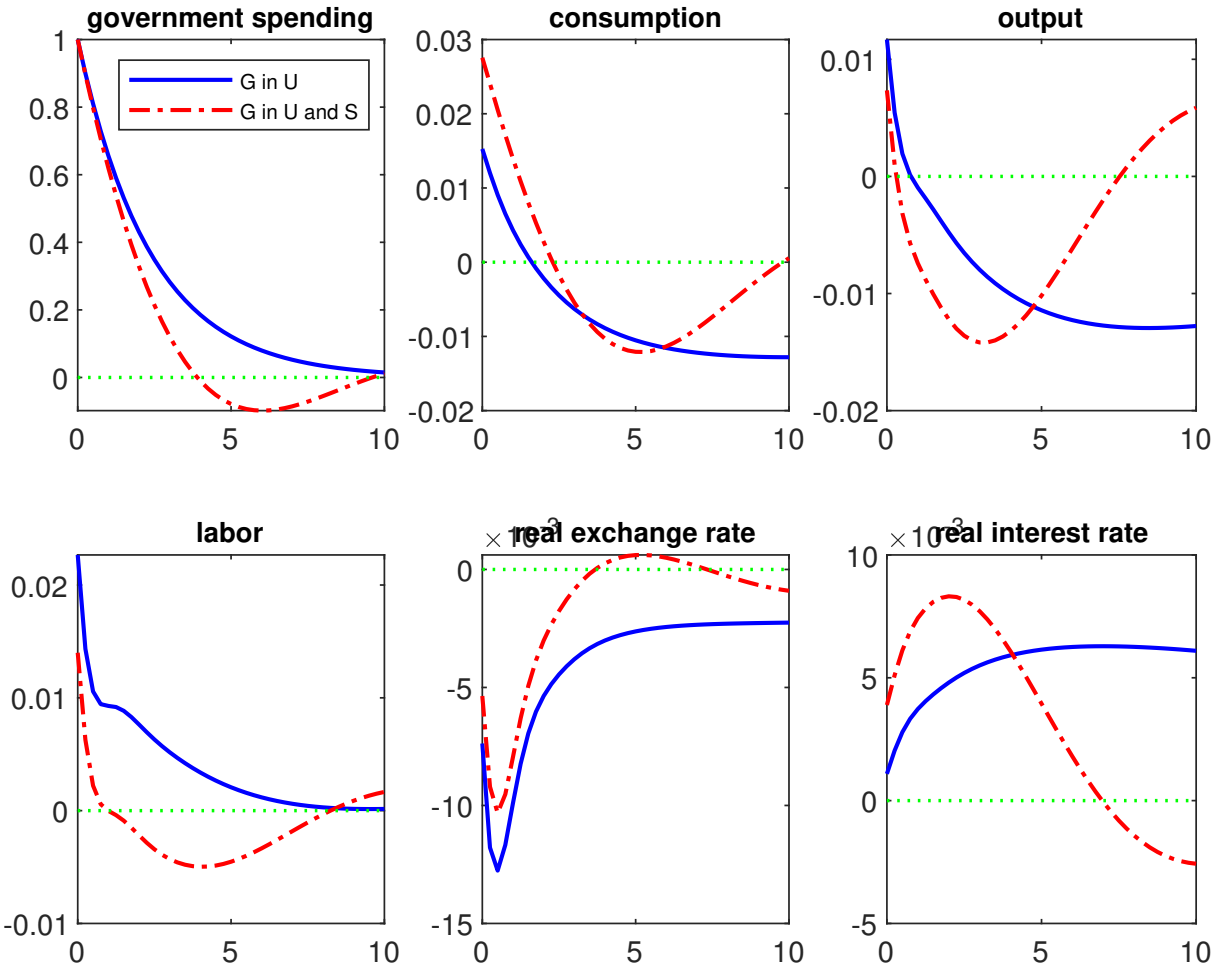

High response has $\gamma_G = 0.12$; Low response has $\gamma_G = 0.02$.

Figure 13: Effects of a Government Spending Shock in Developed Countries: "Spending Reversals" and Hand-to-mouth Consumers



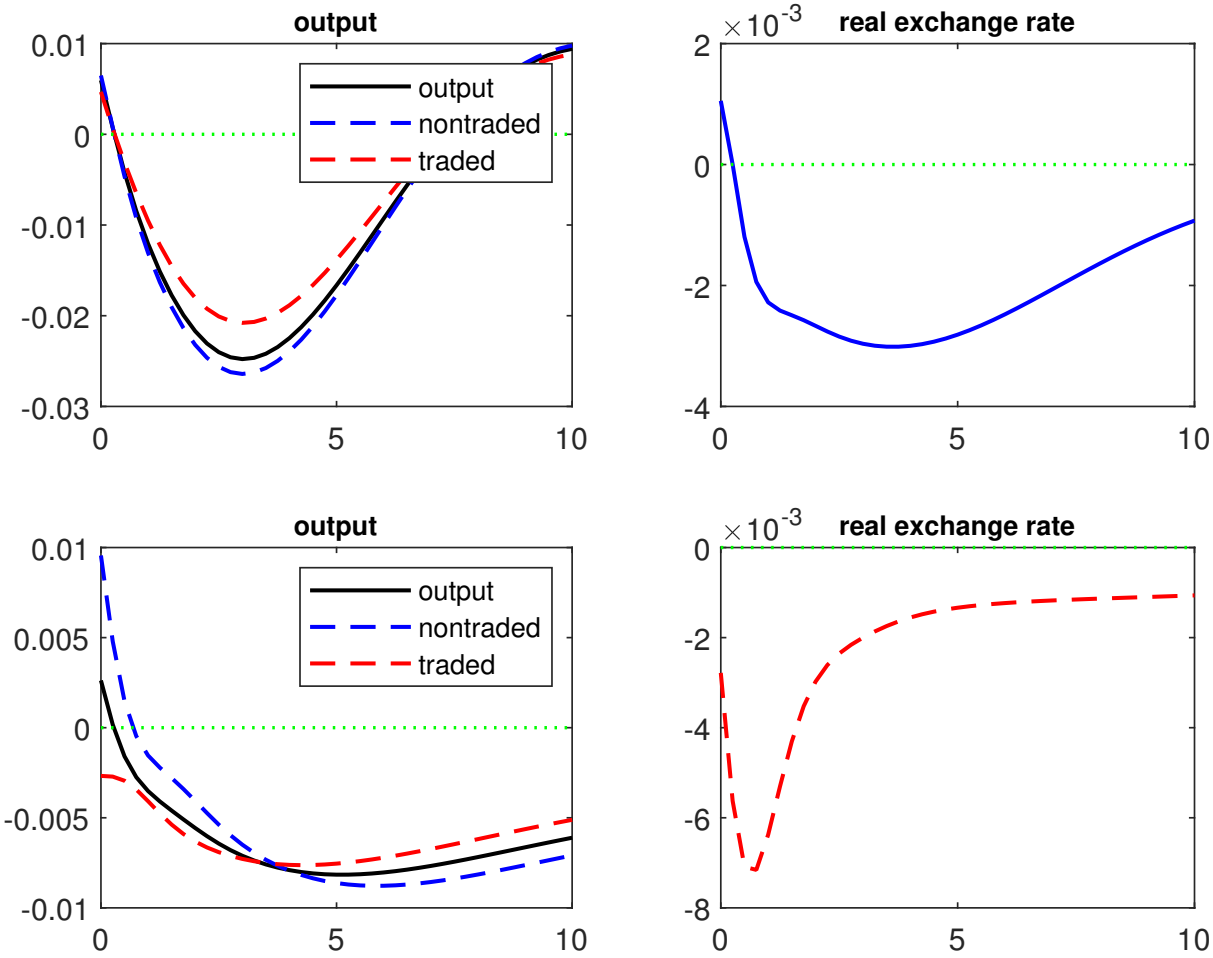

The solid lines are the responses of a model with hand-to-mouth consumers only (H), and the dotted lines are the responses of a model with both hand-to-mouth consumers and "spending reversals" (H and S).

Figure 14: Effects of a Government Spending Shock in Developed Countries: "Spending Reversals" and g in Utility



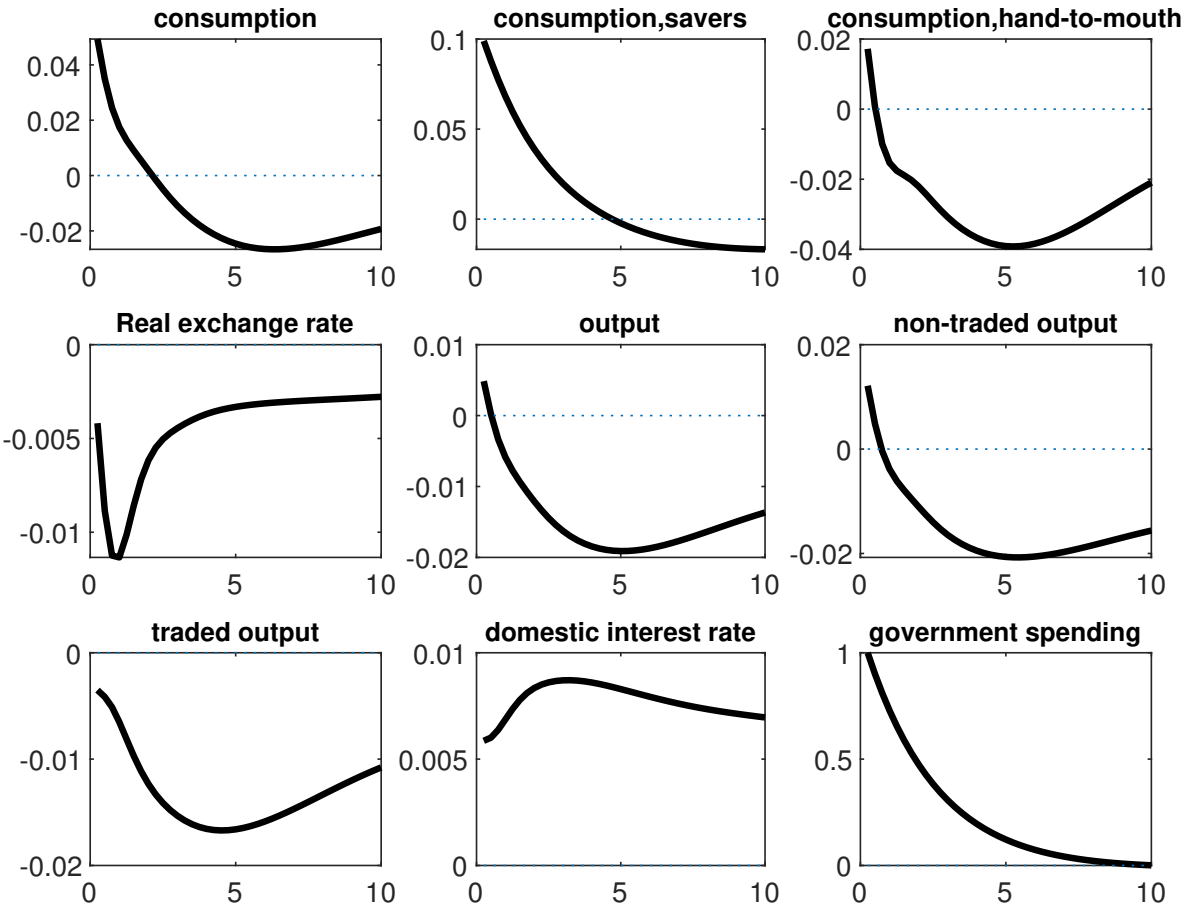

The solid lines are the responses of a model with g in utility only (G in U), and the dotted lines are the responses of a model with both G in Utility and "spending reversals" (G in U and S).

Figure 15: Sensitivity: Home Bias




Effects of a government spending shock in developed and developing countries: upper panel is responses of developed countries with lower degree of home bias ($\varphi = 0.4$); lower panel is responses of developing countries with higher degree of home bias ($\varphi = 0.72$).

Figure 16: Sensitivity: Procyclical Response




Effects of a government spending shock in developing countries: procyclical response to output.

## APPENDIX B: Tables

Table 1: Set of Imposed Sign Restrictions

| Variables | Sign Restrictions |
|---|---|
| Government spending | + |
| Output | + |
| Private consumption | ? |
| Private investment | - |
| Net exports | ? |
| Real exchange rate | ? |
| Budget balance | - |
| Interest rate | + |
| Inflation | + |

Table 2: Summary Statistics: Standard Deviation of Nine Variables

| Sample | g | y | c | nxy | rer | I | bb | r | $\pi$ |
|---|---|---|---|---|---|---|---|---|---|
| Australia | 0.03 | 0.02 | 0.05 | 1.32 | 0.04 | 0.06 | 2.16 | 1.41 | 0.01 |
| Canada | 0.02 | 0.02 | 0.02 | 2.95 | 0.03 | 0.04 | 1.85 | 1.63 | 0.01 |
| Denmark | 0.02 | 0.04 | 0.03 | 1.46 | 0.01 | 0.13 | 2.96 | 1.61 | 0.01 |
| France | 0.05 | 0.02 | 0.02 | 1.54 | 0.01 | 0.05 | 1.68 | 1.59 | 0.00 |
| Germany | 0.02 | 0.02 | 0.01 | 2.13 | 0.01 | 0.05 | 2.10 | 1.59 | 0.00 |
| Italy | 0.03 | 0.02 | 0.02 | 1.46 | 0.01 | 0.04 | 1.70 | 1.59 | 0.01 |
| Portugal | 0.03 | 0.02 | 0.02 | 4.08 | 0.01 | 0.08 | 3.04 | 1.59 | 0.01 |
| Spain | 0.04 | 0.03 | 0.03 | 2.89 | 0.01 | 0.11 | 4.69 | 1.59 | 0.00 |
| United Kingdom | 0.07 | 0.05 | 0.07 | 0.56 | 0.02 | 0.06 | 2.79 | 2.18 | 0.01 |
| United States | 0.05 | 0.03 | 0.04 | 0.99 | 0.03 | 0.09 | 3.56 | 2.17 | 0.00 |
| All_developed countries | 0.04 | 0.03 | 0.04 | 4.14 | 0.02 | 0.08 | 3.55 | 1.87 | 0.01 |
| Argentina | 0.13 | 0.09 | 0.10 | 4.39 | 0.10 | 0.21 | 1.74 | 11.79 | 0.03 |
| Brazil | 0.03 | 0.04 | 0.04 | 2.15 | 0.07 | 0.10 | 1.17 | 4.47 | 0.01 |
| Bulgaria | 0.07 | 0.02 | 0.03 | 6.98 | 0.02 | 0.12 | 3.88 | 1.82 | 0.02 |
| Columbia | 0.03 | 0.03 | 0.03 | 1.88 | 0.05 | 0.07 | 1.55 | 2.66 | 0.01 |
| Israel | 0.03 | 0.03 | 0.03 | 2.07 | 0.03 | 0.07 | 2.78 | 0.01 | 0.01 |
| Malaysia | 0.07 | 0.03 | 0.03 | 5.17 | 0.04 | 0.05 | 2.66 | 0.39 | 0.02 |
| Mexico | 0.05 | 0.02 | 0.02 | 0.58 | 0.04 | 0.04 | 1.62 | 3.65 | 0.01 |
| Peru | 0.08 | 0.03 | 0.04 | 3.72 | 0.02 | 0.10 | 1.92 | 2.03 | 0.01 |
| Philippine | 0.05 | 0.03 | 0.03 | 3.01 | 0.03 | 0.05 | 1.75 | 2.22 | 0.01 |
| Romania | 0.10 | 0.02 | 0.04 | 4.25 | 0.03 | 0.16 | 2.78 | 10.88 | 0.01 |
| South Africa | 0.05 | 0.05 | 0.04 | 2.16 | 0.06 | 0.14 | 2.30 | 2.68 | 0.01 |
| South Korea | 0.03 | 0.03 | 0.03 | 2.07 | 0.03 | 0.07 | 2.78 | 0.01 | 0.01 |
| Thailand | 0.03 | 0.04 | 0.04 | 3.88 | 0.02 | 0.14 | 1.94 | 1.07 | 0.01 |
| Turkey | 0.05 | 0.06 | 0.05 | 2.93 | 0.07 | 0.15 | 2.21 | 27.16 | 0.02 |
| All_developing countries | 0.06 | 0.04 | 0.04 | 6.84 | 0.05 | 0.12 | 3.33 | 10.62 | 0.02 |

This tables shows standard deviations of each variable in each country. g:government spending, y:output, c:private consumption, nxy:net exports to GDP ratio, rer:real exchange rate, I:private investment, bb:budget balance to GDP ratio, r:interest rate, $\pi$:inflation rate.

Table 3: Summary Statistics of Government Spending for Developed Countries

| Sample | GC/GDP(%) | Autocorrelation | Variance(GC)/Variance(GDP) |
|---|---|---|---|
| Australia | 17.70 | 0.86 | 1.99 |
| | (0.37) | . | . |
| Canada | 20.18 | 0.89 | 1.13 |
| | (0.93) | . | . |
| Denmark | 25.38 | 0.80 | 0.21 |
| | (1.18) | . | . |
| France | 23.04 | 0.97 | 7.19 |
| | (0.74) | . | . |
| Germany | 18.71 | 0.89 | 1.13 |
| | (0.56) | . | . |
| Italy | 19.18 | 0.88 | 1.12 |
| | (0.81) | . | . |
| Portugal | 19.68 | 0.92 | 2.29 |
| | (1.00) | . | . |
| Spain | 18.33 | 0.93 | 1.49 |
| | (1.52) | . | . |
| United Kingdom | 19.23 | 0.92 | 1.84 |
| | (1.53) | . | . |
| United States | 15.29 | 0.94 | 2.21 |
| | (0.86) | . | . |
| All_developed countries | 19.67 | 0.88 | 2.26 |
| | (2.80) | (0.07) | (1.91) |

Table 4: Summary Statistics of Government Spending for Developing Countries

| Sample | GC/GDP(%) | Autocorrelation | Variance(GC)/Variance(GDP) |
|---|---|---|---|
| Argentina | 13.94 | 0.94 | 2.11 |
| | (2.36) | . | . |
| Brazil | 19.05 | 0.88 | 0.83 |
| | (0.45) | . | . |
| Bulgaria | 18.23 | 0.42 | 10.91 |
| | (1.96) | . | . |
| Columbia | 16.60 | 0.81 | 1.00 |
| | (0.89) | . | . |
| Israel | 23.76 | 0.50 | 0.77 |
| | (1.43) | . | . |
| Malaysia | 9.93 | 0.12 | 8.30 |
| | (1.08) | . | . |
| Mexico | 7.46 | 0.36 | 6.18 |
| | (0.38) | . | . |
| Peru | 8.02 | 0.80 | 6.99 |
| | (0.66) | . | . |
| Philippine | 10.11 | 0.55 | 3.08 |
| | (0.86) | . | . |
| Romania | 17.06 | 0.23 | 16.75 |
| | (1.96) | . | . |
| South Africa | 19.38 | 0.88 | 1.19 |
| | (0.97) | . | . |
| South Korea | 15.51 | 0.50 | 0.77 |
| | (1.59) | . | . |
| Thailand | 14.79 | 0.30 | 0.49 |
| | (1.56) | . | . |
| Turkey | 13.50 | 0.46 | 0.81 |
| | (1.07) | . | . |
| All_developing countries | 14.81 | 0.55 | 4.30 |
| | (4.71) | (0.27) | (4.93) |

Table 5: Parameter Calibration: Common Values Shared in Two Countries Groups

| | **parameters** | values |
|---|---|---|
| $\beta$ | the discount factor | 0.99 |
| $\pi$ | quarterly CPI inflation | 1 |
| $\sigma$ | savers' inverse of intertemporal substitution elasticity for consumption | 1/0.6 |
| $\psi$ | savers' inverse of the Frisch labor elasticity | 2 |
| $\theta$ | substitution elasticity among nontraded goods | 8 |
| $\delta$ | capital depreciation rate for private capital | 0.025 |
| $\chi$ | substitution elasticity b/w tradables and nontradables | 0.44 |
| $\chi^l$ | substitution elasticity b/w two types of labor | 0.7 |
| $\varphi$ | the degree of home bias in goods | 0.5 |
| $\varphi^G$ | home bias in $g$ | 0.72 |
| $\alpha^G$ | output elasticity to public capital | 0.11 |
| $\alpha^N$ | labor income share of the non-traded sector | 0.47 |
| $\alpha^T$ | labor income share of the traded sectors | 0.6 |
| $\kappa$ | investment adjustment cost (non-tradable and tradable sectors) | 6 |
| $z^N$ | TFP in non-traded good sector, normalization | 1 |
| $\rho_g$ | AR(1) coefficient in $g_t$ | 0.9 |
| $\rho_\tau$ | AR(1) coefficient in $\tau_t$ | 0.9 |
| $\rho_z$ | AR(1) coefficient in $z$ | 0.9 |
| $\rho_{z^T}$ | AR(1) coefficient in $z^T$ | 0.9 |
| $\phi_\pi$ | interest rate response to inflation | 1.5 |
| $g^I/y$ | public investment to output ratio | 0.04 |

Table 6: Parameter Calibration: Developed vs. Developing Countries

| | **parameters** | developed | developing |
|---|---|---|---|
| $F$ | fraction of savers | 0.84 | 0.27 |
| $U^g$ | complementarity of private and public consumption | -0.58 | -2.6 |
| $sb$ | government debt-to-output ratio | 0.29 | 0.49 |
| $c/y$ | private consumption-to-output ratio | 0.56 | 0.66 |
| $\tau$ | income tax rate | 0.143 | 0.13 |
| $\gamma_\tau$ | tax response to public debt-to-output ratio | 0.01 | 0.02 |
| $\gamma_G$ | g response to public debt-to-output ratio | 0.04 | 0 |

## APPENDIX C: The Data

This appendix presents the data collection in the first chapter. To be included in the data set a country must have at least 15 years (or 60 quarters) of consecutive quarterly observations for GDP, private consumption, private investment, net exports, government spending, government budget balance, nominal interest rate and the real effective exchange rate.

Data coverage: 14 developing countries including Argentina, Brazil, Bulgaria, Columbia, Israel, Malaysia, Mexico, Peru, Philippine, Romania, South Africa, South Korea, Thailand, Turkey. 10 developed countries including Australia, Canada, Denmark, France, Germany, Italy, Portugal, Spain, United Kingdom, United States.

For all countries, GDP deflator, Net export-to-GDP ratio, real government spending, government budget balance-to-GDP ratio, and inflation rate are calculated as follows:

$$\text{GDP deflator} = \frac{\text{Nominal GDP}}{\text{Real GDP}}$$

$$\text{Net export-to-GDP ratio} = \frac{\text{Nominal Exports} - \text{Nominal Imports}}{\text{Nominal GDP}} \times 100$$

$$\text{Real government spending} = \frac{\text{Nominal government spending}}{\text{GDP deflator}}$$

$$\text{Government budget balance-to-GDP ratio} = \frac{\text{Government budget balance}}{\text{Nominal GDP}} \times 100$$

$$\text{Inflation rate}_t = \frac{\text{GDP deflator}_t}{\text{GDP deflator}_{t-1}}$$

The big challenge of this quarterly-frequency study of fiscal policy in a large number of counties was collecting the key fiscal data: government expenditure and government budget balance. Since most counties have reported them in an annual frequency, especially for the government budget balance data. Tables 7, 8 and 9 summarize the

sources, time span, and definitions of the two main fiscal data. More details of government expenditure see Ilzetzki *et al.* (2013). Quarterly data on government budget balance for some countries is summed up from the monthly frequency. All Data are seasonally adjusted. Other variables are as follows.

**Gross Domestic Product**

Real and nominal GDP from OECD Quarterly National Accounts section were used for all developed countries and several developing countries (including Brazil, Mexico). Elsewhere, GDP data are taken from the same data source as the government expenditure data for other developing countries.

**Private Consumption**

Same data source as GDP.

**Private Investment**

Same data source as GDP. Gross fixed capital formation serial.

**Net Export**

Same data source as GDP. Goods and services of exports serial and goods and services of imports serial.

**Nominal Interest Rate**

Interbank 3-month rates from OECD Monthly Economic Indicators section was used for developed countries and several developing countries (including Brazil, Mexico). Other nominal interest rates are as follows: Interbank rate from central bank of Argentina (BCRA) is used for Argentina. The basic interest rate (BIR) from National Bank is used for Bulgarian. Policy rates from bank of Israel is used for Israel. Interbank lending rate from Central Bank is used for Malaysia. Interbank rate from Banco de Mexico is used for Mexico. Saving rate from central reserve bank is used for Peru. Policy rates (Repo) from Bangko Sentral ng Pilipinas is used for Philippines. Policy rates from national bank is used for Romania. Policy rate (Repo) from reserve bank is used for South Africa. Policy rates from bank of Thailand is used for Thailand.

Overnight borrowing rate from central bank is used for Turkey. Policy rates from the bank of Korea is used for Korea. Policy rates (intervention rate) from Banco de la Republica is used for Colombia.

**Real Effective Exchange Rate**

A CPI-based real exchange rate was used. Real effective exchange rates from OECD Monthly Economic Indicators section was used for developed countries. For developing counties, where ever available, the narrow real exchange rate index of the Bank for International Settlements was used. Otherwise, the broad index was used.

Table 7: Government Consumption

| Country | Start | End | Source |
|---|---|---|---|
| Argentina | 1993q1 | 2017q1 | MECON |
| Brazil | 1996q1 | 2017q1 | OECD |
| Bulgaria | 2000q1 | 2017q1 | Bulgarian National Bank |
| Colombia | 2000q1 | 2017q2 | DANE |
| Israel | 1995q1 | 2017q2 | Central Bureau of Statistics |
| Malaysia | 1998q1 | 2017q2 | Department of Statistics |
| Mexico | 1993q1 | 2016q4 | OECD |
| Peru | 1980q1 | 2017q1 | Central Reserve Bank of Peru |
| Philippine | 1998q1 | 2017q2 | Philippine Statistics Authority |
| Romania | 1995q1 | 2017q1 | NIS - National Institute of Statistics |
| South Africa | 1960q1 | 2017q1 | Statistics South Africa |
| South Korea | 1999q1 | 2017q1 | Statistics South Africa |
| Thailand | 1993q1 | 2017q2 | NESDB |
| Turkey | 1998q1 | 2017q1 | Turkish Statistical Institute |

Table 8: Government Budget Balance for Developing Countries

| Country | Start | End | Source | Series and Comments |
|---|---|---|---|---|
| Argentina | Jan1993 | Jul2017 | MECON | Public sector, primary balance. |
| Brazil | Jan1997 | Jul2017 | Ministerio tda Fazenda | Central government, primary balance. NSA |
| Bulgaria | 1998q1 | 2017q1 | Ministry of Finance | General budget balance |
| Colombia | Jan1963 | Jul2017 | Banco de la Republica | Central government surplus/deficit |
| Israel | 2000q1 | 2017q2 | Bank of Israel | Federal government budget, excluding credit. |
| Malaysia | 1981q1 | 2017q2 | Central Bank | Federal government budget surplus/deficit |
| Mexico | Jan1990 | Jul2017 | Ministry of Finance and Public Credit (SHCP) | Federal government, primary surplus/deficit |
| Peru | 1990q1 | 2017q1 | Central Reserve Bank | Central government, primary surplus/deficit |
| Romania | Jan1992 | Sep2017 | Ministry of Public Finance | Deficit or Surplus, GFS2001. NSA |
| Philippine | Jan1959 | Jul2017 | Bureau of the Treasury | Central government overall surplus/deficit |
| South Africa | Jan1960 | Jul2017 | Reserve Bank | Central government, budget surplus/deficit |
| South Korea | Dec1999 | Jun2017 | The Bank of Korea | Central government balance. NSA |
| Thailand | Jan1991 | Jul2017 | Bank of Thailand | National government cash surplus/deficit |
| Turkey | Jan1994 | Jul2017 | Ministry of Finance | Central government, budget primary balance |

Table 9: Government Budget Balance for Developed Countries

| Country | Start | End | Source | Series and Comments |
|---|---|---|---|---|
| Australia | Aug1973 | Jul2017 | DOFA | General government budget, operating result. |
| Canada | 1961q1 | 2017q2 | CANSIM | Federal government, general government net lending or borrowing |
| Denmark | 1999q1 | 2017q2 | Statistics Denmark | General government budget |
| France | May1994 | Jul2017 | Ministere du Budget | General government budget |
| Germany | 1991q1 | 2017q1 | Deutsche Bundesbank | General government deficit/surplus |
| Italy | 1985q1 | 2017q1 | National Institute of Statistics | State budget balance. |
| Portugal | 1999q1 | 2017q2 | Eurostat | General government budget is calculated by gross government saving minus government consumption of fixed capital. NSA |
| Spain | 1995q1 | 2017q2 | Eurostat | General government budget is calculated by gross government saving minus government consumption of fixed capital. NSA |
| U.K. | Jan1993 | Aug2017 | ONS | Central government saving, gross. |
| U.S. | 1950q1 | 2017q2 | BEA | Net Federal Government Saving |

## APPENDIX D: Solving the Quantitative Model

This appendix presents the equilibrium conditions, the steady state for the baseline model in the second chapter.

**Optimality Conditions**

Savers' FOC for $c_t^a$:

$$\lambda_t = (c_t^a)^{-\sigma} \tag{1}$$

Savers' FOC for $b_t^{d,a}$:

$$\lambda_t = \beta E_t \left( \lambda_{t+1} \frac{R_t}{\pi_{t+1}} \right) \tag{2}$$

Savers' FOC for $l_t^a$:

$$\mathfrak{a}(l_t^a)^{\psi} = \lambda_t (1 - \tau_t) w_t \tag{3}$$

Savers' FOC for $k_t^N$:

$$Q_t^N = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \left[ (1 - \tau_{t+1}) \, r_{t+1}^N - \frac{\kappa}{2} \left( \frac{i_{t+1}^N}{k_t^N} - \delta \right)^2 + \kappa \left( \frac{i_{t+1}^N}{k_t^N} - \delta \right) \left( \frac{i_{t+1}^N}{k_t^N} \right) + Q_{t+1}^N (1 - \delta) \right] \tag{4}$$

Savers' FOC for $k_t^T$:

$$Q_t^T = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \left[ (1 - \tau_{t+1}) \, r_{t+1}^T - \frac{\kappa}{2} \left( \frac{i_{t+1}^T}{k_t^T} - \delta \right)^2 + \kappa \left( \frac{i_{t+1}^T}{k_t^T} - \delta \right) \left( \frac{i_{t+1}^T}{k_t^T} \right) + Q_{t+1}^T (1 - \delta) \right] \tag{5}$$

Savers' FOC for $i_t^N$:

$$Q_t^N = 1 + \kappa \left( \frac{i_t^N}{k_{t-1}^N} - \delta \right) \tag{6}$$

Savers' FOC for $i_t^T$:

$$Q_t^T = 1 + \kappa \left( \frac{i_t^T}{k_{t-1}^T} - \delta \right) \tag{7}$$

Labor supplied to the nontraded good sector:

$$l_t^N = \varphi^l \left( \frac{w_t^N}{w_t} \right)^{\chi^l} l_t \tag{8}$$

Labor supplied to the traded good sector:

$$l_t^T = (1 - \varphi^l) \left( \frac{w_t^T}{w_t} \right)^{\chi^l} l_t \tag{9}$$

hand-to-mouth consumers' labor

$$l_t^h = l^h \quad \forall t \tag{10}$$

Nontraded good firms' FOC for $P_t^N$:

$$\Pi_t^N = \beta E_t \left( \frac{\lambda_{t+1}}{\lambda_t} \frac{y_{t+1}^N}{y_t^N} \frac{p_{t+1}^N}{p_t^N} \Pi_{t+1}^N \right) + \frac{\theta}{\zeta \alpha^N} \frac{w_t^N l_t^N}{y_t^N p_t^N} + \frac{1-\theta}{\zeta p_t^N} \tag{11}$$

Definition of $\pi_t^N$:

$$\pi_t^N = \frac{P_t^N}{P_{t-1}^N} = \frac{p_t^N}{p_{t-1}^N} \pi_t \tag{12}$$

Nontraded good firm's production:

$$y_t^N = Z^N \left( k_{t-1}^N \right)^{1-\alpha^N} \left( l_t^N \right)^{\alpha^N} \left( k_{t-1}^G \right)^{1-\alpha^G} \tag{13}$$

Market clearing for nontraded goods:

$$y_t^N = (p_t^N)^{-\chi} D_t^N \tag{14}$$

Total demand for nontraded good:

$$D_t^N = \varphi \left( c_t + i_t + ac_t^i + ac_t^p \right) + \varphi^G \left( p_t^G \right)^{\chi} g_t \tag{15}$$

Traded good firm's production:

$$y_t^T = Z^T \left(k_{t-1}^T\right)^{1-\alpha^T} \left(l_t^T\right)^{\alpha^T} \left(k_{t-1}^G\right)^{1-\alpha^G} \tag{16}$$

Demand for $k^N$ and $l^N$:

$$(1-\alpha^N) w_t^N l_t^N = \alpha^N r_t^N k_{t-1}^N \tag{17}$$

Demand for $k^T$:

$$r_t^T k_{t-1}^T = (1-\alpha^T) s_t^T y_t^T \tag{18}$$

Demand for $l^T$:

$$w_t^T l_t^T = \alpha^T s_t^T y_t^T \tag{19}$$

Aggregate $i$:

$$i_t = i_t^N + i_t^T \tag{20}$$

Total labor supplied:

$$l_t = \left[ (\varphi^l)^{-\frac{1}{\chi^l}} \left(l_t^N\right)^{\frac{1+\chi^l}{\chi^l}} + (1-\varphi^l)^{-\frac{1}{\chi^l}} \left(l_t^T\right)^{\frac{1+\chi^l}{\chi^l}} \right]^{\frac{\chi^l}{1+\chi^l}} \tag{21}$$

Law of motion for $k^N$:

$$k_t^N = (1-\delta) k_{t-1}^N + i_t^N \tag{22}$$

Law of motion for $k^T$:

$$k_t^T = (1-\delta) k_{t-1}^T + i_t^T \tag{23}$$

Real price of $c$:

$$1 = \left[ \varphi (p_t^N)^{1-\chi} + (1-\varphi)(s_t)^{1-\chi} \right]^{\frac{1}{1-\chi}} \tag{24}$$

$p^{GC}$:

$$p_t^{GC} = \frac{P_t^{GC}}{P_t} = \left[ \varphi^G (p_t^N)^{1-\chi} + (1-\varphi^G) s_t^{1-\chi} \right]^{\frac{1}{1-\chi}} \tag{25}$$

$p^{GI}$:

$$p_t^{GI} = \frac{P_t^{GI}}{P_t} = \left[\bar{\varphi}^G (p_t^N)^{1-\chi} + (1-\bar{\varphi}^G) s_t^{1-\chi}\right]^{\frac{1}{1-\chi}} \tag{26}$$

Balance of Payment:

$$c_t + i_t + p_t^G (g_t^C + g_t^I) + ac_t^i + ac_t^p = y_t \tag{27}$$

$c^h$:

$$c_t^h = (1-\tau_t) w_t l^h + z \tag{28}$$

Aggregate $c$:

$$c_t = f c_t^a + (1-f) c_t^h \tag{29}$$

Aggregate $l$:

$$l_t = f l_t^a + (1-f) l_t^h \tag{30}$$

Tax:

$$tax_t = \tau_t \left(w_t l_t + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T\right) \tag{31}$$

Government budget balance:

$$tax_t + b_t^d = p_t^{GC} g_t^C + p_t^{GI} g_t^I + z + \frac{R_{t-1} b_{t-1}^d}{\pi_t} \tag{32}$$

GDP in units of consumption:

$$y_t = p_t^N y_t^N + s_t y_t^T \tag{33}$$

$g$:

$$g_t = g_t^C + g_t^I \tag{34}$$

Debt-to-output ratio:

$$s_{t-1}^b = \frac{b_{t-1}^d}{y_{t-1}} \tag{35}$$

Government purchase-to-output ratio:

$$s_t^g = \frac{p_t^{GC} g_t^C + p_t^{GI} g_t^I}{y_t} \tag{36}$$

$$k_t^G = (1 - \delta^G) k_{t-1}^G + \epsilon g_t^I \tag{37}$$

$$\log \frac{g_t^C}{g^C} = \rho_G \log \frac{g_{t-1}^C}{g^C} + \varepsilon_t^C \tag{38}$$

$$\log \frac{g_t^I}{g^I} = \rho_G \log \frac{g_{t-1}^I}{g^I} + \varepsilon_t^I \tag{39}$$

$$\log \frac{\tau_t}{\tau} = \rho_\tau \log \frac{\tau_{t-1}}{\tau} + \gamma_\tau \log \frac{s_{t-1}^b}{s^b} \tag{40}$$

Monetary policy:

$$R_t = R^* + \phi_\pi(\pi_t - \pi^*) + \phi_y(y_t - y^*) \tag{41}$$

Marginal public investment efficiency:

$$\hat{\epsilon}_t = \frac{\bar{\epsilon} - \epsilon}{\epsilon} \hat{g}_t^I \tag{42}$$

Transfer rule:

$$\log \frac{z_t}{z} = \rho_z \log \frac{z_{t-1}}{z} + \gamma_z \log \frac{s_{t-1}^b}{s^b} \tag{43}$$

Technology in traded good sector:

$$\log \frac{z_t^T}{z^T} = \rho_{z^T} \log \frac{z_{t-1}^T}{z^T} + \varepsilon_t^{z^T} \tag{44}$$

Trade balance:

$$td_t = c_t + g_t + i_t - y_t \tag{45}$$

Dummy variable for $\pi_{t-1}^N$:

$$d_t^{\pi_t^N} \equiv \pi_{t-1}^N \tag{46}$$

**Steady State**

There are 46 variables: $\lambda^a, l^a, l^h, c^a, c^h, p^n, s, p^{GC}, p^{GI}, w, w^N, w^T, \pi, \pi^N, d\pi^N, y^N, k^N, i^N, q^N, r^N, l^N, y^T, k^T, i^T, q^T, r^T, l^T, z^T, g, g^C, g^I, k^G, \tau, tax, z, b^d, R, eff, c, i, D^N, l.y, td, sg, sb.$

3 shocks: $ug^C, ug^I, uz^T$

Assume $p^n = s = p^{GC} = p^{GI} = 1$, $\pi = \pi^N = \pi^* = infl$

From equation (2), we get $R = \pi/\beta$.

From equation (4), (5), (6), (7), (22), (23), we get:

$$r^N = r^T = (\frac{1}{\beta} + \delta - 1) * (1 - \tau)^{-1} \tag{47}$$

From equation (11), we get

$$\frac{w^N l^N}{\alpha^N p^N y^N} = \frac{\theta - 1}{\theta} \tag{48}$$

From equation (18), (23), we get:

$$1 = \frac{r^T k^T}{s(1-\alpha^T)y^T} = \frac{r^T(i^T/\delta)}{s(1-\alpha^T)y^T} = \frac{r^T(i^T/y)}{\delta(1-\alpha^T)(sy^T/y)}$$

That is,

$$\frac{i^T}{y} = \frac{\delta(1-\alpha^T)(sy^T/y)}{r^T} \tag{49}$$

From equation (17), (11), we get:

$$\frac{\alpha^N r^N k^N}{1-\alpha^N} \frac{1}{\alpha^N p^N y^N} = \frac{\theta - 1}{\theta}$$

That is,

$$\frac{i^N}{y} = \frac{\theta - 1}{\theta} \frac{\delta(1-\alpha^N)(p^N y^N/y)}{r^N} \tag{50}$$

Given the calibrated value of macroeconomic ratios $\frac{c}{y}$, $\frac{i}{y}$, $\frac{g^I}{y}$ and parameters, we can compute $\frac{y^N}{y}$, $\frac{y^T}{y}$. Since $\frac{i^N}{y}$, $\frac{i^T}{y}$ can be calculated from $\frac{i}{y}$ and $\varphi$, and thus $\frac{y^N}{y}$, $\frac{y^T}{y}$ would be calculated according to equation (49) and (50). For an initial guess of $y^N$

and $c^h$, the following steady-state variables can be calculated: $y$, $y^T$, $c$, $c^a$, $c^h$, $c^N$, $c^T$, $i$, $i^N$, $i^T$, $k$, $k^N$, $k^T$, $g^N(= y^N - c^N - i^N)$, $g$, $g^T$, $g^C$, $g^I$, $k^G$, $\lambda$, $b^d$

Assume the steady-state share of labor in the nontraded good sector, $\varphi^l$, equals the weight of its labor income share in total labor income of the economy, that is,

$$\varphi^l = \frac{\alpha^N y^N}{\alpha^N y^N + \alpha^T y^T}$$

Next, assume $l^a = l^h$, and then $l = fl^a + (1-f)l^h = l^a$, so equations (3) becomes

$$\mathfrak{a}(l_t)^{\psi} = \lambda_t(1-\tau_t)w_t \tag{51}$$

And then $l^N$, $l^T$, $l$, $w^N$, $w^T$, and $w$, can be simultaneously solved from equation (8), (9), (19), (48), (51), as well as the aggregate wage equation (52).

$$w_t = \left[\varphi^l \left(w_t^N\right)^{1+\chi^l} + (1-\varphi^l)\left(w_t^T\right)^{1+\chi^l}\right]^{\frac{1}{1+\chi^l}} \tag{52}$$

As for fiscal variables, given $\tau$, $g^C$, $g^I$, $b^d$, $R$, $\pi$, transfer is

$$z = \tau\left(wl + r^N k^N + r^T k^T\right) + \left(1 - \frac{R}{\pi}\right) b^d - p^{GC} g^C - p^{GI} g^I \tag{53}$$

Another way to solve labor and wage variables. Assume $l = 1$, then, $l^n = \varphi^l$, $l^t = 1 - \varphi^l$, $w = w^N = w^T = \frac{\theta-1}{\theta}\alpha^N p^N y^N/(\varphi^l * l)$. And thus, $\mathfrak{a} = (1 - tau)w\lambda/l^{\psi}$.

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