Essays on International Repercussions of Fiscal Policy and the Analysis of Migration Restrictions

Dissertation

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By

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Abstract

Chapter 1 of my dissertation, “Fiscal Shocks and Cross-Border Spillovers”, develops an open economy DSGE model to analyze the cross-border spillovers from fiscal shocks in different instruments, namely government spending, transfers, capital tax rate, labor tax rate and consumption tax rate. I document a new empirical fact regarding the negative relationship between a country’s output spillover from government spending shocks to other countries and its domestic government debt-to-GDP ratio, which was never observed before. Countries that bear a large debt-to-GDP ratio, such as Portugal and Belgium, generate relatively large negative output spillovers to other countries, while countries that have smaller debt-to-GDP ratio, such as Norway and New Zealand, spread positive spillovers. The fiscal consolidation regime built in the theoretical model is essential in generating this empirical fact. More specifically, the government responds to a higher level of sovereign debt by cutting its spending and transfers while at the same time raising its taxation on capital income, labor income and consumption. The fiscal consolidation regime affects the spillovers of a domestic fiscal shock through the interest rate channel. When a stimulating fiscal shock (a positive spending shock, a positive transfers shock, or a negative tax rate shock) strikes the domestic economy, the global real interest rate is driven up by a higher level of domestic government debt, dampening foreign activity (high domestic debt and low output spillovers). However, due to the fiscal consolidation regime, the public debt ratio will decrease and so
will the global real interest rate, leading to a considerable increase in foreign output (low domestic debt and high output spillovers).

The paper extends the two-good, two-country model in Backus, Kehoe and Kydland (1994) by adding a fully-specified government sector in each country and by allowing households in each country to purchase bonds issued by their own government as well as the internationally traded bonds. The model is estimated on US and EU (15 countries) quarterly data from 1961q1 to 2013q4 using Bayesian estimation techniques. In addition to replicating the empirical fact, three main model results are obtained: (1) cross-country spillovers of all fiscal instruments are significant, i.e. foreign variables respond in magnitude comparable to that of domestic variables; (2) instead of smoothly reverting back to steady states, macroeconomic variables display waning fluctuations after a fiscal shock; (3) the fiscal consolidation mechanism is essential in generating the fluctuations. If we shut off this channel, the fluctuations would disappear following a fiscal shock.

Chapter 2, “Government Spending Shocks and Default Risk in Emerging Markets”, links two distinct lines of research: empirical time series analysis on government spending shocks and applied theory on sovereign default with productivity shocks. I first study the effects of government spending shocks on default risk by developing VAR evidence based on a panel of 18 countries. I find empirically that in response to a 10% government spending increase, (1) the real effective exchange rate appreciates by 1.0% and the current account to GDP ratio deteriorates by 0.0025 on impact; (2) external debt increases by an average of 3.5% in the year following the shock; and (3) the EMBI Global spread rises by an average of 25 basis points within two years following the shock, peaking at 132 basis points 14 quarters after the shock. I then build a general equilibrium small open economy model to explore the dynamics between government spending shocks and default risk. The theoretical model
performs well in matching the dynamics of the current account and external debt in response to the government spending shock. It also captures the rise in the sovereign spread. External debt rises on impact and stays positive for five periods before reverting back to its steady state. Hence default risk rises following increased government spending.

Chapter 3, “Migration Restrictions: Implications on Human Capital, Output, and Welfare”, is joint work with Byoung Hoon Seok and Hye Mi You. This paper studies impacts of restrictions on rural-to-urban migration in China (Hukou restrictions) on human capital accumulation, efficiency loss from labor misallocation, and welfare. We build a general equilibrium model with an explicit migration decision of rural residents and present macroeconomic implications of the restrictions. The Hukou restrictions are incorporated into our model in the form of both a fixed migration cost and a lower wage for migrants relative to urban workers. By reducing either type of restriction, we quantify potential gains from efficient labor allocation and its welfare implications on both rural and urban residents. We find that a decline in both types of restrictions on migration by half increases total output and welfare by 1.4% and 2.5%, respectively. The policy change also strengthens the positive selection into migration in terms of education.
To Ming and Michael
Acknowledgments

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to the States and helped me take care of my baby. Without them, I could not be able to graduate in this spring.
Vita

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Fields of Study

Major Field: Economics
**Contents**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Dedication</td>
<td>v</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>vi</td>
</tr>
<tr>
<td>Vita</td>
<td>viii</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xi</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xiii</td>
</tr>
<tr>
<td>1. Fiscal Shocks and Cross-Border Spillovers</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Empirical Fact</td>
<td>7</td>
</tr>
<tr>
<td>1.3 Model Structure</td>
<td>11</td>
</tr>
<tr>
<td>1.3.1 Households</td>
<td>12</td>
</tr>
<tr>
<td>1.3.2 Firms</td>
<td>13</td>
</tr>
<tr>
<td>1.3.3 Fiscal Policy</td>
<td>14</td>
</tr>
<tr>
<td>1.3.4 National Accounts</td>
<td>15</td>
</tr>
<tr>
<td>1.3.5 Competitive Equilibrium</td>
<td>16</td>
</tr>
<tr>
<td>1.4 Estimation</td>
<td>16</td>
</tr>
<tr>
<td>1.4.1 Policy Rules</td>
<td>17</td>
</tr>
<tr>
<td>1.4.2 Prior Distributions</td>
<td>18</td>
</tr>
<tr>
<td>1.4.3 Posterior Distributions</td>
<td>20</td>
</tr>
<tr>
<td>1.5 Quantitative Analysis</td>
<td>21</td>
</tr>
<tr>
<td>1.5.1 Domestic Government Spending Shock</td>
<td>22</td>
</tr>
<tr>
<td>1.5.2 Domestic Transfers Shock</td>
<td>24</td>
</tr>
<tr>
<td>1.5.3 Domestic Capital Tax Rate Shock</td>
<td>25</td>
</tr>
<tr>
<td>1.5.4 Domestic Labor Tax Rate Shock</td>
<td>26</td>
</tr>
</tbody>
</table>
# List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Regression of Spillovers on Debt and Control Variables</td>
<td>10</td>
</tr>
<tr>
<td>1.2</td>
<td>Parameters in the Fiscal Policy Rules</td>
<td>18</td>
</tr>
<tr>
<td>1.3</td>
<td>Calibrated Parameters for the Estimated Model</td>
<td>19</td>
</tr>
<tr>
<td>1.4</td>
<td>Prior and Posterior Distributions</td>
<td>20</td>
</tr>
<tr>
<td>1.5</td>
<td>Domestic Output Multipliers</td>
<td>28</td>
</tr>
<tr>
<td>1.6</td>
<td>Foreign Output Multipliers</td>
<td>29</td>
</tr>
<tr>
<td>1.7</td>
<td>Fraction Attributed to Productivity Shocks and Fiscal Shocks (1)</td>
<td>32</td>
</tr>
<tr>
<td>1.8</td>
<td>Fraction Attributed to Productivity Shocks and Fiscal Shocks (2)</td>
<td>32</td>
</tr>
<tr>
<td>1.9</td>
<td>Regression of Domestic Effect on Debt and Control Variables</td>
<td>49</td>
</tr>
<tr>
<td>2.1</td>
<td>Parameter Values</td>
<td>78</td>
</tr>
<tr>
<td>2.2</td>
<td>Episodes of De-Facto Fixed and Flexible Exchange Rates: 1993Q1-2010Q4</td>
<td>82</td>
</tr>
<tr>
<td>2.3</td>
<td>External Default/Restructuring: 1800-2010</td>
<td>83</td>
</tr>
<tr>
<td>3.1</td>
<td>Parameterization</td>
<td>101</td>
</tr>
<tr>
<td>3.2</td>
<td>The Benchmark Model Results</td>
<td>101</td>
</tr>
<tr>
<td>3.3</td>
<td>Inputs and Outputs in the Benchmark Economy</td>
<td>102</td>
</tr>
<tr>
<td>3.4</td>
<td>The Effects of Relaxed Hukou Restrictions</td>
<td>102</td>
</tr>
</tbody>
</table>
3.5 Output Gain or Loss from the Relaxed Hukou Restrictions (Unit: %) . . . . 102

3.6 Welfare Gain or Loss (Unit: Per-Period Consumption) . . . . . . . . . . . . . 102
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>General Government Structural Balance</td>
<td>3</td>
</tr>
<tr>
<td>1.2</td>
<td>Government Debt and Output Spillovers from Spending Shocks</td>
<td>9</td>
</tr>
<tr>
<td>1.3</td>
<td>Domestic Government Debt and Foreign Output Multipliers</td>
<td>31</td>
</tr>
<tr>
<td>1.4</td>
<td>Responses to a One Standard Deviation Increase in Domestic Government Spending Shock: Key Domestic Variables</td>
<td>35</td>
</tr>
<tr>
<td>1.5</td>
<td>Responses to a One Standard Deviation Increase in Domestic Government Spending Shock: Cross-Country Spillovers</td>
<td>36</td>
</tr>
<tr>
<td>1.6</td>
<td>Responses to a One Standard Deviation Increase in Domestic Transfers Shock: Key Domestic Variables</td>
<td>37</td>
</tr>
<tr>
<td>1.7</td>
<td>Responses to a One Standard Deviation Increase in Domestic Transfers Shock: Cross-Country Spillovers</td>
<td>38</td>
</tr>
<tr>
<td>1.8</td>
<td>Responses to a One Standard Deviation Decrease in Domestic Capital Tax Rate Shock: Key Domestic Variables</td>
<td>39</td>
</tr>
<tr>
<td>1.9</td>
<td>Responses to a One Standard Deviation Decrease in Domestic Capital Tax Rate Shock: Cross-Country Spillovers</td>
<td>40</td>
</tr>
<tr>
<td>1.10</td>
<td>Responses to a One Standard Deviation Decrease in Domestic Labor Tax Rate Shock: Key Domestic Variables</td>
<td>41</td>
</tr>
<tr>
<td>1.11</td>
<td>Responses to a One Standard Deviation Decrease in Domestic Labor Tax Rate Shock: Cross-Country Spillovers</td>
<td>42</td>
</tr>
</tbody>
</table>
2.3 Impulse Responses to a 10% Shock to Government Consumption in Episodes of Fixed Exchange Rates and Flexible Exchange Rates. 71

2.4 Impulse Responses to a 10% Shock to Government Consumption in Latin American Countries and European Countries. 72

2.5 Impulse Responses to Government Spending Shock Alone. 80
1.1 Introduction

The global recession of 2008-09 prompted large accumulations of government debt in many countries. Lower tax revenues due to high unemployment and weak profits, fiscal stimulus packages implemented to battle the recession, and huge financial bail-outs have all contributed to the unprecedented piling up of public debt. There has been much debate about whether and how quickly fiscal consolidation policies should be implemented.\(^1\) Figure 1.1 depicts the evolution of general government structural balance as a percent of GDP in the United States, Japan, Germany, France and the United Kingdom.\(^2\) All cases feature a decrease in the structural balance from 2007 to 2009. The UK was the first to act towards abstinence and ended its stimulus in 2010. The US, Germany and France saw an increase in their structural balance in 2011. Japan kept spending and its structural balance did not improve until 2012. Many other countries have been focusing on fiscal consolidation, including a mixture of tax increases and spending cuts. For example, the Hungarian government adopted the “Szell Kalman Plan” and “Szell Kalman Plan 2.0” deficit cuts packages in 2011.

---

\(^1\)Fiscal consolidation, as defined in the OECD Economic Outlook, is “a policy aimed at reducing government deficits and debt accumulation”.

\(^2\)The structural balance is the government’s budget balance purged of the estimated influences on the budget from the business cycle of the economy. It is designed to be indicative of the government’s discretionary fiscal policy adjustments.
and 2012 respectively. In fact, reducing the fiscal deficit to within 3% of GDP is an EU-mandated target, as outlined in the Stability and Convergence Programmes. According to the OECD Economic Outlook, most OECD countries need to stabilize their debt-to-GDP ratio. The OECD expects its members to carry out fiscal consolidation efforts mainly via spending reduction, which is thought to be exerting less adverse effects on the economy than taxes would.

Empirical evidence of fiscal consolidation in the US can be found in Corsetti et al. (2011). They estimate a VAR model on US time series using both the Blanchard-Perotti identification scheme (Blanchard and Perotti, 2002) and the forecast error identification scheme (Ramey, 2011). They find that, robust across the two identification strategies, a positive government spending shock induces a large build-up of public debt, and that government spending falls below trend a few quarters after the shock. In order to examine cross-border spillovers of a US government spending shock, Corsetti and Müller (2013) extend the VAR model to include both US variables and euro area (or UK) variables. Under this extended VAR model, government spending reversal still occurs, i.e. the current spending increase is accompanied by future spending cuts.
The motivation for this paper is best illustrated in Figure 1.2, which documents the relationship between output spillovers from domestic government spending shocks and the domestic central government debt-to-GDP ratio\(^3\). The construction of output spillovers will be discussed in detail in the next section. The main information we can obtain from Figure 1.2 is that there is a negative relation between the two variables, which was never observed

\(^3\)Central government data are used due to the lack of general government data for some countries. For countries where both general and central government data are available, the correlations between the two are larger than 0.9.
before. Countries that bear a large debt-to-GDP ratio, such as Portugal and Belgium, generate relatively large negative output spillovers to other countries, while countries that have smaller debt-to-GDP ratios, such as Norway and New Zealand, spread positive spillovers.

This paper emphasizes the role of fiscal consolidation in generating the negative relationship between output spillovers from government spending shocks and the government debt-to-GDP ratio as shown in Figure 1.2. I build a two-country DSGE model based on Backus et al. (1994) (hereafter BKK) and estimate it on US and EU data using Bayesian estimation techniques. Government spending, lump-sum transfers, the capital tax rate, the labor tax rate and the consumption tax rate are allowed to adjust systematically to public debt-to-GDP ratio. I follow common practice and estimate the five feedback rules for fiscal policy outside the DSGE model by single-equation OLS. Estimation results show that fiscal consolidation is operative in the US. As the debt-to-GDP ratio increases, the government will reduce its spending, decrease its transfers and increase its taxation on capital income, labor income and consumption expenditures. The speed of fiscal consolidation affects cross-border spillovers in two opposite directions. First, expansionary fiscal shocks stimulate the domestic economy and boost its imports from the foreign country. A higher speed of consolidation attenuates the stimulating effect and hence mitigates spillovers to the foreign country. On the other hand, a higher speed of consolidation leads to less accumulation of government debt and a lower global real interest rate, thus boosting foreign activity. Model results show that a higher speed of fiscal consolidation is associated with a larger output spillover, suggesting that the interest rate channel dominates. As a result, the domestic debt-to-GDP ratio in the model economy is negatively related to the output spillover from a domestic expansionary spending shock.
Empirical VAR studies find conflicting results on the cross-border output spillovers from fiscal stimulus. For example, combining a panel VAR model and a gravity trade equation, Beetsma et al. (2006) find that fiscal stimuli in Germany and France have non-negligible and positive output spillovers in all the other 13 European countries in their sample. Hebous and Zimmermann (2010) use a global VAR model to estimate the spillover effects of a domestic shock to the primary budget balance to GDP ratio in 12 euro area countries. The signs of pair-wise spillovers are mixed, with most of them being negative.

These different estimates come as no surprise if we look at their sample periods and endogenous variables included in the VAR. The sample period in Beetsma et al. (2006) is 1965-2004 and their VAR does not include any government debt variable. In contrast, Hebous and Zimmermann (2010) add the ratio of public debt to GDP over a sample period of 1979-2009, the later years of which feature high debt ratios following the financial crisis. This paper is able to accommodate both positive and negative output spillovers. Due to the fiscal consolidation regime, domestic and foreign macroeconomic variables display waning fluctuations after a fiscal shock. Therefore, there will be both positive and negative spillovers following a domestic fiscal shock.

There have also been theoretical DSGE studies assessing the impact of fiscal spillovers. This paper is most closely related to Corsetti et al. (2010) and Corsetti and Müller (2013). In both papers, the authors allow government spending to consolidate public debt and thus their simulated government spending shock displays a reversal feature, i.e. the current spending increase is accompanied by future cuts in spending. Because the foreign real long-term interest rate decreases in response to a domestic spending increase in their models, foreign output first rises before falling below trend at around the 20th quarter. As a result,

\footnote{Because of the spending reversal, agents expect that real short-term interest rate will decrease in the future. As a result, long-term interest rate falls on impact.}
their models generate positive output spillovers first when domestic debt is high and then negative spillovers as debt is consolidated, opposite to the empirical fact shown in Figure 1.2. Moreover, while Corsetti et al. (2010) and Corsetti and Müller (2013) study the cross-border spillovers of government spending shocks, this paper compares the different spillovers of government spending shocks, transfers shocks and tax rate shocks. I find remarkable differences in the spillover effects in the short run and in the long run. First, a domestic spending increase is most favored by the foreign economy to improve its output in the short run; domestic expansionary shocks to transfers and tax rates have contractionary effects on the foreign output in the short run, implying that negative consequences from higher debt dominate positive effects from increased demand for imports. Second, in the long run, the foreign economy would prefer a domestic labor tax cut, with a present value multiplier of 0.53 additional unit of foreign output per unit cut of domestic labor tax revenue. Finally, a capital tax rate cut or a labor tax rate cut is more effective in stimulating the domestic economy than increased spending, increased transfers or a consumption tax rate cut. However, the strength of the stimulating effects is mitigated by the fiscal consolidation regime. The paper is also related to Leeper et al. (2010a) and Leeper et al. (2010b) which use similar fiscal policy rules and explore the impacts of fiscal shocks in a closed economy environment.

The rest of the paper is organized as follows. Section 1.2 contains the new empirical fact. Section 1.3 describes the model and the assumptions regarding fiscal policies. Section 1.4 presents the techniques I use to estimate the model and the prior and posterior distributions. Section 1.5 discusses in detail the spillovers of domestic fiscal shocks. The forecast-error-variance decomposition and the historical decomposition are implemented in sections 1.6 and 1.7 respectively. Section 1.8 concludes.
1.2 Empirical Fact

Using single equation estimation, Auerbach and Gorodnichenko (2013) estimate cross-border output spillover of government spending with data for a panel of OECD countries. They first regress real-time one-period-ahead forecast errors for government spending from the OECD’s “Outlook and Projections Database” in each country on that country’s lagged macroeconomic variables (output, government spending, exchange rate, inflation, investment, and imports) as well as a set of country and period fixed effects. The residual from the regression, which is orthogonal to the professional forecasts and lags of the macroeconomic variables, is defined as each country’s own fiscal shock. Then for each country, they construct the fiscal shock emanating from other countries by aggregating the other countries’ own fiscal shocks weighted according to bilateral trade. After this, they can obtain the cross-border government spending multiplier through panel OLS.

Since my focus is different, i.e. exploring the dynamics between a country’s fiscal spillovers and its government debt level, I estimate the effect of each country’s own fiscal shock on the other countries’ output instead of estimating the effect of the aggregated fiscal shock emanating from other countries. Specifically, each country \( i \)’s government spending spillover to another country \( q \) over a horizon \( h \in \{0, 1, \ldots, H\} \) is obtained by running the following regression:

\[
\frac{Y_{q,t+h} - Y_{q,t-1}}{Y_{q,t-1}} = \alpha_{iqh} \frac{\text{Shock}_{i,t}}{G_{i,t-1}} + \beta_{iqh} \frac{Y_{q,t-1} - Y_{q,t-2}}{Y_{q,t-2}} + \delta_{iqh} \frac{G_{q,t-1} - G_{q,t-2}}{Y_{q,t-2}} + \text{constant}_{iqh} + \text{error}_{iqh,t} \tag{1.2.1}
\]

where \( \text{Shock}_{i} \) is country \( i \)'s own spending shock in real terms, \( Y \) is real GDP and \( G \) is real government spending, all measured in terms of local currency in fixed prices of the base year. The variables are scaled by lagged output or spending in their respective country so that (i) I do not have to worry about exchange rate issues, (ii) the estimated coefficients are put in
similar units for different country pairs, and (iii) $\alpha_{iqh}$ denotes country $q$’s output elasticity with respect to country $i$’s government spending, a measure of spillover effect. Country $i$’s spillover to country $q$ is then averaged across different horizons: $\alpha_{iq} = \frac{1}{H+1} \sum_{h=0}^{H} \alpha_{iqh}$. Country $i$’s overall output spillover to other countries is computed as the weighted average according to bilateral trade:

$$\alpha_i \equiv \sum_{q \neq i} \frac{M_{iq,B}}{M_{iT,B}} \alpha_{iq}$$

where $M_{iq,B}$ is country $q$’s imports from country $i$ in the base year measured in US dollars and $M_{iT,B}$ is the total imports from country $i$ to other countries in the base year measured in US dollars.

All the data in this section, including $\text{Shock}_{i,t}$, are directly from the database constructed by Auerbach and Gorodnichenko (2013) and are available for 27 OECD countries. The data frequency is semiannual. The sample period for “old” OECD members such as the US is 1984s1-2010s1. For newer members such as Poland, the sample period starts from the mid-1990s. The base year is 2005, which is the OECD reference year. I set $H$ equal to 4 (a two year horizon window). Increasing $H$ does not change the pattern of Figure 1.2 but the estimates are less accurate because of larger standard errors.

Figure 1.2 plots each country’s output spillover, $\alpha_i$, against its debt-to-GDP ratio. The debt series is total central government debt as percentage of GDP extracted from OECD.Stat. 1998-2009 are those years over which the debt series is available for all the sample countries. Thus the debt ratio is the average across 1998-2009. The horizontal line and the vertical line represent the average output spillover and the average debt ratio across

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5The 27 countries include Australia, Austria, Belgium, Canada, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Hungary, Ireland, Iceland, Italy, Japan, Korea, Mexico, Netherlands, Norway, New Zealand, Poland, Portugal, Slovak Republic, Sweden, and United States.
the 27 countries, respectively. The scatterplot reveals a negative relation between a country’s output spillover to other countries and its domestic debt-to-GDP ratio. Regression results in Table 1.1 validate this negative relation. $\alpha_i$ is regressed on the debt ratio. The negative relation is robust after controlling for GDP growth, the ratio of trade volume to GDP (openness) and the real effective exchange rate (REER). When Japan is excluded from the sample, the negative relation becomes significant.

Figure 1.2: Government Debt and Output Spillovers from Spending Shocks

Source: Author’s calculations using data for spillovers from Auerbach and Gorodnichenko (2013) and data for debt from OECD.Stat
Table 1.1: Regression of Spillovers on Debt and Control Variables

<table>
<thead>
<tr>
<th>Sample</th>
<th>All</th>
<th>Japan excluded</th>
<th>Japan and Italy excluded</th>
</tr>
</thead>
<tbody>
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<td>Debt</td>
<td>-0.0011</td>
<td>-0.0017</td>
<td>-0.0036*</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>GDP growth</td>
<td>-4.4337</td>
<td>-5.3094</td>
<td>-4.3082</td>
</tr>
<tr>
<td></td>
<td>(5.332)</td>
<td>(4.966)</td>
<td>(4.627)</td>
</tr>
<tr>
<td>Openness</td>
<td>0.0195</td>
<td>0.1264</td>
<td>0.2022</td>
</tr>
<tr>
<td></td>
<td>(0.145)</td>
<td>(0.143)</td>
<td>(0.138)</td>
</tr>
<tr>
<td>REER</td>
<td>0.6652</td>
<td>1.0457</td>
<td>1.2656**</td>
</tr>
<tr>
<td></td>
<td>(0.665)</td>
<td>(0.643)</td>
<td>(0.605)</td>
</tr>
<tr>
<td>Obs</td>
<td>27</td>
<td>27</td>
<td>26</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.10

The effect of country $i$’s spending shock on its own output over a horizon $h \in \{0, 1, \ldots, H\}$, $\alpha_{ih}$, can be easily obtained by running the following regression

$$\frac{Y_{i,t+h} - Y_{i,t-1}}{Y_{i,t-1}} = \alpha_{ih} \frac{\text{Shock}_{i,t}}{G_{i,t-1}} + \beta_{ih} \frac{Y_{i,t-1} - Y_{i,t-2}}{Y_{i,t-2}} + \delta_{ih} \frac{G_{i,t-1} - G_{i,t-2}}{Y_{i,t-2}} + \text{constant}_{ih} + \text{error}_{ih,t}. $$

Appendix A plots this domestic effect against the debt-to-GDP ratio. The stimulating effect of a country’s government spending on its own output is also negatively related to its debt-to-GDP ratio. The negative relation is less significant compared to that of the spillover effect.
1.3 Model Structure

In order to analyze the spillover effects of fiscal shocks, I add a fully-specified government sector in each country in an otherwise standard two-good, two-country BKK model. Moreover, households in each country can purchase bonds issued by their own government as well as the internationally traded bonds.

The model economy consists of two countries, country 1 and country 2. Country 1 specializes in the production of good $X$ and country 2 in the production of good $Z$. Labor and capital are internationally immobile. Consumption, investment, and government spending have both domestic and foreign content and use the same proportions of the two goods. They are composites of domestic and foreign goods as follows:

\[
C_{1t} + I_{1t} + G_{1t} \equiv Q(X_{1t}, Z_{1t})
\]

\[
C_{2t} + I_{2t} + G_{2t} \equiv Q(Z_{2t}, X_{2t})
\]

where $Q(X, Z) \equiv \left[ \omega \frac{1}{1 - \eta} X^{\eta - 1} + \frac{1}{1 - \eta} \right]^{\frac{1}{1 - \eta}}$ is a CES aggregator. $\eta$ measures the elasticity of substitution between domestic and foreign goods. The weight $\omega$ in $Q$ determines the domestic and foreign content of domestic spending.

This is a model without money; all variables are real. Let $q_{1t}$ and $q_{2t}$ denote the prices of the two goods in period $t$ in units of a numeraire (to be described shortly). The price indices in the two countries are given by

\[
P_{1t} \equiv \left[ \omega (q_{1t})^{1 - \eta} + (1 - \omega)(q_{2t})^{1 - \eta} \right]^{\frac{1}{1 - \eta}}
\]

\[
P_{2t} \equiv \left[ \omega (q_{2t})^{1 - \eta} + (1 - \omega)(q_{1t})^{1 - \eta} \right]^{\frac{1}{1 - \eta}}.
\]

Thus the aggregate demand for the two goods is given by

\[
X_{1t} = \omega \left( \frac{q_{1t}}{P_{1t}} \right)^{-\eta} Q(X_{1t}, Z_{1t})
\]
\[ Z_{1t} = (1 - \omega) \left( \frac{q_{2t}}{P_{1t}} \right)^{-\eta} Q(X_{1t}, Z_{1t}) \]

\[ Z_{2t} = \omega \left( \frac{q_{2t}}{P_{2t}} \right)^{-\eta} Q(Z_{2t}, X_{2t}) \]

\[ X_{2t} = (1 - \omega) \left( \frac{q_{1t}}{P_{2t}} \right)^{-\eta} Q(Z_{2t}, X_{2t}) \]

where \( X_{2t} \) represents exports from country 1 to country 2, and \( Z_{1t} \) denotes imports into country 1. The numeraire is defined as a world price index: \( (P_{1t})^{\frac{1}{2}} (P_{2t})^{\frac{1}{2}} = 1 \). The real exchange rate, \( RER_t \), is defined as follows:

\[ RER_t \equiv \frac{P_{1t}}{P_{2t}}. \]

Therefore, from the perspective of country 1, the real exchange rate is the ratio of the domestic price level relative to the foreign price level.

### 1.3.1 Households

The representative household in each country \( i \) maximizes intertemporal utility characterized by functions of the form

\[
E_0 \sum_{t=0}^{\infty} \beta_{it} \left( \frac{C_{it}^{1-\gamma} - 1}{1 - \gamma} - \theta \frac{L_{it}^{1+\kappa}}{1 + \kappa} \right)
\]

\[ \beta_{i0} = 1, \beta_{i,t+1} = (1 + \psi C_{it})^{-1} \beta_{it}, \ t > 0 \]

where \( C_{it} \) and \( L_{it} \) are consumption and hours worked, respectively, in country \( i \). The endogenous discount factor is used to ensure that the model is stationary.\(^6\)

There are two types of bonds in each country, government bonds \( D \) and internationally traded bonds \( B \). The household's budget constraint in country \( i \) is

\[
(1 + \tau_{it}^c)P_{it}C_{it} + P_{it}I_{it} + D_{it} + B_{it} = (1 - \tau_{it}^l)q_{it}w_{it}L_{it} + (1 - \tau_{it}^k)q_{it}R_{it}K_{i,t-1}
\]

\[ + R_{i,t-1}^c D_{i,t-1} + R_{i,t-1}B_{i,t-1} + P_{it}T_{it} \quad (1.3.1) \]

\(^6\)Schmitt-Grohé and Uribe (2003) show that this feature makes the steady-state independent of initial conditions, i.e., the initial level of financial wealth, physical capital, and total factor productivity.
where labor income, capital income, government and internationally traded bonds plus interest payments, and lump-sum transfers from the domestic government, $T_{it}$, can be allocated to consumption, investment in physical capital and the purchase of new government and international bonds. $R_{it}^k$ is the capital rental rate. $\tau_{it}^c$, $\tau_{it}^l$ and $\tau_{it}^k$ are tax rates on consumption, labor income and capital income.\textsuperscript{7}

The law of motion for capital is given by

$$K_{it} = (1 - \delta)K_{i,t-1} + I_{it} - \xi \left( \frac{I_{it}}{K_{i,t-1}} - \delta \right)^2 K_{i,t-1}$$

where $\delta$ is the depreciation rate. The last item captures the capital adjustment cost.\textsuperscript{8} The household maximizes utility subject to its budget constraint and the law of motion for capital.

1.3.2 Firms

The representative firm in country 1 specializes in producing good $X$ and the representative firm in country 2 specializes in producing good $Z$. They rent capital and labor from the household. Production functions in the two countries take the same form:

$$F(K, L) = K^\alpha L^{1-\alpha}$$

where $\alpha \in [0, 1]$. The resource constraints in the two countries are

$$X_{1t} + X_{2t} = Y_{1t} = A_{1t}F(K_{1,t-1}, L_{1t})$$

$$Z_{1t} + Z_{2t} = Y_{2t} = A_{2t}F(K_{2,t-1}, L_{2t})$$

where $Y_{it}$ represents output in country $i$ in units of the domestic good, and $X_{it}$ and $Z_{it}$ are uses of the two goods in country $i$.

\textsuperscript{7}Note that labor income and capital income are in units of the domestic good. Thus they are multiplied by the price of the domestic good. Bond holdings, bond prices and bond returns are expressed in terms of the numeraire.

\textsuperscript{8}International business cycle models use capital adjustment costs to reduce the volatility of investment in response to productivity shocks. BKK uses a time-to-build structure for capital formation as in Kydland and Prescott (1982). But convex capital adjustment costs have become more common since the publication of Baxter and Crucini (1995).
The productivity shocks are assumed to follow the processes

\[
\log(A_{1t}) = \rho_a \log(A_{1,t-1}) + \nu \log(A_{2,t-1}) + \varepsilon_{1t}^a
\]

\[
\log(A_{2t}) = \nu \log(A_{1,t-1}) + \rho_a \log(A_{2,t-1}) + \varepsilon_{2t}^a
\]

where \( \varepsilon_{it}^a \sim N(0, \sigma_a^2) \) and the contemporaneous correlation of the productivity shocks is \( \lambda \in (0, 1) \). The parameter \( \nu \) measures technology spillovers.

The representative firm in each country \( i \) maximizes its profit

\[
Y_{it} - w_{it}L_{it} - R_{k_{it}}K_{i,t-1}.
\]

Thus, wages and capital rental rates are

\[
w_{it} = \frac{(1 - \alpha)Y_{it}}{L_{it}}
\]

\[
R_{k_{it}} = \frac{\alpha Y_{it}}{K_{i,t-1}}.
\]

### 1.3.3 Fiscal Policy

Government spending and lump-sum transfers are financed through issuance of one-period bonds, and taxation on capital income, labor income and consumption. The government’s period budget constraint in each country \( i \) is

\[
R_{k_{it}}^i D_{i,t-1} + P_{it}G_{it} + P_{it}T_{it} = D_{it} + \tau_{it}^q q_{it} R_{k_{it}}^i K_{i,t-1} + \tau_{it}^l q_{it} w_{it} L_{it} + \tau_{it}^c P_{it} C_{it}.
\]

All the five fiscal instruments follow exogenous feedback rules. They are allowed to respond to the debt-to-GDP ratio, as motivated by the empirical fact. Additionally, the output growth rate is included in the rules, reflecting the cyclical influences from the states of the economy.\(^9\) Specifically,

\(^9\)The output is detrended. The output growth rate is the gap between GDP growth and trend growth.
\[
\log(F_{it}) = (1 - \rho_F) \log(F_t) + \rho_F \log(F_{i,t-1}) + \varphi_F \frac{Y_{it-1} - Y_{it-2}}{Y_{it-2}} + \gamma_F (\log(\tilde{D}_{i,t-1}) - \log(\tilde{D}_i)) + \sigma_F \varepsilon_{it}^F
\]

where \( F_{it} \), with \( F \in \{ G, T, \tau_k, \tau_l, \tau_c \} \), denote the fiscal instruments of government spending, lump-sum transfers, the capital tax rate, the labor tax rate, and the consumption tax rate in country \( i \) at time \( t \), \( \tilde{D}_i \equiv D_i/q_iY_t \), and each \( \varepsilon_{it} \) is an i.i.d. innovation with mean zero and standard deviation one. The variables without a subscript \( t \) denote steady state values. The parameters \( \varphi_F \) represent the responsiveness of the fiscal instruments to lagged output growth rate, a measure of output gap (and consistent with that used in Section 2). \( \varphi_F > 0 \) (\( \varphi_F < 0 \)) implies the procyclicality (countercyclicality) of the policy rule. The parameters \( \gamma_F \) capture the responsiveness of these instruments to lagged debt-to-GDP ratio, a measure of government liabilities. \( \gamma_G < 0, \gamma_T < 0, \gamma_{\tau_k} > 0, \gamma_{\tau_l} > 0, \) or \( \gamma_{\tau_c} > 0 \) corresponds to the debt consolidation feature of each fiscal policy. Specifically, government debt is redeemed through decreased spending, decreased transfers, increased capital tax rate, increased labor tax rate, or increased consumption tax rate. Lagged variables rather than contemporaneous variables are used because of delayed fiscal decision and implementation.

### 1.3.4 National Accounts

Recall that the optimal aggregate demand for the two goods in country 1 is given by
\[
X_{1t} = \omega \left( \frac{q_{1t}}{P_{1t}} \right)^{-\eta} Q(X_{1t}, Z_{1t}) \quad \text{and} \quad Z_{1t} = (1 - \omega) \left( \frac{q_{2t}}{P_{2t}} \right)^{-\eta} Q(X_{1t}, Z_{1t}).
\]
The aggregate demand for the two goods in country 2 is given by
\[
Z_{2t} = \omega \left( \frac{q_{2t}}{P_{2t}} \right)^{-\eta} Q(Z_{2t}, X_{2t}) \quad \text{and} \quad X_{2t} = (1 - \omega) \left( \frac{q_{1t}}{P_{1t}} \right)^{-\eta} Q(Z_{2t}, X_{2t}).
\]
Using \( C_{it} + I_{it} + G_{it} = Q_{it} \) and the resource constraints in the two countries, output can be decomposed as
\[
Y_{1t} = \left( \frac{P_{1t}}{q_{1t}} \right)^{\eta} (C_{1t} + I_{1t} + G_{1t}) + X_{2t} - \left( \frac{q_{2t}}{q_{1t}} \right)^{\eta} Z_{1t}
\]
where \( Y_{1t} \) is the absorption and \( Y_{2t} \) is the net exports.
\[
Y_{2t} = \left( \frac{P_{2t}}{q_{2t}} \right)^\eta (C_{2t} + I_{2t} + G_{2t}) + Z_{1t} - \left( \frac{q_{1t}}{q_{2t}} \right)^\eta X_{2t}
\]

where \( \left( \frac{P_{2t}}{q_{2t}} \right)^\eta (C_{it} + I_{it} + G_{it}) \) is absorption and the rest is net exports. The trade balance is defined as the ratio of net exports to output:

\[
TB_{1t} \equiv \left[ X_{2t} - \left( \frac{q_{2t}}{q_{1t}} \right)^\eta Z_{1t} \right] / Y_{1t}
\]

\[
TB_{2t} \equiv \left[ Z_{1t} - \left( \frac{q_{1t}}{q_{2t}} \right)^\eta X_{2t} \right] / Y_{2t}.
\]

### 1.3.5 Competitive Equilibrium

A competitive equilibrium for this economy is a sequence of

prices \( \{q_{1t}, q_{2t}, P_{1t}, P_{2t}, R_{t}, R_{1t}^1, R_{1t}^2, R_{2t}^k, R_{k1t}^k, R_{k2t}^k, w_{1t}, w_{2t}\}_{t=0}^\infty \) and

quantities \( \{C_{1t}, C_{2t}, L_{1t}, L_{2t}, D_{1t}, D_{2t}, B_{1t}, B_{2t}, I_{1t}, I_{2t}, I_{1t}, I_{2t}, K_{1t}, K_{2t}\}_{t=0}^\infty \) such that:

1. households and firms behave optimally in each country;
2. the government budget constraint holds in each country;
3. the goods markets clear, i.e. \( X_{1t} + X_{2t} = Y_{1t} \) and \( Z_{1t} + Z_{2t} = Y_{2t} \);
4. the bond market clears, i.e. \( B_{1t} + B_{2t} = 0 \).

Because households can hold international bonds and domestic government bonds, and can rent capital to firms, the no arbitrage condition implies that \( R_{t} = R_{1t}^1 = R_{1t}^2 = R_{2t}^k \).

Appendix B lists the optimality conditions for the model.

### 1.4 Estimation

The model is estimated on US and EU (15 countries\(^{10}\)) quarterly data from 1961q1 to 2013q4 using Bayesian estimation techniques. Appendix C describes the data sources and construction.

\(^{10}\)The countries are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom.
1.4.1 Policy Rules

As is common practice, the feedback rule for each fiscal instrument $F \in \{G, T, \tau^k, \tau^l, \tau^c\}$, 
\[
\log(F_{it}) = (1 - \rho_F) \log(F_i) + \rho_F \log(F_{i,t-1}) + \varphi_F \frac{y_{i,t-1} - y_{i,t-2}}{y_{i,t-2}} + \gamma_F (\log(\tilde{D}_{i,t-1}) - \log(\tilde{D}_i)) + \sigma_F \varepsilon_{it}^F,
\]
is estimated outside the model and is then fed into the model. Seven US time series including real government spending, real government transfers, capital, labor and consumption tax rates, the GDP growth rate, and the debt-to-GDP ratio are used in the estimation. The estimation results are summarized in Table 1.2.

As described above, a positive (negative) $\varphi_F$ suggests procyclicality (countercyclicality) of the fiscal policy. The estimation results show that government spending, the capital tax rate and the labor tax rate are procyclical. In contrast, transfers and the consumption tax rate are countercyclical, although the latter is not significantly so. The signs of $\gamma_F$ reveal fiscal consolidation efforts by the government: in response to a higher debt-to-GDP ratio, the government cuts spending and transfers while at the same time raising taxation on capital income, labor income and consumption expenditures. Government spending reacts most significantly to the debt-to-GDP ratio, followed by the capital tax rate and the consumption tax rate. The responsiveness of transfers or the labor tax rate, however, is not significant. Overall, the estimation results for $\gamma_F$ point to operative fiscal consolidation in the US. Finally, estimates for the autoregressive parameters $\rho_F$ reveal the high persistence of fiscal shocks.
1.4.2 Prior Distributions

Five US time series and four EU time series are used as observable variables in the Bayesian estimation. The US data series include real GDP, real consumption, real investment, real government spending, and hours worked. The EU data series include real GDP, real government spending, real exports of goods and services, and real imports of goods and services.

In order to pin down steady state values of the estimated model, some parameters are kept fixed to their calibrated values (which can be viewed as infinitely strict priors). Table 1.3 reports the calibrated parameters. The discount factor in steady state, $\beta$, is set to equal 0.99 (so that the annual steady state real interest rate is 4%). The risk aversion parameter, $\gamma$, takes a standard value of 2. Following Chetty et al. (2011), I set the Frisch elasticity of labor supply to $1/\kappa = 0.75$. The utility weight of work parameter, $\theta$, is set to 13.1 (so that hours worked in steady state is 0.33). The depreciation rate of capital, $\delta$, is 0.02 (so that the annual depreciation rate is 8%). The capital share in production, $\alpha$, is set equal to 0.36 (so
to imply a labor share of 64%). The steady state spending to output ratio, debt to output ratio, and tax rates are set to equal their sample means.

Table 1.3: Calibrated Parameters for the Estimated Model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>β</th>
<th>γ</th>
<th>κ</th>
<th>θ</th>
<th>δ</th>
<th>α</th>
<th>C/Y</th>
<th>D/Y</th>
<th>τ^k</th>
<th>τ^l</th>
<th>τ^c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>0.99</td>
<td>2</td>
<td>1/0.75</td>
<td>13.1</td>
<td>0.02</td>
<td>0.36</td>
<td>0.176</td>
<td>0.543</td>
<td>0.376</td>
<td>0.216</td>
<td>0.093</td>
</tr>
</tbody>
</table>

The remaining parameters are estimated and their prior distributions are shown in Table 1.4. The prior and posterior probability density functions are plotted in Appendix D. The prior information is based on previous studies at both the macro and micro level. A Beta distribution is assumed for ω, with a mean of 0.7 and a standard deviation equal to 0.2. Estimates of the elasticity of substitution between domestic and foreign goods η vary substantially in the literature, with disaggregated studies producing much larger estimates than macroeconomic data. In this paper η is assumed to follow a Gamma distribution with mean 3 and standard deviation 1.5 (so that approximately it is centered on 2 and ranges from 0 to 8). The capital adjustment cost ξ is distributed as Gamma with a mean of 2 and a standard deviation of 0.5.

A Beta distribution is assumed for the technology autoregressive coefficient ρ_a, with mean 0.8 and standard deviation 0.1 (so that it will range approximately between 0.5 and 1). The standard deviation of the technology innovation, σ_a, is assumed to be distributed as Inverse Gamma with mean 0.01 and standard deviation 0.01. The technology spillover ν is assumed to follow a Gamma distribution centered on a value of 0.1 with a standard deviation of 0.02. The technology correlation λ is assumed to have a Beta distribution with a mean of 0.4 and a standard deviation of 0.2. The distributions of the two technology
parameters span a range of values including those calibrated in Baxter and Crucini (1993) and Backus et al. (1994).

Table 1.4: Prior and Posterior Distributions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior distribution</th>
<th>Posterior distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Density</td>
<td>Mean</td>
</tr>
<tr>
<td>Domestic share $\omega$</td>
<td>beta</td>
<td>0.7</td>
</tr>
<tr>
<td>Elasticity of subs. $\eta$</td>
<td>gamma</td>
<td>3</td>
</tr>
<tr>
<td>Capital adj. cost $\xi$</td>
<td>gamma</td>
<td>2</td>
</tr>
<tr>
<td>Tech. AR coeff. $\rho_a$</td>
<td>beta</td>
<td>0.8</td>
</tr>
<tr>
<td>Tech. s.d. $\sigma_a$</td>
<td>invg</td>
<td>0.01</td>
</tr>
<tr>
<td>Tech. spillover $\nu$</td>
<td>gamma</td>
<td>0.1</td>
</tr>
<tr>
<td>Tech. correlation $\lambda$</td>
<td>beta</td>
<td>0.4</td>
</tr>
</tbody>
</table>

1.4.3 Posterior Distributions

The posterior distributions of the estimated parameters are obtained in two steps. First, Chris Sims’s optimization routine csminwel is used to maximize the log posterior function. Second, the random walk Metropolis–Hastings algorithm is used to sample from the posterior. Right columns of Table 1.4 summarize estimated means and 5% and 95% percentiles. Two Markov chains were run starting from different initial conditions randomly selected around the posterior mode. The acceptance ratios are 24.82% and 24.78%, respectively. A sample of 100,000 draws was created with the first 50,000 used as a burn-in period. Convergence was checked using standard diagnostics as in Brooks and Gelman (1998). The mean estimates for the domestic share ($\omega$) and elasticity of substitution between domestic and foreign goods ($\eta$) are 0.6929, and 3.3757, respectively. These estimates imply a steady state
imports to output ratio of 30.71%, which is between the US imports share 14.45% and the EU imports share 35.71% over the sample period. The means of technology persistence ($\rho_a$) and standard deviation ($\sigma_a$) are 0.9021 and 0.0068, respectively. The technology spillover ($\nu$) and correlation ($\lambda$) are estimated to have a mean of 0.0732 and 0.2676, respectively.

1.5 Quantitative Analysis

Before turning to the results, let me first discuss the channels through which fiscal shocks exert influence on both domestic and cross-border economic activities. In the domestic economy, the government finances fiscal expansions by issuing government bonds. Since part of the government bonds are purchased by foreign residents, domestic private wealth necessarily decreases. Because of negative wealth effect, domestic consumers increase their labor supply while at the same time cutting their consumption. In the meantime, a higher level of government debt pushes up the real interest rate in the economy, thus crowding out private investment.

There are three international transmission channels of fiscal shocks in the model. The first one is the trade channel. Following an expansionary fiscal shock, the domestic levels of consumption, investment and government spending will change. Since these three components of output are an aggregate of domestic and foreign products, consumers will directly spend part of their income abroad, changing the demand for foreign imports and thus foreign production. The second channel is the interest rate channel. Debt financed fiscal expansions will drive up real interest rate in the bond markets. Recall that cross-border arbitrage of returns across capital and bonds implies a common interest rate in the model. Hence a higher level of interest rate will discourage foreign investment. The third channel is the exchange rate channel. In response to a fiscal expansion, the domestic consumers’ demand for the imports to output ratio is equal to $1 - \omega$. 

$^{11}$
home goods will be relatively larger than that for the foreign goods because of home bias in the Armington aggregator. As a result, the exchange rate appreciates for the domestic consumers and the foreign country’s international competitiveness is enhanced, boosting its exports to the domestic economy.

We now turn to the domestic and spillover effects of expansionary fiscal shocks. Figures 1.4-1.13 plot the impulse responses following a temporary one standard deviation exogenous change in each fiscal instrument in country 1. The blue solid line is generated with the mean of the posterior distribution. The red dashed line represents the simulation result where debt stabilization is realized through non-distortionary transfers only.\textsuperscript{12} Foreign economy variables are indicated with an asterisk (*).\textsuperscript{13}

\subsection*{1.5.1 Domestic Government Spending Shock}

Figure 1.4 shows how key domestic variables adjust to the domestic government spending impulse. On impact, because of the negative wealth effect, consumption decreases and the labor supply increases. Domestic consumers become borrowers in the international bond market as shown by a negative response of the international bond. Since the increased spending is debt-financed, we see an increase in the government debt level and hence an increased real interest rate in the economy. Private investment is crowded out and stays below steady state until quarter 17. With a lower marginal product of labor, labor turns

\begin{itemize}
  \item \textsuperscript{12}I shut off the fiscal consolidation regime by setting $\gamma_G = \gamma_{ck} = \gamma_c = \gamma_{cr} = 0$ and $\gamma_T = -0.114$ (so that the simulations are not explosive). The other parameters are kept the same as in Section 1.4 (mean value for the estimated parameters are used).
  \item \textsuperscript{13}Overall, we observe a considerable amount of fluctuations following a fiscal shock. For model validation purpose, I implement an eleven variable VAR with a lag length of 4 to see if fluctuations appear following a fiscal shock. The variables are Cholesky-ordered as follows: US fiscal variable, US real GDP, US real consumption, US real investment, US hours worked, EU real GDP, EU real consumption, EU real investment, US real exports, US real imports and US real government debt, where the US fiscal variable belongs to one of the five fiscal instruments. The data sources and the time span are the same as those used in the Bayesian estimation. The results are shown in Appendix E. It turns out that the VARs also display fluctuations. Changing the order of the variables or the lag length does not affect this feature.
\end{itemize}
negative in quarter 11 and stays so till quarter 17. The below steady-state investment and labor lead to negative responses of output between quarter 4 and quarter 31.

However, responses of these variables change signs as a result of the spending reversal: government spending drops below steady-state in quarter 15 to consolidate debt. The negative responses of spending between quarter 15 and quarter 26 in turn contribute to a below steady-state government debt level between quarter 20 and quarter 38. This fiscal consolidation regime results in fluctuations in the responses of macroeconomic variables.\(^{14}\)

In contrast, these fluctuations disappear when lump-sum transfers are the only instrument used to stabilize debt. In this case, government spending reverts back to its steady state smoothly as do other variables in the economy (except government debt and transfers). Labor supply stays above steady-state throughout the 40 years. Consumption decreases by a larger margin without the fiscal consolidation regime. Investment is crowded out between quarter 0 and quarter 38. Investment turns positive in quarter 39 (but only slightly so because the effect of above steady-state marginal product of capital and the effect of above steady-state interest rate nearly cancel each other out). These responses of investment and labor lead to positive responses of output throughout the 40 years.

The cross-border impacts of a one standard deviation increase in domestic government spending appear in Figure 1.5. We can analyze the responses through the three international transmission channels. (i) The trade channel: the fall in domestic consumption and investment decreases imports from the foreign country whereas the increase in government spending raises imports. (ii) The exchange rate channel: real exchange rate appreciates in the domestic country, boosting its imports and reducing its exports. The overall effect of (i) and (ii) is that imports increase (and stay positive till quarter 4) and exports decrease (and

\(^{14}\)Fluctuations also exist in Corsetti et al. (2010) and Corsetti and Müller (2013).
stay negative till quarter 5) in the domestic country. Correspondingly, the trade balance turns positive in the foreign country. (iii) The interest rate channel: the increased global real interest rate depresses foreign investment which stays negative till quarter 3. Higher demand from the domestic country leads to an increase of output and labor supply in the foreign country. Higher real interest rate encourages foreign consumers to reduce consumption and hold more international bonds (which stay above steady state till quarter 8, not shown in Figure 1.5) and government bonds. With respect to the other components of the foreign government’s budget constraint (not shown in Figure 1.5), spending stays positive till quarter 36; capital tax revenues and labor tax revenues stay positive till quarter 29 and quarter 32 respectively; consumption tax revenues stay negative till quarter 40; transfers stay positive between quarter 2 and quarter 35. Again, we can see fluctuations of responses when the fiscal consolidation regime is in place.

We may summarize the main findings for the effects of a positive domestic government spending shock: (1) cross-country spillovers are significant, i.e. foreign variables respond in magnitude comparable to that of domestic variables; (2) the fiscal consolidation regime leads to fluctuations of macroeconomic variables both at home and abroad.

1.5.2 Domestic Transfers Shock

Figure 1.6 reports the domestic responses to a one standard deviation increase in the domestic lump-sum transfers shock. Government debt stays positive till quarter 18. Domestic households spend their increased transfers on more consumption goods and leisure and they hold more international bonds and government bonds. In spite of higher government debt, higher demand for bonds pushes down real interest rate which stays negative till quarter 29. Labor also stays negative till quarter 29. Due to lower labor supply hence lower marginal
production of capital, investment falls. Decreased investment and labor result in negative responses of output.

The spillovers of a one standard deviation increase in the domestic transfers shock are illustrated in Figure 1.7. Imports decrease on impact and stay negative till quarter 19. This negative impact response can be attributed to the negative response of domestic government spending (not shown in Figure 1.6). In contrast, under a government spending shock, domestic spending stays positive for a while as shown in Figure 1.4. Because part of government spending falls directly on foreign goods, decreased spending leads to decreased demand for foreign goods. As domestic households save in the international bond market, foreign households become borrowers and the negative responses of international bonds (not shown in Figure 1.7) are accompanied by positive responses of consumption.

Again, the fluctuating responses after the fiscal shock can be attributed to the fiscal consolidation regime. If only transfers adjust to stabilize debt, we shall see zero responses of macroeconomic variables both at home and abroad (except government debt and transfers), since transfers are non-distortionary in the model.

1.5.3 Domestic Capital Tax Rate Shock

Figure 1.8 describes the domestic responses to a one standard deviation decrease in the domestic capital tax rate. Because of a higher return on capital, investment jumps up and stays positive till quarter 32. With a delay of 2 quarters, consumption rises above steady-state. Labor stays positive for 4 quarters before it turns below steady-state. Output stays positive till quarter 51. Domestic households are borrowers in the international bond market in the first 26 quarters but later on they become savers. We can conclude that fiscal stimulus via a capital tax rate cut is more effective in boosting domestic economy than increased government spending or transfers, in the sense that output, consumption and
investment remain above steady-state for the first 8 years after the shock. The cross-border spillovers are shown in Figure 1.9. Although foreign trade balance increases on impact and stays positive for 6 quarters, foreign output stays negative between quarter 2 and quarter 49. This is because foreign investment decreases by a very large margin due to higher global real interest rate.

Under a domestic capital tax rate shock, output, consumption and investment behave very differently at home and abroad. The capital tax rate cut effectively stimulates domestic output, consumption and investment. In the foreign country, however, it has contractionary effect for the first few years.

1.5.4 Domestic Labor Tax Rate Shock

Impacts of a one standard deviation decrease in the domestic labor tax rate appear in Figures 1.10 and 1.11. In the domestic economy, the labor supply increases in response to the tax rate cut. The labor tax rate shock raises disposable income of households who increase their consumption and bond holdings accordingly. The real interest rate stays negative till quarter 28 because of higher demand for bonds. Output stays positive till quarter 10. The domestic households save in the international bond market throughout the 40 years. For spillover effects, the real exchange rate depreciates on impact, meaning that the domestic economy has gained international competitiveness after a labor tax rate cut. The patterns of the foreign variables are similar to those under the transfers shock.

1.5.5 Domestic Consumption Tax Rate Shock

Figure 1.12 illustrates the domestic effects of a lower domestic consumption tax rate. The behavioral patterns of domestic variables are very similar to those under the transfers shock,
as both shocks tend to boost domestic consumption but depress investment and output. The spillover effects, shown in Figure 1.13, are also similar to those under the transfers shock.

### 1.5.6 Fiscal Multipliers

To further compare the domestic and cross-border effects of fiscal shocks, as well as between the two scenarios with and without the fiscal consolidation regime, I document present value output multipliers in Tables 1.5 and 1.6. The following formula is used to calculate present value output multipliers over a \( k \)-quarter horizon window:

\[
\sum_{j=0}^{k} \left( \prod_{i=0}^{j} R_{t+i}^{-1} \right) \Delta Y_{t+j} / \sum_{j=0}^{k} \left( \prod_{i=0}^{j} R_{t+i}^{-1} \right) \Delta F_{t+j}
\]

or

\[
\sum_{j=0}^{k} \left( \prod_{i=0}^{j} R_{t+i}^{-1} \right) \Delta Y_{t+j}^* / \sum_{j=0}^{k} \left( \prod_{i=0}^{j} R_{t+i}^{-1} \right) \Delta F_{t+j}
\]

where \( \Delta Y_{t+j}, \Delta Y_{t+j}^* \) and \( \Delta F_{t+j} \) denote level changes of the variables from their steady states and \( F \in \{ \text{government spending, transfers, capital tax revenues, labor tax revenues, consumption tax revenues} \} \).\(^\text{15}\)

The domestic effects of fiscal shocks are summarized in Table 1.5. Consistent with Mountford and Uhlig (2009), capital tax multipliers and labor tax multipliers are larger than spending multipliers. Moreover, capital and labor tax cuts work better when only non-distortionary transfers adjust to stabilized debt, indicating that the fiscal consolidation regime attenuates the domestic stimulating effects of fiscal shocks. Under the fiscal consolidation regime, spending multipliers are positive in the short run but turn negative in the long run. In contrast, spending multipliers are positive in the long run without the fiscal consolidation regime.

---

\(^\text{15}\)The present value multiplier formula follows from Mountford and Uhlig (2009) and Leeper et al. (2010a). Tax revenues are computed as \( T_t^k = \tau_t^k \alpha Y_t, T_t^{k*} = \tau_t^{k*} \alpha Y_t^*, T_t^l = \tau_t^l (1-\alpha) Y_t, T_t^{l*} = \tau_t^{l*} (1-\alpha) Y_t^*, T_t^c = \tau_t^c C_t, T_t^{c*} = \tau_t^{c*} C_t^* \).
Table 1.5: Domestic Output Multipliers

<table>
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<tr>
<th>Instrument</th>
<th>Specification</th>
<th>Impact</th>
<th>4</th>
<th>8</th>
<th>20</th>
<th>40</th>
<th>∞</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.28</td>
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<td>0.30</td>
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<tr>
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<td>-0.80</td>
<td>-0.74</td>
<td>-0.88</td>
</tr>
<tr>
<td></td>
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<td>0.00</td>
</tr>
<tr>
<td>Capital tax</td>
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<td>-0.72</td>
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<tr>
<td></td>
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<td>-0.47</td>
<td>-0.78</td>
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<td>-1.08</td>
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<tr>
<td>Labor tax</td>
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<td>-0.32</td>
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<tr>
<td></td>
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<tr>
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</tr>
<tr>
<td></td>
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<td>-0.07</td>
<td>-0.07</td>
<td>-0.07</td>
<td>-0.06</td>
<td>-0.07</td>
<td>-0.13</td>
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</tbody>
</table>

fiscal consolidation regime, since agents do not expect a reversal of fiscal variables. Increasing transfers or cutting labor tax would reduce output in the domestic economy. Overall, the domestic output multipliers are smaller than 1, which is typical for real business cycle models.

Table 1.6 shows the cross-border output spillovers from domestic fiscal shocks. Short-run and long-run multipliers differ remarkably. Under both the baseline and the alternative specifications, impact and long run multipliers have opposite signs for all five fiscal instruments.\(^{16}\) Within two years under the fiscal consolidation regime, a domestic transfers increase, or a domestic tax rate cut would lead to a decrease in the foreign output. Therefore, a spending increase is most favored by the foreign economy in the short run. In the long run, the

\(^{16}\)Except the “transfers only” case for transfers shocks where all the multipliers are zero.
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Specification</th>
<th>Impact</th>
<th>4</th>
<th>8</th>
<th>20</th>
<th>40</th>
<th>∞</th>
</tr>
</thead>
<tbody>
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<td>0.08</td>
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<td>-0.05</td>
<td>-0.23</td>
</tr>
<tr>
<td>Transfers</td>
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<td>0.35</td>
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<tr>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Capital tax</td>
<td>Baseline</td>
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<td>0.06</td>
<td>0.16</td>
<td>0.34</td>
<td>0.35</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
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<td>0.42</td>
<td>0.35</td>
</tr>
<tr>
<td>Labor tax</td>
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<td>0.05</td>
<td>0.03</td>
<td>-0.14</td>
<td>-0.29</td>
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<td>Transfers only</td>
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<td>0.03</td>
<td>0.03</td>
<td>0.01</td>
<td>-0.06</td>
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</tr>
<tr>
<td>Cons. tax</td>
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<td>0.01</td>
<td>0.00</td>
<td>-0.10</td>
<td>-0.11</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>Transfers only</td>
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<td>-0.03</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.07</td>
<td>0.17</td>
</tr>
</tbody>
</table>

A foreign economy would prefer a domestic labor tax rate cut, with a present value multiplier of 0.53 (0.21) additional unit of foreign output under the fiscal consolidation (alternative) specification.

1.5.7 Domestic Government Debt and Foreign Output Multipliers

In Section 1.2, I have shown that output spillovers from domestic spending shocks are negatively related to the domestic economy’s average debt-to-GDP ratio. This section investigates the model prediction of the relationship between these two variables. In order to generate different levels of average debt-to-GDP ratio, I vary the speed of fiscal consolidation in the fiscal policy rules. More specifically, $\gamma_F$ is multiplied by the speed variable $s$. 
\[
\log(F_{it}) = (1 - \rho_F) \log(F_i) + \rho_F \log(F_{i,t-1}) + \varphi_F \frac{Y_{it-1} - Y_{it-2}}{Y_{it-2}} \\
+ s \gamma_F (\log(\tilde{D}_{i,t-1}) - \log(\tilde{D}_i)) + \sigma_F e_{it}^{F}
\]

while the other parameters are kept the same as in Section 1.4 (mean value for the estimated parameters are used). \(s > 1\) \((s < 1)\) corresponds to a higher (lower) speed of fiscal consolidation. Appendix F plots the debt ratio against \(s\). It shows that a higher speed of fiscal consolidation is associated with a smaller average debt-to-GDP ratio. Figure 1.3 plots foreign present value output multipliers over a horizon of two years (same as in the empirical section) against the domestic average debt-to-GDP ratio over the simulation periods (40 years). The present value foreign output multiplier is a good proxy for the output spillover in Section 1.2, which is foreign output elasticity with respect to domestic government spending. As we can see from Figure 1.3, the model succeeds in capturing the negative relation between the two variables as observed in the empirical fact. The mechanism is the dominating interest rate channel: higher domestic debt drives up global real interest rate and dampens foreign activity while lower domestic debt is associated with a lower interest rate, boosting foreign activity.

The two figures imply that a higher speed of fiscal consolidation is associated with a higher foreign output multiplier. The speed of fiscal consolidation influences foreign output in two opposite directions. First, domestic expansionary shocks can stimulate foreign output through increased imports (the trade channel and the exchange rate channel). A faster consolidation regime, however, mitigates this positive effect, leading to smaller foreign output multipliers. On the other hand, accelerated fiscal consolidation ensures less debt accumulation and lower global interest rates, leading to larger foreign output multipliers (the interest rate channel). Therefore, the results reveal that the interest rate channel dominates in the model economy.
1.6 Variance Decomposition

Tables 1.7 and 1.8 present the contributions of productivity and fiscal shocks to the variance of key model variables. The decompositions help us evaluate the relative importance of productivity shocks and fiscal shocks in accounting for business cycle fluctuations in key model variables. The forecast-error-variance decompositions are reported on 6 horizons.
The quarterly fluctuations in output and consumption are largely dominated by productivity shocks both in the short and the long run. In contrast, fiscal shocks account for major part of fluctuations in government spending, the trade balance, the real interest rate, government debt and the international bond.

In terms of short horizons, most (around 85 percent) of the variation in labor supply are explained by fiscal shocks, and they still represent 82 percent after five years, while productivity shocks gain more importance in the long run. The exchange rate is strongly affected in the short run by productivity shocks and, in the long run, by both productivity shocks and government spending.
and fiscal shocks. For the variation in investment, both shocks play a role with fiscal shocks being slightly more important.

1.7 Historical Decomposition

The observed data (deviations from the steady state) for US GDP, US investment, US hours, US government spending, EU output and EU trade balance over the 1961q1-2013q4 period are decomposed into the contributions of productivity and fiscal shocks.\textsuperscript{17} The results are shown in Figures 1.14-1.19. It comes as no surprise that both US and EU GDP fluctuations are driven mostly by productivity shocks\textsuperscript{18}, and that most of the variations in US government spending are identified as fiscal shocks. Interestingly, fiscal shocks are more important than productivity shocks behind the historical fluctuations in US hours and EU trade balance. Fiscal shocks have also contributed strongly to US investment movements since 2007.\textsuperscript{19}

1.8 Conclusion

In this paper, I document the fact that the output spillover of increased government spending is negatively related to the domestic government debt-to-GDP ratio. In order for the model to generate results consistent with this fact, I incorporate the fiscal consolidation component in the policy rules of all five fiscal instruments. For example, after a temporary increase above steady-state, spending has to fall below steady-state to consolidate debt. By varying the speed of fiscal consolidation, the model successfully replicates the negative

\textsuperscript{17}Each data series is decomposed into a productivity shocks component, a fiscal shocks component and an initial value component. The initial value component dies out quickly and is not plotted in the figures.

\textsuperscript{18}Fiscal shocks have become more relevant in the historical movements of US GDP in the later years of the sample.

\textsuperscript{19}The forecast-error-variance decomposition and the historical decomposition conducted here only assess the relative importance of productivity shocks and fiscal shocks in explaining the business cycle movements of key model variables. More non-policy shocks need to be modeled if we want to investigate the role of fiscal shocks as sources of business cycle fluctuations.
relationship between domestic debt and foreign output. With a slower speed of fiscal consolidation, the domestic economy accumulates more debt and the global real interest rate is higher, hurting the foreign economy. In contrast, when the domestic economy quickly consolidates its debt, the increase in global interest rate is smaller and thus the foreign activity is not dampened as much.

I have also compared the domestic and cross-border effects of different fiscal instruments. In the domestic economy, capital tax rate and labor tax rate cuts are more effective in stimulating output than spending or transfers increase, or a consumption tax rate cut. However, the fiscal consolidation regime mitigates the strength of the stimulating effects. This is because the fiscal consolidation regime leads to waning fluctuations of macroeconomic variables before they return to steady states. If we shut off the fiscal consolidation regime, the fluctuations would disappear and the stimulating effects would be stronger. For the foreign country, the impact and cumulative effects of domestic fiscal shocks can differ a lot. In the short run, a domestic government spending increase is most favorable to the foreign country, while in the long run a domestic labor tax cut works best in boosting foreign output.

The current model abstracts from monetary policies which may alter the way the interest rate channel works as described in this paper. It would be important to explore how the interplay between monetary and fiscal policies influences cross-border spillovers of fiscal stimulus. I am interested in pursuing this direction of research in the future.
Figures

Figure 1.4: Responses to a One Standard Deviation Increase in Domestic Government Spending Shock: Key Domestic Variables

Notes: Baseline (solid line) vs. debt stabilization through lump-sum transfers only ($\gamma_G = \gamma_{r^k} = \gamma_{r^t} = \gamma_{r^c} = 0$, dashed line). Interest rate is measured in basis points deviation from the steady-state. International bond and the trade balance are measured in level deviation from the steady-state. All other variables are measured in percentage deviation from the steady-state. Horizontal axes measure time in years.
Figure 1.5: Responses to a One Standard Deviation Increase in Domestic Government Spending Shock: Cross-Country Spillovers

Notes: Baseline (solid line) vs. debt stabilization through lump-sum transfers only ($\gamma_G = \gamma_{r^k} = \gamma_{r^l} = \gamma_{r^c} = 0$, dashed line). Interest rate is measured in basis points deviation from the steady-state. International bond and the trade balance are measured in level deviation from the steady-state. All other variables are measured in percentage deviation from the steady-state. Horizontal axes measure time in years.
Figure 1.6: Responses to a One Standard Deviation Increase in Domestic Transfers Shock: Key Domestic Variables

Notes: Baseline (solid line) vs. debt stabilization through lump-sum transfers only (γ_G = γ_{y^k} = γ_{y^l} = γ_{y^c} = 0, dashed line). Interest rate is measured in basis points deviation from the steady-state. International bond and the trade balance are measured in level deviation from the steady-state. All other variables are measured in percentage deviation from the steady-state. Horizontal axes measure time in years.
Figure 1.7: Responses to a One Standard Deviation Increase in Domestic Transfers Shock: Cross-Country Spillovers

Notes: Baseline (solid line) vs. debt stabilization through lump-sum transfers only ($\gamma_G = \gamma_{\tau k} = \gamma_{\tau l} = \gamma_{\tau c} = 0$, dashed line). Interest rate is measured in basis points deviation from the steady-state. International bond and the trade balance are measured in level deviation from the steady-state. All other variables are measured in percentage deviation from the steady-state. Horizontal axes measure time in years.
Figure 1.8: Responses to a One Standard Deviation Decrease in Domestic Capital Tax Rate Shock: Key Domestic Variables

Notes: Baseline (solid line) vs. debt stabilization through lump-sum transfers only ($\gamma_G = \gamma_{\tau k} = \gamma_{\tau l} = \gamma_{\tau c} = 0$, dashed line). Interest rate is measured in basis points deviation from the steady-state. International bond and the trade balance are measured in level deviation from the steady-state. All other variables are measured in percentage deviation from the steady-state. Horizontal axes measure time in years.
Figure 1.9: Responses to a One Standard Deviation Decrease in Domestic Capital Tax Rate Shock: Cross-Country Spillovers

Notes: Baseline (solid line) vs. debt stabilization through lump-sum transfers only \((\gamma_G = \gamma_{r^k} = \gamma_{r^l} = \gamma_{r^c} = 0, \text{ dashed line})\). Interest rate is measured in basis points deviation from the steady-state. International bond and the trade balance are measured in level deviation from the steady-state. All other variables are measured in percentage deviation from the steady-state. Horizontal axes measure time in years.
Figure 1.10: Responses to a One Standard Deviation Decrease in Domestic Labor Tax Rate Shock: Key Domestic Variables

Notes: Baseline (solid line) vs. debt stabilization through lump-sum transfers only ($\gamma_G = \gamma_{\tau k} = \gamma_{\tau l} = \gamma_{\tau c} = 0$, dashed line). Interest rate is measured in basis points deviation from the steady-state. International bond and the trade balance are measured in level deviation from the steady-state. All other variables are measured in percentage deviation from the steady-state. Horizontal axes measure time in years.
Figure 1.11: Responses to a One Standard Deviation Decrease in Domestic Labor Tax Rate Shock: Cross-Country Spillovers

Notes: Baseline (solid line) vs. debt stabilization through lump-sum transfers only ($\gamma_G = \gamma_{\tau} = \gamma_{\tau}^l = \gamma_{\tau}^c = 0$, dashed line). Interest rate is measured in basis points deviation from the steady-state. International bond and the trade balance are measured in level deviation from the steady-state. All other variables are measured in percentage deviation from the steady-state. Horizontal axes measure time in years.
Figure 1.12: Responses to a One Standard Deviation Decrease in Domestic Consumption Tax Rate Shock: Key Domestic Variables

Notes: Baseline (solid line) vs. debt stabilization through lump-sum transfers only ($\gamma_G = \gamma_{\tau_k} = \gamma_{\tau_l} = \gamma_{\tau_c} = 0$, dashed line). Interest rate is measured in basis points deviation from the steady-state. International bond and the trade balance are measured in level deviation from the steady-state. All other variables are measured in percentage deviation from the steady-state. Horizontal axes measure time in years.
Figure 1.13: Responses to a One Standard Deviation Decrease in Domestic Consumption Tax Rate Shock: Cross-Country Spillovers

Notes: Baseline (solid line) vs. debt stabilization through lump-sum transfers only ($\gamma_G = \gamma_{\tau^k} = \gamma_{\tau^l} = \gamma_{\tau^c} = 0$, dashed line). Interest rate is measured in basis points deviation from the steady-state. International bond and the trade balance are measured in level deviation from the steady-state. All other variables are measured in percentage deviation from the steady-state. Horizontal axes measure time in years.
Figure 1.14: Stochastic Components of US GDP

Figure 1.15: Stochastic Components of US Investment
Figure 1.18: Stochastic Components of EU GDP

Figure 1.19: Stochastic Components of EU Trade Balance
Addendum A. Domestic Output Effect from a Spending Increase and Domestic Debt-to-GDP Ratio

Figure 1.20: Domestic Effect and Domestic Debt

Source: Author’s calculations using data for spillovers from Auerbach and Gorodnichenko (2013) and data for debt from OECD.Stat
Table 1.9: Regression of Domestic Effect on Debt and Control Variables

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<th>Japan and Italy excluded</th>
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<td>-0.0017</td>
<td>-0.0040**</td>
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<td>(0.002)</td>
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Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.10

Addendum B. Optimality Conditions

Euler equation for bonds

\[
\frac{C_{it}^{-\gamma}}{(1 + \tau_{it}^c)P_{it}} = (1 + \psi C_{it})^{-1} E_t \frac{C_{i,t+1}^{-\gamma} R_t}{(1 + \tau_{it+1}^c)P_{i,t+1}}
\]

Euler equation for capital

\[
\frac{1}{1 - \xi \left( \frac{I_{it}}{K_{i,t-1} - \delta} \right)} = (1 + \psi C_{it})^{-1} E_t \frac{C_{i,t+1}^{-\gamma}(1 + \tau_{it}^c)}{C_{it}^{-\gamma}(1 + \tau_{i,t+1}^c)} \times \ldots
\]

\[
\left\{ (1 - \tau_{i,t+1}^k) \frac{q_{i,t+1} \alpha Y_{i,t+1}}{P_{i,t+1} K_{it}} + \frac{1}{1 - \xi \left( \frac{I_{i,t+1}}{K_{it} - \delta} \right)} \left[ 1 - \delta + \frac{\xi}{2} \left( \frac{I_{i,t+1}}{K_{it}} \right)^2 - \frac{\xi \delta^2}{2} \right] \right\}
\]

FOC for labor

\[
\theta L_{it}^{1+\kappa} (1 + \tau_{it}^c) P_{it} = C_{it}^{-\gamma}(1 - \tau_{it}^l) q_{it}(1 - \alpha) Y_{it}
\]

49
Addendum C. Data Sources and Construction

C.1. General Description

The four EU time series (GDP, general government final consumption expenditure, exports of goods and services, and imports of goods and services) are from OECD.Stat’ Quarterly National Accounts (CPCARSA: Millions of US dollars, current prices, current PPPs, annual levels, seasonally adjusted).

US hours worked are defined as $\frac{H \times Emp}{100}$ where $H$ is nonfarm business sector average weekly hours (PRS85006023) and $Emp$ is Civilian Employment (CE16OV), both from the Bureau of Labor Statistics. The construction of ten US time series (GDP, consumption, investment, exports, imports, capital, labor and consumption tax rates, government consumption, and transfers) uses data from the Bureau of Economic Analysis’ NIPA. The government debt series uses additional data from the Federal Reserve Bank of St. Louis and the Federal Reserve Bank of Dallas. The source and methodology of processing these data are the same as in Leeper et al. (2010b). Fiscal variables include federal and state and local governments.

Nominal data are converted to real values using the price deflater for private final consumption expenditure from OECD.Stat (DOBSA: Deflator, OECD reference year, seasonally adjusted). The logarithm of each variable is detrended with a quadratic trend.

C.2. Construction of US Tax Rates and Government Debt

The average consumption tax rate is calculated as $\tau^c = \frac{T^c}{C-T^c}$ where $T^c$ is taxes on production and imports less property taxes. Jones’s (2002) definition of average personal income tax rate is $\tau^p = \frac{IT}{W+PRT/2+CI}$ where $IT$ is personal current tax revenues, $W$ is wage and salary accruals, $PRT$ is proprietors’ income and $CI$ is capital income. Capital income
is computed as the sum of rental income, corporate profits, interest income, and $PRI/2$. Then the average labor income tax rate is calculated as 

$$\tau^l = \frac{\tau_p (W + PRI/2) + CSI}{EC + PRI/2} \quad \text{where } CSI \text{ is contributions for government social insurance and } EC \text{ is compensation of employees.}$$

The average capital income tax rate is computed as 

$$\tau^k = \frac{\tau_p CI + CT + PT}{CT + PT} \quad \text{where } CT \text{ is taxes on corporate income and } PT \text{ is property taxes.}$$

Government debt at $t$ is defined as the sum of net borrowing at $t$ and government debt at $t - 1$ less seigniorage. Net borrowing is the sum of government consumption, interest payment and transfers less total tax revenues. Seigniorage is $M_t - M_{t-1}$ where $M$ is St. Louis Fed's adjusted monetary base.
C.3. Comparison of Debt-to-GDP Ratios

The following figure compares the debt-to-GDP ratio constructed following Leeper et al. (2010b) and the central government debt-to GDP ratio from OECD.Stat.

Figure 1.21: Comparison of Debt-to-GDP Ratios
Addendum D. Prior and Posterior Distributions

Figure 1.22: Prior and Posterior Distributions

Notes: Prior (dashed line) vs. posterior (solid line) distributions.
Addendum E. VAR Evidence

The VAR exercise includes 11 variables Cholesky-ordered as follows: US fiscal variable, US real GDP, US real consumption, US real investment, US hours worked, EU real GDP, EU real consumption, EU real investment, US real exports, US real imports and US real government debt, where the US fiscal variable belongs to one of the five fiscal instruments. The data sources and the time span are the same as those used in the Bayesian estimation. The lag length is 4. Changing the order of the variables or the lag length does not affect the fluctuating feature of the macroeconomic variables.
Figure 1.23: Responses to a One Standard Deviation Shock to US Government Spending

Addendum F. Speed of Fiscal Consolidation and Average Government Debt Ratio

55
Figure 1.24: Responses to a One Standard Deviation Shock to US Transfers
Figure 1.25: Responses to a One Standard Deviation Shock to US Capital Tax Rate
Figure 1.26: Responses to a One Standard Deviation Shock to US Labor Tax Rate
Figure 1.27: Responses to a One Standard Deviation Shock to US Consumption Tax Rate
Figure 1.28: Speed of Fiscal Consolidation and Average Government Debt Ratio
Chapter 2: Government Spending Shocks and Default Risk in Emerging Markets

2.1 Introduction

The J.P. Morgan Emerging Markets Bond Index Global (“EMBI Global”) spread has been used to evaluate the sovereign default risk of a developing country.\textsuperscript{20} A higher EMBI Global spread is associated with a higher sovereign default risk. Empirical evidence shows that a spike in the EMBI Global spread is usually preceded by a steady increase of a country’s external debt. Figure 1 describes the historical movements of the EMBI Global spread and the external debt in Argentina, Ecuador, South Africa and El Salvador between 1993Q3 and 2012Q4. In all four countries, the spikes of the EMBI Global spread followed an accumulation of the external debt to a considerably high level. The difference is that in Argentina and Ecuador where there was an external default or restructuring\textsuperscript{21}, the external debt was cut down, whereas in South Africa and El Salvador where was no external default or restructuring, the external debt did not decrease. A natural question to ask is what factors

\textsuperscript{20}EMBI Global tracks total returns for U.S. dollar-denominated Brady bonds, Eurobonds, and traded loans issued by emerging market sovereign and quasi-sovereign entities. Spread over Treasury is calculated as the difference between the yield to maturity of each bond (i.e. the internal rate of return of the bond instrument) and the yield to maturity of the corresponding point on the U.S. Treasury spot curve. For more details see Bunda et al. (2009) and Jaramillo and Tejada (2011).

\textsuperscript{21}In Argentina, 2001-2005 is the external default/restructuring episode. In Ecuador, both 1999-2000 and 2008 are external default/restructuring episodes. See the Appendix for a complete list of external default/restructuring episodes.
contribute to the huge accumulation of external debt and hence a spike of the spread. Elevated government spending is one of the factors that could accelerate the build-up of a nation’s sovereign debt, especially if the spending is debt financed. The existing literature has studied the dynamics between sovereign debt and default risk (see for example Aguiar and Gopinath (2006) and Arellano (2008)). However, whether a government spending expansion will influence a nation’s default risk is not well understood. This paper fills the gap by investigating the effects of government spending shocks in an environment where a country cannot commit to repay its debt.

This paper links two distinct strands of research. The first is empirical work on the effects of fiscal shocks. There are two main strategies of identifying government spending shocks: structural vector autoregression (SVAR) analysis as in Blanchard and Perotti (2002) and the narrative approach developed by Ramey and Shapiro (1998). Blanchard and Perotti (2002) identify fiscal shocks by assuming that government spending is predetermined within one quarter so that it does not respond to other structural shocks contemporaneously. Ramey and Shapiro (1998) add a military build-up dummy variable in the autoregressive model to isolate an exogenous component of government spending. The two methods usually produce different responses to government spending shocks. Specifically, the first approach finds that consumption and real wages rise after a positive government spending shock, consistent with the predictions of Keynesian models. In contrast, the second approach generates a fall in the two variables which is often consistent with neoclassical models. In this paper, I use a panel VAR to identify government spending shocks. The reason for using a panel VAR is twofold: first, the narrative approach cannot be applied to the panel of developing countries studied in this paper, since it requires that wars be extraterritorial, which is not the case for most of the developing countries; second, the inception of the EMBI Global spread data varies
from 1993Q4 to 2009Q4 in different countries, making individual VAR analysis impractical in many countries.

The VAR approach has been criticized for ignoring the “anticipation effect”: the VAR-identified fiscal shocks may have been expected by the private sector, who will take action even before the spending is realized. Ilzetzki et al. (2013) show in their online appendix that this is not the case in developing countries. They argue that agents in developing countries could not have a good estimate of fiscal shocks because fiscal shocks are sufficiently
volatile in developing countries. The authors compare the central bank’s estimation errors of government consumption with the VAR residuals in four developing countries. Central bank errors are computed as the difference between final statistics on government consumption and the central bank’s estimate in the quarter following the time of the government expenditure. The authors find a strong correlation between central bank errors and VAR residuals.

There have also been disputes related to the responses of exchange rate and trade balance under the VAR strategy. Using Cholesky decomposition, Kim and Roubini (2008) conclude that the exchange rate depreciates and that the trade balance improves after a fiscal shock. With a different identification scheme, Monacelli and Perotti (2010) find that the trade balance deteriorates, although the exchange rate still depreciates. Ilzetzki et al. (2013) examine the effects of fiscal stimulus for different groups of countries and episodes, and suggest that different country characteristics, such as exchange rate regime and openness to trade, lead to quite different responses of macroeconomic variables. However, none of the empirical analysis takes into consideration the risk of sovereign default, which is an innovative and important feature of this paper. Since a higher level of government spending motivates the sovereign state to borrow more from abroad, it tends to induce a higher level of sovereign debt, which in turn may affect the country’s default decisions. Therefore, it is important to study the effects of government spending shocks in an environment where sovereign states can default.

The second line of literature related to this paper is applied theory on sovereign default with technology shocks. The quantitative model of this paper is based on Aguiar and Gopinath (2006) and Arellano (2008). Distinct mechanisms in these two papers are employed in order to match default frequency and business cycle moments observed in the data: the asymmetric output penalty in case of default is crucial in Arellano (2008), whereas trend
shocks to output are the key to explaining the default frequency in Aguiar and Gopinath (2006). This paper extends these models to include government spending shocks and focuses on the effects of spending shocks on sovereign default risk.

Section 2 examines the time-series evidence of government spending effects. Section 3 builds a general equilibrium small open economy model to investigate the mechanism through which government spending shocks affect sovereign default risk. Section 4 concludes.

2.2 Empirical Analysis

2.2.1 Data

This paper uses quarterly-frequency data for 18 developing countries: Argentina, Brazil, Bulgaria, Chile, Colombia, Croatia, Ecuador, El Salvador, Hungary, Lithuania, Malaysia, Mexico, Peru, Poland, South Africa, Thailand, Turkey, and Uruguay. It is a subset of the 44 countries in Ilzetzki et al. (2013). The choice of countries is based on the availability of J.P. Morgan’s EMBI Global spread data and individual country’s quarterly government spending data. Except for Lithuania and Malaysia, all other countries have experienced sovereign debt default or restructuring as documented in Table 1 in the Appendix. On average, a typical emerging economy defaulted 5 times during the last 211 years, indicating an annual default frequency of 0.02396, or 0.00599 in quarterly terms.

Quarterly external debt data are taken from the Joint External Debt Hub. Series “liabilities to BIS banks, locational, total” is used as external debt in the regression because it is the longest data series available, dating back to 1993Q3. This paper’s results are robust to choosing other external debt series covering a shorter time span. All the other variables

22Those series include “liabilities to BIS banks, consolidated, total”, “cross-border loans from BIS reporting banks”, “international debt securities, all maturities”, and “multilateral loans, total”.
(GDP, government consumption, private consumption, the current account, and the real effective exchange rate) come from the same data source as in Ilzetzki et al. (2013).

### 2.2.2 Estimation Methodology

The following system is estimated by Panel OLS regression with fixed effects:

\[
AY_{n,t} = \sum_{k=1}^{K} C_k Y_{n,t-k} + Bu_{n,t},
\]

where \( n, t, \) and \( k \) represent a country index, a time index and lag length, respectively.

\( Y_{n,t} = (gc_{n,t}, gdp_{n,t}, prcon_{n,t}, debt_{n,t}, CA_{n,t}, spread_{n,t}, REER_{n,t}) \), where \( gc_{n,t} \) is real government consumption, \( gdp_{n,t} \) real GDP, \( prcon_{n,t} \) real private consumption, \( debt_{n,t} \) external debt, \( CA_{n,t} \) the ratio of the current account balance to GDP, \( spread_{n,t} \) the EMBI Global spread, and \( REER_{n,t} \) the real effective exchange rate. Government and private consumption, GDP, external debt and REER are in natural logarithms. Variables that show seasonal patterns are deseasonalized using the SEATS algorithm. The non-stationary government and private consumption, GDP, and debt data are included in the regression as deviations from their quadratic trend. The current account ratio is included in levels and the spread is in basis points. REER is included in first differences. \( u_{n,t} \) is a vector of orthogonal, i.i.d. structural shocks with \( Eu_{n,t} = 0 \) and \( Eu_{n,t}u_{n,t}' = I \). The coefficient matrices \( A, B \) and \( C_k \) are assumed to be invariant across time and countries.

Additional restrictions must be imposed to estimate the coefficients. Government spending is ordered first. This is based on the assumption that it takes more than a quarter for fiscal authorities to respond to shocks to other macroeconomic variables. I use Cholesky
decomposition for the other restrictions required to estimate the matrices. Since only govern-
ment spending shocks are of interest in this paper, the ordering of the remaining variables is irrelevant.

The baseline regression includes data for all the 18 developing countries from 1993Q1 to 2012Q4. The dataset is then divided into fixed exchange rate periods versus flexible exchange rate periods, as well as Latin American countries versus European countries.\textsuperscript{23} A lag length of four is chosen for all regressions so that the difference between regressions should not result from a different lag length. The results are robust to choosing lag length according to lag order selection criteria: Akaike Information Criterion, Schwarz Criterion, Hannan-Quinn Criterion, Likelihood Ratio Test and Wald Test. Actually this paper’s results are robust to choosing any alternative lag length from 1 to 8.

\subsection*{2.2.3 All Sample Countries}

Figure 2 shows the responses of all the seven variables to a 10\% government spending shock at quarter 0.\textsuperscript{24} One period refers to one quarter. Shaded areas represent 68\% confidence intervals. GDP increases by 1.33\% on impact and remains positive till quarter 8. However, the responses of GDP are negative in the long run, implying that the increase in government spending is more-than-fully crowded out by the decrease in other components.

\textsuperscript{23}The sample size of panel data for Asian countries is relatively small and the confidence bands are quite wide. This paper does not divide the dataset into sub-groups according to openness to trade as in Ilzetzki et al. (2013). By the definitions in Ilzetzki et al. (2013), closed (large) economies are basically Latin American countries in the sample, and open (small) economies are the rest of the sample countries. Ilzetzki et al. (2013) also break up their sample into high versus low debt countries. This paper directly includes external debt as a variable of interest in the regression.

\textsuperscript{24}The responses of private consumption are not shown because the patterns are very similar to those of GDP.
Figure 2.2: Impulse Responses to a 10% Shock to Government Consumption.
of GDP. As shown in Figure 1, the responses of private consumption are negative starting from quarter 11.

The real effective exchange rate (REER) appreciates on impact. In the short run, an increase in government spending raises the demand for domestic goods, leading to the appreciation of domestic goods. Starting from quarter 7, the responses of REER remain significantly below zero. Thus the long-run effect of government spending shocks is a depreciation of domestic goods. Correspondingly, the current account balance to GDP ratio first falls but then turns positive at quarter 12. The reversal in the current account and the REER could be attributed to the deterioration of the domestic country’s debt position. Foreign agents may become reluctant to lend to the domestic country because of a higher default risk. In extreme cases, there might even be sudden stops, i.e. a sudden slowdown in capital inflows into the domestic country.

External debt increases by 1.19% on impact. On average, external debt increases by 3.45% in the year following the government spending shock. At quarter 20, the response of external debt turns negative. There are two possible reasons for this change of sign in external debt. First, governments may have engaged in fiscal consolidation efforts as reflected by the negative responses of government consumption since quarter 13. Second, governments may intend to reduce their borrowing because of higher cost, as shown by a higher spread.

With a delay, the EMBI Global spread rises significantly and remains positive throughout the simulation. Within two years following the shock, the spread increases by an average of 25 basis points. The response peaks at 132 basis points 14 quarters after the spending shock. Overall, the expansionary spending of a sovereign is accompanied by an increased level of sovereign spread hence default risk.
2.2.4 Fixed and Flexible Exchange Rate Regimes

In this section each of the 18 developing countries is divided into episodes of fixed exchange rate regime and episodes of flexible exchange rate regime. Not surprisingly, for the fixed exchange rate sub-group, the impact response of REER is insignificant. In contrast, there is significant appreciation of REER on impact for the flexible exchange rate counterpart. The responses of current account balance to GDP ratio are also quite different for these two groups: no significant changes in the fixed exchange rate regime versus significant worsening of this ratio in the flexible regime. Moreover, the impact response of GDP in the flexible exchange rate regime group is larger (1.76%) than that in the fixed regime group (1.14%).

It is interesting to notice that the magnitude of spread increase in the fixed exchange rate regime is larger than that in the flexible regime. This suggests that when an expansionary government spending shock hits the economy, the increase of default risk in countries with flexible exchange rate regimes tends to be smaller compared to those with fixed exchange rate. Hence the latter countries face larger increase in the interest rate at which they borrow in the international credit market.

2.2.5 Latin American and European Countries

25 The de facto classification of Ilzetzki et al. (2010) is used to determine the exchange rate regime of each country in each quarter. Fixed exchange rate regime in a given country includes the episodes with no legal tender, hard pegs, crawling pegs, and de facto or pre-announced bands or crawling bands with margins no larger than ±2%. All other episodes in this country are classified as flexible. See the Appendix for a detailed list of episodes of de facto fixed and flexible exchange rates in each country.

26 The confidence bands contain zero in most of the simulation periods.
Figure 2.3: Impulse Responses to a 10% Shock to Government Consumption in Episodes of Fixed Exchange Rates and Flexible Exchange Rates.
Figure 2.4: Impulse Responses to a 10% Shock to Government Consumption in Latin American Countries and European Countries.
Figure 4 compares the impulse responses to a 10% shock to government spending in Latin American countries and European countries in the sample. In Latin American countries, government spending shocks are more persistent. With a delay, the EMBI Global spread shows significant increase in both groups. However, the increase is much larger for Latin American countries (peaking at 248 basis points) than for European countries (peaking at 90 basis points), implying that default risk rises by a much larger margin in Latin American countries after a fiscal expansion.

In Latin American countries, government spending expansion leads to exchange rate appreciation throughout the simulation. The response of the ratio of the current account to GDP is negative in the long run, implying that current account balance worsens in the long run. In European countries, there is a significant depreciation of REER in the long run and current account improves in the long run. The stimulative effect on GDP is larger in European countries than in Latin American countries: GDP increases by 2.20% on impact in the former and by 1.41% in the latter.

2.3 Economic Model

This section builds a dynamic stochastic general equilibrium small open economy model with government spending shocks. The sovereign debt and default model is based on the seminal framework of Eaton and Gersovitz (1981) and quantitative models of sovereign default developed later by other researchers such as Aguiar and Gopinath (2006) and Arellano (2008). The sovereign government borrows using one-period, non-contingent discount bonds in the international credit market. Since the government cannot commit to repay its debt, it has to pay an interest rate that is higher than the risk-free rate in order to borrow from
foreign lenders. The difference between the interest rate the sovereign pays and the risk-free rate is defined as the sovereign spread.

While previous work on sovereign default solely examines productivity shocks, this paper focuses on the role of government spending shocks in affecting default risk and sovereign spread. As the empirical evidence shows in Section 2, a positive government spending shock has non-neglectable influence on sovereign spread. Therefore, it is very important to include government spending shocks in a sovereign default model and to investigate the mechanism through which spending shocks affect default risk.

2.3.1 The Model Economy

The economy is inhabited by an infinitely-lived, risk averse representative household who values consumption and leisure. The government maximizes the household’s utility and borrows on behalf of it in the international credit market. The government can choose to default depending on the debt level of the sovereign \(d\), productivity \(z\) and government spending \(g\). Let \(V_{\text{pay}}(d, z, g)\) the value of repaying its debt, and \(V_{\text{def}}(z, g)\) the value of default. In each period, given the initial debt level and observing the productivity shock and the spending shock, the government chooses the larger value between repaying its debt and default:

\[
V(d, z, g) = \max\{V_{\text{pay}}(d, z, g), V_{\text{def}}(z, g)\}. \tag{2.3.1}
\]

If the government repays its debt, it has access to the international credit market and can borrow at an endogenous bond price of \(q(d', z, g)\):

\[
V_{\text{pay}}(d, z, g) = \max_{c, t, d'}\{u(c, l) + \beta E[V(d', z', g')|z, g]\}
\quad \text{s.t.} \quad c + g + d = e^{z}f(k, l) + q(d', z, g)d', \tag{2.3.2}
\]

74
where \( u(\cdot) \) is the representative household’s utility function. \( c \) and \( l \) are consumption and labor respectively. \( f(\cdot) \) is the production function of the economy where capital \( k \) is kept a constant for computational ease.

If the government defaults, it faces a twofold punishment: temporary exclusion from the international credit market and additional output cost.\(^{27} \)\(^{28} \) With probability \( \theta \), the country is able to reenter the market next period. When the country reenters, its debt is cleared and is equal to 0. Hence, the value of default can be written as:

\[
V_{def}(z, g) = \max_{c, l} \left\{ u(c, l) + \theta \beta E[V(0, z', g')|z, g] + (1 - \theta) \beta E[V_{def}(z', g')|z, g] \right\}, \quad (2.3.3)
\]

where \( \gamma \) is the proportional output cost.

Foreign lenders are assumed to be risk neutral; they are willing to lend to the sovereign as long as they receive an expected return of the international risk-free rate, \( r^* \). Define the default function

\[
D(d', z, g) = \begin{cases} 
1 & \text{if } V_{def}(z, g) > V_{pay}(d', z, g) \\
0 & \text{otherwise}
\end{cases}
\]

Then the risk neutrality of foreign lenders implies that

\[
q(d', z, g) = \frac{E[1 - D(d', z, g)]}{1 + r^*}. \quad (2.3.4)
\]

\(^{27}\)Bulow and Rogoff (1989) pointed out that if the cost of default is merely no access to international capital markets and if a country can save at the international market interest rate, default happens with probability one and no country should be able to borrow anything. This is the well-known Bulow-Rogoff paradox. Bulow and Rogoff (1989) thus proposed the idea of additional punishments as a rationale behind why countries repay.

\(^{28}\)There are two main methods of modeling output cost in the literature. In the endowment economy of Arellano (2008), if the realized output is larger than an exogenously specified amount, this amount is smaller than the expected value of output, the available quantity of output is reduced to this specified value. Otherwise, output is unchanged. The other method is a proportional output cost regardless of the level of output realized or produced. This paper takes a simple stance and employs a proportional output cost as in Aguiar and Gopinath (2006).
Finally, the country’s gross interest rate is the inverse of the discount bond price: $\frac{1}{q} = 1 + r^c$, and the sovereign spread is defined as the difference between the country interest rate and the risk-free rate, $r^c - r^*$.  

### 2.3.2 Equilibrium 

Definition: The recursive equilibrium for this economy is defined as a set of functions for decision rules $c(d, z, g)$, $l(d, z, g)$, $d'(d, z, g)$, $D(d', z, g)$; values $V(d, z, g)$, $V_{pay}(d, z, g)$, $V_{def}(z, g)$ and bond price $q(d', z, g)$ such that 

1. Taking as given the bond price function $q(d', z, g)$, $c(d, z, g)$, $l(d, z, g)$, $d'(d, z, g)$, $D(d', z, g)$, $V(d, z, g)$, $V_{pay}(d, z, g)$, and $V_{def}(z, g)$ solve the sovereign’s optimization problem (1). 

2. Bonds prices $q(d'(d, z, g), z, g)$ satisfy foreign lenders’ risk neutrality condition (4). 

### 2.3.3 Calibration and Functional Forms 

The model is calibrated to Argentina’s quarterly data over 1993Q1-2012Q4. The risk-free interest rate is set to be equal to the return on U.S. Treasury bonds for a maturity comparable with that of the bonds included in the EMBI Global. Following Bunda et al. (2009), 10-year U.S. Treasury Bond quarterly yield (1.66%) is used as the benchmark risk-free rate. The production function is Cobb–Douglas: 

$$ f(k, l_t) = k^\alpha l_t^{1-\alpha} $$

with a capital share $\alpha$ of 0.36. The constant capital is set to 0.975 so that the quarterly steady state capital-output ratio is $2^{29}$.

---

29This is the converging capital-output ratio for Argentina in Kydland and Zarazaga (2002).
The household’s period utility function takes the GHH form:

$$u(c_t, l_t) = \left( c_t - \kappa \frac{\omega}{l_t} \right)^{1-\sigma} \frac{1}{1-\sigma}$$

where the coefficient of relative risk aversion, $\sigma$, is set to 2. The curvature parameter of labor supply, $\omega$, is set to 1.455 so that Frisch wage elasticity is equal to 2.2. $\kappa$ is the relative importance parameter of leisure and is calibrated to target a steady state labor supply of 0.33.

A small subjective time discount factor is needed for default to occur in equilibrium. In the literature, $\beta$ ranges from 0.72 to 0.95. Here I set $\beta$ equal to 0.8 as in Aguiar and Gopinath (2006). The probability of reentry $\theta = 10\%$ (implying an average stay in autarky of 2.5 years) and the loss of output in autarky $\gamma = 2\%$ are also taken from Aguiar and Gopinath (2006).

Both the productivity shock and the government spending shock are assumed to follow an AR (1) process:

$$z_t = \mu_z (1 - \rho_z) + \rho_z z_{t-1} + \varepsilon^z_t, \quad \varepsilon^z_t \sim N(0, \sigma^2_z)$$

$$\log(g_t) = \mu_g (1 - \rho_g) + \rho_g \log(g_{t-1}) + \varepsilon^g_t, \quad \varepsilon^g_t \sim N(0, \sigma^2_g)$$

where $\mu_z$ is set to 0; $\rho_z$ and $\sigma^2_z$ are set to match the autocorrelation and standard deviation of Argentine GDP. $\rho_g$ and $\sigma^2_g$ are obtained directly from the AR(1) regression of the (detrended) log of government spending. Finally, $\mu_g$ is calculated to be -2.737 so that the steady state ratio of government spending to output is equal to 13.3%, which is the

$^{30}$GHH preferences are commonly used in small open economy models in order to match the countercyclicality of net exports observed in the data. See Neumeyer and Perri (2005).

77
average ratio of government spending to output over the sample period. Table 1 provides a summary of the parameter values used in the computation.

Table 2.1: Parameter Values

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk-free interest rate</td>
<td>$r^*$</td>
<td>1.66% US 10-Year quarterly yield</td>
</tr>
<tr>
<td>Capital share in output</td>
<td>$\alpha$</td>
<td>0.36 Standard</td>
</tr>
<tr>
<td>Coefficient of relative risk aversion</td>
<td>$\sigma$</td>
<td>2 Standard</td>
</tr>
<tr>
<td>Curvature parameter of labor supply</td>
<td>$\omega$</td>
<td>1.455 Frisch wage elasticity (2.2)</td>
</tr>
<tr>
<td>Relative importance parameter of leisure</td>
<td>$\kappa$</td>
<td>1.565 $l = 0.33$</td>
</tr>
<tr>
<td>Subjective time discount factor</td>
<td>$\beta$</td>
<td>0.8 literature: 0.72-0.95</td>
</tr>
<tr>
<td>Reentry Probability</td>
<td>$\theta$</td>
<td>0.1 2.5-year exclusion</td>
</tr>
<tr>
<td>Output cost if default</td>
<td>$\gamma$</td>
<td>0.02 Standard</td>
</tr>
<tr>
<td>Serial correlation of $g$</td>
<td>$\rho_g$</td>
<td>0.916 Regression estimate</td>
</tr>
<tr>
<td>Variance of innovation to $g$ process</td>
<td>$\sigma_g^2$</td>
<td>0.018^2 Regression estimate</td>
</tr>
<tr>
<td>Serial correlation of $z$</td>
<td>$\rho_z$</td>
<td>0.960 GDP autocorrelation</td>
</tr>
<tr>
<td>Variance of innovation to $z$ process</td>
<td>$\sigma_z^2$</td>
<td>0.005^2 GDP std. deviation</td>
</tr>
</tbody>
</table>

2.3.4 Results

This section presents the impulse responses of the model economy following a positive government spending shock.

Figure 5 shows the impulse responses when I feed the path of government spending from the panel VAR into the model. Productivity is kept constant. External debt increases by 0.57\% on impact at quarter 0 and stays positive for 5 periods after the shock before reverting
back to its steady state. The ratio of current account to GDP falls on impact and then turns positive, which behaves similar to what is observed in the data.

The impact response of the spread is 9 basis points. The increase in sovereign spread can be explained by the increase in external debt, since a higher level of external debt raises the probability of default. However, the responses are much smaller than those in the data. This difference is due to the one-to-one mapping between the default probability and the sovereign spread. Recall that the sovereign spread is the difference between the country’s interest rate and the risk-free rate, \( \frac{1+r^*}{1-E[D(d', z, g)]} -(1 + r^*) \). A spread of 132 basis points, together with a risk-free rate of 1.66%, implies that \( E[D(d', z, g)] = 0.0128 \), which is 1.5 times the default frequency of Argentina (0.008294). Therefore, even if I calibrate \( \beta \) to match the default frequency, the model response of the sovereign spread would still be much lower compared to the response of the J.P. Morgan Global spread.\(^{31}\)

### 2.4 Conclusion

VAR evidence from a panel of 18 emerging countries shows that sovereign spread increases in response to a positive government spending shock, implying that sovereign default risk rises after the increased level of government spending. The J.P. Morgan Global spread rises by an average of 25 basis points within two years following a 10% spending shock and the peak value is as high as 132 basis points. In the meantime, there is a significant increase (3.45% on average) in external debt in the year following the shock. The short-run and long-run responses are different for the other four macroeconomic variables under consideration. In the short run, the responses of GDP and private consumption are positive; real

\(^{31}\)The puzzle that a low default probability coexists with a high level of spread in bonds is well known in the finance literature on corporate defaultable bonds. Arellano (2008) uses risk averse pricing kernel to achieve a higher level of spread in her model.
effective exchange rate appreciates and the current account deteriorates. In the long-run, those responses change sign.

The sovereign default model with government spending shock is able to match the behavior of the current account to GDP ratio and the external debt quantitatively. The model can also capture the increase in spread. However, the positive responses of sovereign spread are not large enough to match those in the data. Solving the puzzle of huge increase in the spread is left for future work.
Addendum

Computation

The model is solved using the discrete state-space method. The space for debt is discretized into 300 grid points with a lower bound of 0. The upper bound is set to be 0.1 and never binds along the equilibrium paths. For both shocks, the AR(1) process is approximated by a Markov Chain using the Tauchen algorithm. 9 grids are used for the government spending shock and 69 grids for the productivity shock.\textsuperscript{32}

The solution algorithm consists of an inner loop and an outer loop:

- Inner loop: value function iteration. Given the price function $q^0$ in the outer loop, solve for the optimal policies in equations (2) and (3) using initial values $V^0_{\text{pay}}, V^0_{\text{def}},$ and $V^0 = \max \left\{ V^0_{\text{pay}}, V^0_{\text{def}} \right\}$. Then obtain new values $V^1_{\text{pay}}, V^1_{\text{def}},$ and $V^1 = \max \left\{ V^1_{\text{pay}}, V^1_{\text{def}} \right\}$. Update $V^0_{\text{pay}}, V^0_{\text{def}},$ and $V^0$ by $V^1_{\text{pay}}, V^1_{\text{def}},$ and $V^1$ until convergence.

- Outer loop: price function iteration. Using the default policy $D^0$ obtained in the inner loop, update the price $q^0$ by $q^1 = \frac{E[1-D^0]}{1+r^*}$ until convergence.

After the model has been solved, find the steady state in which the sovereign borrows the same amount of debt in each period. Then feed the paths of government spending and GDP into the model and obtain the impulse responses.

\textsuperscript{32}A lot more grids for the productivity shock are needed than for the government spending shock. This is because a 10\% shock to government spending is accompanied by only a 1.369\% increase in output. Thus, when I feed the paths of government spending and GDP into the model, much finer grids for GDP are required.
Table 2.2: Episodes of De-Facto Fixed and Flexible Exchange Rates: 1993Q1-2010Q4

<table>
<thead>
<tr>
<th>Country</th>
<th>Fixed</th>
<th>Flexible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>1993Q1-2001Q4; 2007Q2-2010Q4</td>
<td>2002Q1-2007Q1</td>
</tr>
<tr>
<td>Brazil</td>
<td>1994Q3-1999Q1</td>
<td>1993Q1-1994Q2; 1999Q2-2010Q4</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>1997Q1-2010Q4</td>
<td>1993Q1-1996Q4</td>
</tr>
<tr>
<td>Chile</td>
<td>n.a.</td>
<td>1993Q1-2010Q4</td>
</tr>
<tr>
<td>Colombia</td>
<td>n.a.</td>
<td>1993Q1-2010Q4</td>
</tr>
<tr>
<td>Croatia</td>
<td>1994Q4-2010Q4</td>
<td>1993Q4-1994Q3</td>
</tr>
<tr>
<td>Ecuador</td>
<td>1997Q2-1997Q3; 2000Q2-2010Q4</td>
<td>1993Q1-1997Q1; 1997Q4-2000Q1</td>
</tr>
<tr>
<td>El Salvador</td>
<td>1993Q1-2010Q4</td>
<td>n.a.</td>
</tr>
<tr>
<td>Hungary</td>
<td>1994Q3-1999Q1</td>
<td>1993Q1-1994Q2; 1999Q2-2010Q4</td>
</tr>
<tr>
<td>Lithuania</td>
<td>1995Q2-2010Q4</td>
<td>1993Q1-1995Q1</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1993Q1-1997Q3; 1998Q4-2010Q4</td>
<td>1997Q4-1998Q3</td>
</tr>
<tr>
<td>Mexico</td>
<td>1993Q1-1994Q4</td>
<td>1995Q1-2010Q4</td>
</tr>
<tr>
<td>Peru</td>
<td>1994Q1-2010Q4</td>
<td>1993Q1-1993Q4</td>
</tr>
<tr>
<td>Poland</td>
<td>n.a.</td>
<td>1993Q1-2010Q4</td>
</tr>
<tr>
<td>South Africa</td>
<td>n.a.</td>
<td>1993Q1-2010Q4</td>
</tr>
<tr>
<td>Thailand</td>
<td>1993Q1-1997Q2; 1999Q4-2010Q4</td>
<td>1997Q3-1999Q3</td>
</tr>
<tr>
<td>Turkey</td>
<td>n.a.</td>
<td>1993Q1-2010Q4</td>
</tr>
<tr>
<td>Uruguay</td>
<td>1995Q4-2001Q4; 2005Q3-2007Q4</td>
<td>1993Q1-1995Q3; 2002Q1-2005Q2; 2008Q1-2010Q4</td>
</tr>
</tbody>
</table>

Data Sources: Ilzetzki et al. (2010) and Ilzetzki et al. (2013)
Table 2.3: External Default/Restructuring: 1800-2010

<table>
<thead>
<tr>
<th>Country</th>
<th>Episodes</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>1828-1834; 1898-1901; 1902-1910; 1914-1919; 1931-1933; 1937-1943; 1961; 1964; 1983-1990</td>
<td>9</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>1932; 1990</td>
<td>2</td>
</tr>
<tr>
<td>Colombia</td>
<td>1826-1845; 1850-1861; 1873; 1880-1896; 1900-1904; 1932-1934; 1935-1944</td>
<td>7</td>
</tr>
<tr>
<td>Croatia</td>
<td>1993-1996</td>
<td>1</td>
</tr>
<tr>
<td>El Salvador</td>
<td>1828-1860; 1898; 1921-1922; 1932-1935; 1938-1946</td>
<td>5</td>
</tr>
<tr>
<td>Hungary</td>
<td>1932-1937; 1941-1967</td>
<td>2</td>
</tr>
<tr>
<td>Mexico</td>
<td>1828-1830; 1833-1841; 1844-1850; 1854-1864; 1866-1885; 1914-1922; 1928-1942; 1982-1990</td>
<td>8</td>
</tr>
<tr>
<td>Poland</td>
<td>1932-1939; 1940-1952; 1981-1994</td>
<td>3</td>
</tr>
<tr>
<td>South Africa</td>
<td>1985-1987; 1989; 1993</td>
<td>3</td>
</tr>
<tr>
<td>Thailand</td>
<td>1997-1998 &quot;near&quot;</td>
<td>0</td>
</tr>
<tr>
<td>Turkey</td>
<td>1876-1881; 1915-1928; 1931-1932; 1940-1943; 1959; 1965; 1978-1979; 1982; 2000-2001 &quot;near&quot;</td>
<td>8</td>
</tr>
</tbody>
</table>

Data Source: Reinhart and Rogoff (2011)
Chapter 3: Migration Restrictions: Implications on Human Capital, Output, and Welfare

3.1 Introduction

A recent literature on China’s economic growth focused on various sources of economic inefficiency in Chinese economy and potential productivity gains from eliminating such distortions. Hsieh and Klenow (2009) pointed out capital misallocation in China and Song et al. (2011) reported distortions associated with state-owned enterprises. In the spirit of the literature, this paper studies restrictions on rural-to-urban migration in China and their impacts on human capital accumulation in both rural and urban areas, efficiency loss from labor misallocation, and welfare implications.

The restrictions on rural-to-urban migration, so-called Hukou restrictions, have been explored in the previous literature, yet a unified macroeconomic approach has been missing. Our study is a step forward from the previous literature in that we build a general equilibrium model with an explicit migration decision of rural residents and present a quantitative measure of potential gains from relaxing the restrictions on migration. We incorporate the Hukou restrictions into our model by having rural-to-urban migrants pay a fixed cost of migration and face a lower wage than urban counterparts. By reducing migration costs and/or eliminating wage gap between migrants and urban workers, we compute potential gains from labor reallocation and its welfare implications on both rural and urban residents.
We find that the mitigation of the Hukou restrictions promotes rural-to-urban migration significantly. Moreover, such policy changes strengthen the positive selection into migration in terms of education. The increased migration and the added human capital of migrants raise the productivity of urban physical capital, thus capital reallocation from rural to urban area follows. The efficiency gain from the relaxed Hukou restrictions is equivalent to 1.4% if both types of restrictions are reduced by half. The efficiency gain comes at the expense of rural residents. Rural residents suffer from a sizable welfare loss in response to the relaxed restrictions on labor mobility, while migrants gain the most.

This paper is related to two lines of literature. The first consists of studies that find macroeconomic implications of the Hukou system. Dollar and Jones (2013) attempt to explore the Hukou system as a potential explanation for China’s high saving and investment rates. They argue that migrant workers’ wage is less than their marginal products because the Hukou system makes migrant workers’ bargaining power over wages weak by reducing urban job vacancies for them. This lowers labor share and increases firms’ savings in China, ultimately generating its high saving and investment rates. Garriga et al. (2014) study the impact of the Hukou system on China’s housing market. They claim that increasing rural-to-urban migration caused by the mitigation of the Hukou system contributes to the recent housing boom in China by raising demands for urban housing. Our paper is different from these papers in that it focuses on the impact of the Hukou restrictions on human capital accumulation and labor reallocation. We quantify the efficiency gain from the relaxed Hukou restrictions and examine their welfare implications. Whalley and Zhang (2007) also measure efficiency gain from eliminating the Hukou restrictions, although their main goal is to explore the Hukou restrictions as sources of income and wealth inequality in China. Our contribution relative to their work is that we endogenize human capital accumulation.
and migration decision of agents in the presence of two explicit channels through which labor mobility is restricted. We find that the Hukou restrictions have important effects on human capital accumulation of migrants and selection into migration, which amplifies the efficiency gain from labor reallocation. We further explore the welfare implications of weakening restrictions on labor mobility.

Our study also relates to empirical micro studies that focus on the impact of the Hukou system on educational attainment of youth in rural area or migrants’ economic outcomes in China. De Brauw and Giles (2008) find that migrant labor market opportunity has a negative effect on high school enrollment. Zhao (1997) shows that schooling raises the possibility of migration to urban areas and claims that this positive relationship between schooling and migration can explain why the schooling rates are high in rural areas although returns to schooling are low. Démurger et al. (2009) and Liu (2005) find that the Hukou system that denies rural migrants’ access to quality education lowers their educational attainment and this rural migrants’ low education attainment generates earnings differences between urban residents and rural migrants. Our paper is motivated by these studies and explores the impact of various policies which mitigate migration restrictions of the Hukou system on output and welfare through human capital accumulation and labor reallocation.

The remainder of the paper is organized as follows. Section 2 provides a brief overview of the Hukou system in China. We introduce our model in section 3 and present how we calibrate the model in section 4. Section 5 presents the main quantitative results and section 6 concludes the paper.
3.2 The Hukou System

The Hukou system in China records the citizens’ identifying information such as name, residence, and date of birth. When the system was first enacted, it was mainly used for registration purpose and did not interfere with the flow of population. However, as migrants flooded into cities for better opportunities in the late 1950s, the government implemented strict controls over rural-to-urban migration by stratifying its citizens into urban Hukou and rural Hukou in 1958. Citizens with a rural Hukou must hold an entry permit in order to migrate to cities. The Hukou system is a major barrier to rural-urban migration, causing a significant divide between rural and urban areas.

With the launch of the reform and opening-up policies initiated by Deng Xiaoping in 1978, the Hukou policy has been somewhat relaxed. In 1984, citizens with a rural Hukou were legitimately allowed to live in cities, providing cheap labor to urban firms. Since then, the Chinese government has carried out a series of Hukou system reform, aiming to improve the welfare of rural Hukou holders.

Nonetheless, migrants still have limited access to housing, medical insurance, etc. and suffer from discriminatory practices in work and education opportunities, For instance, some local governments stipulate recruiting policies that give privileges to unemployed urban residents over migrants; others set quotas on the number of migrants. Migrant workers typically receive much lower hourly wages than urban workers, and their work environment tends to be worse than urban counterparts.

3.3 Model

The model consists of two spatially separated regions, rural and urban. Capital is mobile between two regions but labor mobility is restricted by the Hukou system. We denote the
Hukou type by \( i \) where \( i \in \{r, u\} \). The initial period in agent’s life corresponds to the age of six. Each agent draws her utility cost of attending school \( x \sim N(\mu, \sigma) \), when she is born.

Agents in each region choose between continued education and labor market entry. Urban Hukou owners (urban agents) enter urban labor market and stay in urban region forever. To the contrary, rural Hukou owners (rural agents) have two options in both continued education and labor market entry in either rural or urban areas.

### 3.3.1 Rural Agents

In each period, agents face a survival probability \( \lambda \in (0, 1) \) and discount future utility with a discount factor \( \beta \in (0, 1) \). Agents trade a risk-free asset and are allowed to borrow up to \( \phi \). Unclaimed assets of dying agents are collected and redistributed to all agents in a lump-sum transfer, \( T \). Since urban areas offer higher wages and better quality of education, rural agents wish to migrate to urban areas if possible. However, migration is costly because they should pay a fixed cost \( \psi \) of migration, which includes not only usual costs of moving but also the Hukou restrictions such as limited access to public services in urban area. Agents are endowed with one unit of time in each period and enjoy utility flows from consumption, \( c \). If a rural agent enters rural labor market \((I_w = 1)\), she supplies one unit of time and earns \( w_r h \), where \( w_r \) is real wage per efficiency unit of labor in the rural area and \( h \) is her human capital. The rural worker can choose either to migrate to the urban area \((I_m = 1)\) and work for the urban firm or continue to work in the rural area \((I_m = 0)\) in the next period. The rural worker’s value function is given by

\[
V^w(r, x, a, h) = \max_{I_m, c, a'} \left\{ u(c) + \beta \lambda \max \left[ V^{mw}(r, x, a', h), V^w(r, x, a', h) \right] \right\}
\]
subject to
\[ c + a' + I_m \psi = (1 + r)a + w_mh + T; \]
\[ a' \geq -\phi, \]

where \( r \) is real interest rate on the risk-free asset. If a rural agent attends a school \( (I_w = 0) \), her utility is reduced by utility cost \( x \) and her human capital, \( h \), increases according to the law of motion for human capital, \( h' = h + \rho_r h^\theta \). A rural student’s problem is then given by

\[
V^e(r, x, a, h) = \max_{I_m, c, a', h} \{ u(c) - x + \beta \lambda \max \{ V^e(r, x, a', h'), V^{mw}(r, x, a', h'), V^{me}(r, x, a', h'), V^w(r, x, a', h') \} \}
\]

subject to
\[ c + a' + I_m \psi = (1 + r)a + w_mh + T; \]
\[ h' = h + \rho_r h^\theta; \]
\[ a' \geq -\phi. \]

The migrant worker \( (I_w = 1) \)’s value function is written as

\[
V^{mw}(r, x, a, h) = \max_{c,a'} \{ u(c) + \beta \lambda V^{mw}(r, x, a', h) \}
\]

subject to
\[ c + a' = (1 + r)a + w_mh + T; \]
\[ a' \geq -\phi, \]

where \( w_m \) is real wage per efficiency unit of labor for migrants in the urban area. If a migrant decides to attend a school in the urban area, her value function is defined as

\[
V^{me}(r, x, a, h) = \max_{c,a', h} \{ u(c) - x + \beta \lambda \max \{ V^{me}(r, x, a', h'), V^{mw}(r, x, a', h') \} \}
\]
subject to
\[ c + a' = (1 + r)a + T; \]
\[ h' = h + \rho_u h^\theta; \]
\[ a' \geq -\phi, \]

where \( \rho_r < \rho_u. \)

### 3.3.2 Urban Agents

Urban agents receive an additional transfer, \( T_u \), from the urban government. The urban government imposes a tax on urban firms if they hire migrant workers. The tax introduces a friction, which lowers migrant wages relative to urban wages and ultimately restricts rural-to-urban migration. The tax revenue is redistributed to urban agents in a lump-sum fashion. Urban agents begin to choose whether to continue schooling or to enter urban labor market. An urban worker \((I_w = 1)\)'s problem is similar to rural worker's problem except that workers face higher wages in urban area and receive an additional transfer \( T_u \) from the local government as follows:

\[
V^u(u, x, a, h) = \max_{c, a'} \{ u(c) + \beta \lambda V^u(u, x, a', h) \}
\]

subject to
\[ c + a' = (1 + r)a + w_u h + T + T_u; \]
\[ a' \geq -\phi, \]

where \( w_u \) is real wage per efficiency unit of labor for urban agents. An urban student \((I_w = 0)\)'s problem are written as:

\[
V^e(u, x, a, h) = \max_{c, a', h'} \{ u(c) - x + \beta \lambda \max \{ V^e(u, x, a', h'), V^u(u, x, a', h') \} \}
\]
subject to
\[ c + a' = (1 + r)a + T + T_u; \]
\[ h' = h + \rho_u h^\theta; \]
\[ a' \geq -\phi. \]

### 3.3.3 Firms

Firms hire labor and capital in competitive markets. In each region, firm’s technology is given by a Cobb-Douglas production function. Specifically, a rural firm’s profit maximization problem is given by

\[
\max_{K_r, H_r} z_r K_r^\alpha H_r^{1-\alpha} - w_r H_r - (r + \delta) K_r.
\]

The rural firm’s profit maximization implies

\[ r + \delta = z_r \alpha (K_r / H_r)^{\alpha - 1}, \]
\[ w_r = z_r (1 - \alpha) (K_r / H_r)^\alpha. \]

Urban firms hire two types of workers, urban workers and migrants. A typical urban firm’s problem is given by

\[
\max_{K_u, H_u, H_m} z_u K_u^\alpha H_u^{1-\alpha} - w_u H_u - (w_m + \nu) H_m - (r + \delta) K_u,
\]
where \( H \equiv [\chi H_u^\eta + (1 - \chi) H_m^{\eta}]^{\frac{1}{\eta}} \). These two types of workers are imperfectly substitutable in producing output, where their elasticity of substitution is \( \frac{1}{1-\eta} \). Urban firms are required to pay a tax \( \nu \) per efficiency unit of migrant labor. This tax has been introduced to capture observed wage differences between urban and migrant workers in the data. An increase in the tax \( \nu \) implies strengthened Hukou restrictions in favor of urban workers. The urban firm’s profit maximization implies
\[ r + \delta = z_u \alpha (K_u / H)^{\alpha - 1}, \]

\[ w_u = z_u (1 - \alpha) \chi (K_u / H)^{\alpha H^{1 - \eta} H_u^{\eta - 1}}, \]

\[ w_m = z_u (1 - \alpha) (1 - \chi) (K_u / H)^{\alpha H^{1 - \eta} H_m^{\eta - 1}} - v. \]

### 3.3.4 Stationary Equilibrium

A recursive stationary equilibrium consists of a set of value functions \( \{ V^e(i, x, a, h), V^w(i, x, a, h), V^{me}(r, x, a, h), V^{mw}(r, x, a, h) \} \), a set of agents’ optimal policies \( \{ c(i, x, a, h), a'(i, x, a, h), h'(i, x, a, h), I_w(i, x, a, h), I_m(r, x, a, h) \} \), a set of aggregate inputs \( \{ K_r, H_r, K_u, H_u, H_m \} \), a set of prices \( \{ r, w_r, w_m, w_u \} \), a set of taxes \( \{ v, T_u \} \), and a distribution of agents \( G(i, x, a, h) \) such that:

1. Given \( r, w_r, w_m, w_u, T_u \), and \( G \), agents optimally choose \( c(i, x, a, h), a'(i, x, a, h), h'(i, x, a, h), I_w(i, x, a, h), I_m(r, x, a, h) \) that are consistent with agents’ problems,

2. Given \( v \), firms chooses \( K_r, H_r, K_u, H_u, \) and \( H_m \) to maximize profits,

3. The goods market clears:

   \[
   \sum_i \int \left\{ c(i, x, a, h) + a'(i, x, a, h) + I_m(i, x, a, h)v \right\} dG(i, x, a, h) \\
   = z_r K_r^\alpha H_r^{1 - \alpha} + z_u K_u^\alpha \left\{ [\chi H_u^{\eta} + (1 - \chi) H_m^{\eta}]^{\frac{1}{\eta}} \right\}^{1 - \alpha} + (1 - \delta)(K_r + K_u),
   \]

4. Factor markets clear:

   \[
   H_r = \int h (1 - I_m(r, x, a, h)) I_w(r, x, a, h) dG(r, x, a, h),
   \]

   \[
   H_u = \int h I_w(u, x, a, h) dG(u, x, a, h),
   \]

   \[
   H_m = \int h I_m(r, x, a, h) I_w(r, x, a, h) dG(r, x, a, h),
   \]

   \[
   K_r + K_u = \sum_i \int a dG(i, x, a, h).
   \]
5. Urban government budget constraint is satisfied:

\[ \nu H_m = \int T_u dG(u, x, a, h), \]

6. The distribution of agents, \( G \), is stationary.

### 3.4 Calibration

We select a set of parameters based on the related literature. The utility function is a standard CRRA function: \( u(c) = \frac{c^{1-\gamma}}{1-\gamma} \). The relative risk aversion \( \gamma \) is set to 1.5, based on common estimates between 1 and 2 in the literature. Following Song et al. (2011), time discount factor \( \beta \) is chosen to match the annual real interest rate of 0.0175 and capital depreciation rate \( \delta \) is set to 0.10. For the capital share \( \alpha \) in the production function, we assign 0.5, consistent with the empirical labor share of 0.5 in China. We choose the survival probability \( \lambda \) to match the average work life of 40 years. It is hard to find a counterpart for the elasticity of substitution \( \frac{1}{1-\eta} \) between migrants and urban workers in the literature. Since urban workers tend to obtain much longer years of schooling than migrants, we use an estimate for the substitution elasticity between skilled and unskilled workers in the literature as an alternative. We select 0.5 for \( \eta \) so that the elasticity is 1.5 as in Card and Lemieux (2001). The borrowing limit of agents is given by \( -1 \), which is about 15% of the average annual wage income of rural residents in our benchmark model.

Another set of model parameters is calibrated by targeting relevant data moments. Our primary data source is the household-level survey conducted by China Household Income Project at the end of 2002 (CHIP 2002). The CHIP 2002 contains three subsamples: urban households, rural households, and rural-to-urban migrants. Our sample is restricted to males aged between 25 and 65 years who are not self-employed. The fixed cost of migration \( \psi \) is
selected to match the ratio of migrants to urban residents of 0.194 in the data. The tax \( v \) imposed on urban firms hiring migrant workers, which generates wage gap between migrant and urban workers, is set by matching the relative wages of urban workers to migrants in our sample. We normalize the TFP of rural firms to 1 and choose urban firm’s TFP by targeting the relative wages of urban workers to rural workers. Normalizing the efficiency \( \rho_r \) of rural education system to 1, other two parameters \( \theta \) and \( \rho_u \) governing the human capital production technology are set to replicate the Mincerian returns to schooling in our rural and urban samples. We then select the mean and the variance of the utility cost of schooling by matching the average years of schooling and the variance of years of schooling of the total population in China. Table 1 summarizes these parameters.

3.5 Results

This section begins by presenting benchmark results of our model. We then conduct counterfactual exercises in which either migration cost or the wage gap between migrants and urban workers is reduced. We examine how such changes in the Hukou restrictions affect human capital accumulation and income of migrants and both rural and urban residents, which is followed by the implications of such policy changes on aggregate output. Lastly, this section discusses how the restrictions affect rural workers’s migration decision by reducing the migration cost of either workers or students.

3.5.1 Benchmark Results

Our benchmark economy targets Chinese economy in 2002. Table 2 presents key benchmark results along with their data counterparts. Urban residents form 73.74% of the total population in our benchmark model while the shares of rural residents and migrants are 11.97% and 14.29%, respectively. By construction, these numbers exactly match their data
counterparts. Our benchmark model also generates a significant wage gap between urban and rural workers, consistent with data. Note that rural wage is normalized to 1 to focus on relative wages. The return to human capital of urban workers is 63% larger than that of rural workers. Migrant wage is greater than rural wage, yet there is still a substantial gap between migrant and urban wages.

The rural-urban divide is also present in human capital accumulation. In the model, the average years of schooling of urban residents are 9.02 years, whereas rural agents on average stay 5.04 years in school, in line with their data counterparts. However, in contrast with the data, where migrants stay in school slightly longer than rural residents, our model implies that migrants are negatively selected from rural population in terms of educational attainment. The discrepancy is attributed to a tight borrowing limit in our model. In our model, agents borrow from others when young to finance their consumption during the schooling period. Migrants also need to pay a fixed cost of migration before they begin to earn wage income in urban sector, thus they cannot afford to obtain as much education as those who decide to stay in rural area. The last two columns of Table 2 presents the average savings of each worker group relative to per capita GDP. In the data, urban residents are much richer than rural residents and migrants are the poorest. In our model, migrants hold less amount of wealth relative to rural residents, yet urban residents are poorer than rural residents unlike the data. One reason is that urban workers have significantly higher wage income than other worker groups, so they don’t have to accumulate as much savings as others. Without an idiosyncratic productivity shock, agents do not have strong incentives to accumulate a buffer stock of precautionary savings and thus there is not much differences in saving across the worker groups.
Table 3 summarizes factor inputs exploited and outputs produced by rural and urban firms and their sum. Urban firm’s physical capital stock is larger than that of the rural firm by a factor of 14, while urban firm hires labor input more than three times that used by rural firm. The higher productivity of urban firm as well as greater amount of both physical and human capital inputs make the urban firm produce more than 90% of the total output. All in all, there is significant inequality in human capital, income, and output between rural and urban areas and migrants do not fare as well as otherwise the same urban residents in our benchmark model.

3.5.2 Relaxing the Hukou Restrictions

This subsection discusses how each type of agents are affected by relaxing the Hukou restrictions. We consider the impact of a decline in either the fixed cost of migration or the wage gap between migrants and urban workers. It is then followed by an exercise where both types of restrictions are simultaneously reduced.

A Reduction in Migration Cost

The fixed cost $\psi$ of migration represents the frictions rural agents face in migrating to urban area, which includes costs associated with the Hukou restrictions such as limited access to housing and medical insurance and hardship in locating education and work opportunities relative to urban residents and also usual moving costs. In this counterfactual experiment, we reduce the migration cost $\psi$ by half to relax the restrictions on labor mobility. The results are reported in Table 4.

The lower migration cost induces more rural agents to migrate to urban area in order to take advantage of higher real wages, increasing the population share of migrants from 14.29% to 14.46%. The increased rural-to-urban migration raises labor supply in urban
firms, reducing the real wage of both migrants and urban workers. As a result, the return to capital in urban firms rises. The higher return to capital in urban firms attracts more capital from rural area. Consequently, rural firms lose physical capital and thus rural wage is negatively affected. The reduction in migration cost help migrants spend more time in school. In addition, more educated workers newly join migrants because the return from migration is increasing in one’s human capital. This results the average years of schooling of rural residents to decline.

The reduction in migration cost improves the efficiency of labor allocation. Although rural firm’s output falls by 3.06%, urban produces 0.5% more output, compared to the benchmark results. The efficiency gain from the halved migration cost, measured by an increase in total output, amounts to 0.28% of the benchmark GDP.

**A Decline in the Migrants-Urban Workers Wage Gap**

Another mechanism through which rural-to-urban migration is controlled is the migrant hiring tax $\nu$. The tax $\nu$ pushes migrant wages below their marginal product of labor, making migrants earn lower wage income than otherwise the same urban workers. The tax $\nu$ can also reflect other types of discriminatory practices against migrants in urban firms or weaker bargaining power of migrants relative to urban workers.

Suppose that the migrant hiring tax $\nu$ declined by 50%. Table 4 indicates that the halved tax $\nu$ on hiring migrants has stronger impacts on labor reallocation and output than the halved migration cost. The population share of migrants rises from 14.29% to 16.6%. Migrants also gain from a rise in their wages, while both rural and urban residents suffer from a decline in their wages. As in the case of the halved migration cost, new migrants are positively selected from the education distribution of rural residents, reducing the gap in
educational attainment between rural residents and migrants. The increased migrants and their added human capital pushes the return to urban firm’s physical capital significantly.

The labor reallocation has sizable effects on capital reallocation and output. Together with the increased rural-to-urban labor migration, physical capital is also reallocated to urban firm. Losing both physical and human capital stocks by more than 20%, rural firm’s output declines by 23.26%. Instead, urban firm’s output increases by 2.01%. For the entire economy, the total output increases by 0.40% with the migrant hiring tax cut by half.

A Decrease in Both Migration Cost and Wage Gap

This section examines how three worker groups are affected when both types of the restrictions on rural-to-urban migration are simultaneously cut by half. The last three columns of Table 4 present the results. The effects of the decline in both types of restrictions are greater than a simple sum of the effects described in previous subsections. Migrants now form 21.22% of the total population. Migrants can now afford more human capital accumulation due to a decline in the fixed cost of migration. There is also a stronger positive selection in migration in terms of education. With the comprehensive mitigation of the Hukou restrictions, the average years of schooling of migrants exceeds those of rural residents. Migrants gain from a rise in their wages, but their wage does not rise as much as in the case of the halved migrant hiring tax. Combined with the decline in the migration cost, the reduction in the migrant-urban wage gap causes more rural agents to migrate to urban area, reducing the rental price of migrant human capital, which is the general equilibrium effect. Both rural and urban workers face reduced wages, compared to the benchmark results. Urban workers are negatively affected by the increased labor supply while rural workers get hurt by capital reallocation from rural to urban area seeking for a higher return to capital.
When both migration cost and the migrant hiring tax decrease by half, the efficiency gain from labor and capital reallocation is fairly large. Rural firm loses about three quarters of its physical and human capital stocks and thus its output plummets to a quarter of its benchmark value. On the other hand, urban firm produces 6.55% more output, attracting more physical and human capital inputs. The total output for the entire economy rises by 1.4%.

### 3.6 Welfare Analysis

This section proceeds by reporting welfare changes for the three worker groups from the mitigation of the Hukou restrictions. Table 6 presents how the welfare of rural and urban residents, and migrants is affected by a decline in either migration cost or the migrant-urban wage gap, and in both. The results imply that relaxing the Hukou restrictions benefit both migrants and urban residents at the cost of rural residents. By reducing the migrant cost by half, both migrants and urban residents become slightly better off, compared to the benchmark model. Even though their real wage per efficiency unit of labor decline with the decline in the migration cost, their capital income rises as the real interest rate increases. Rural agents, on the other hand, have to bear a small welfare loss due to

The decrease in the migrant hiring tax followed by reduced migrant-urban wage gap has a sizable welfare impact on migrants. Migrant wage rises almost by half following the policy change. As a result, migrant wage income rises substantially, making them be able to enjoy 26% more consumption in each period, compared to the benchmark results. To the contrary, rural agents experience a similar magnitude of welfare loss with the reduced tax on hiring migrants, which is attributable to their wage loss from the flight of capital from rural to
urban area and mitigated human capital stocks held by them. Urban workers gain slightly from the increased capital income.

Cutting both types of restrictions by half increases welfare of migrants by 70% while hurting rural agents by the similar magnitude. Changes in both the real wage and human capital stocks increase wage income of migrants while reducing that of rural agents. Urban agents are in favor of these policy changes because they gain from the improved efficiency of urban firm’s production activity through the rise in their capital income.

3.7 Conclusion

In this study, we explore the macroeconomic implications of the restrictions on rural-to-urban migration in China. Chinese government has controlled rural-to-urban migration and the literature view this as an important barrier to economic development of China. This paper quantifies how the mitigation of such restrictions affects the patterns of migration and human capital investment of rural and urban residents. We further quantify the efficiency gain from labor reallocation associated with the relaxed Hukou restrictions and its welfare implications.

The Hukou restrictions are modeled in two ways: rural-to-urban migrants pay a fixed cost of migration and urban firms pay a tax when hiring migrants. By reducing the migration cost and/or the migrant hiring tax between migrants and urban workers, rural agents’ migration decision is affected. The lower cost of migration induces more agents to move to urban area, while the decline in the migrant hiring tax reinforces the positive selection into migration in terms of education. Labor reallocation occurs by supplying more labor to urban firms with more educational attainment.
Table 3.1: Parameterization

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Target (Source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma = 1.5$</td>
<td>Intertemporal elasticity of substitution: 0.67</td>
</tr>
<tr>
<td>$\beta = 0.991$</td>
<td>Annual real interest rate: 0.0175</td>
</tr>
<tr>
<td>$\delta = 0.1$</td>
<td>Song et al. (2011)</td>
</tr>
<tr>
<td>$\alpha = 0.5$</td>
<td>Labor share in China: 0.5</td>
</tr>
<tr>
<td>$\lambda = 0.975$</td>
<td>Average length of work life: 40 years</td>
</tr>
<tr>
<td>$\eta = 0.5$</td>
<td>Elasticity of substitution of 1.5 in Card and Lemieux (2001)</td>
</tr>
<tr>
<td>$\phi = 1$</td>
<td>Borrowing limit</td>
</tr>
<tr>
<td>$\psi = 219.2$</td>
<td>Migrants to urban residents ratio in CHIP 2002: 0.194</td>
</tr>
<tr>
<td>$v = 5.715$</td>
<td>$w_u/w_m$ in CHIP 2002: 1.593</td>
</tr>
<tr>
<td>$z_u = 2.130$</td>
<td>$w_u/w_r$ in CHIP 2002: 1.634</td>
</tr>
<tr>
<td>$\theta = 0.052$</td>
<td>Mincer return to schooling in Rural area in CHIP 2002: 0.044</td>
</tr>
<tr>
<td>$\rho_u = 2.750$</td>
<td>Mincer return to schooling in Urban area in CHIP 2002: 0.064</td>
</tr>
<tr>
<td>$\mu = 6.137$</td>
<td>Average years of schooling in CHIP 2002: 7.1</td>
</tr>
<tr>
<td>$\sigma = 3.030$</td>
<td>Standard deviation of years of schooling in CHIP 2002: 1.5</td>
</tr>
</tbody>
</table>

Table 3.2: The Benchmark Model Results

<table>
<thead>
<tr>
<th>Share</th>
<th>Wage</th>
<th>Schooling</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>11.97</td>
<td>1.0000</td>
<td>5.62</td>
</tr>
<tr>
<td>Migrant</td>
<td>14.29</td>
<td>1.0255</td>
<td>5.80</td>
</tr>
<tr>
<td>Urban</td>
<td>73.74</td>
<td>1.6338</td>
<td>8.63</td>
</tr>
</tbody>
</table>

We find that the mitigation of the Hukou restrictions promotes rural-to-urban migration substantially, which is followed by capital reallocation from rural to urban area. The efficiency gain from the relaxed Hukou restrictions is equivalent to 1.4% if both types of restrictions are reduced by half. The efficiency gain comes at the expense of rural residents. Rural residents suffer from a sizable welfare loss in response to the relaxed restrictions on labor mobility, while migrants gain the most.
Table 3.3: Inputs and Outputs in the Benchmark Economy

<table>
<thead>
<tr>
<th></th>
<th>Capital Input ($K$)</th>
<th>Labor Input ($H$)</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>55.62</td>
<td>3.07</td>
<td>13.07</td>
</tr>
<tr>
<td>Urban</td>
<td>817.57</td>
<td>9.95</td>
<td>192.13</td>
</tr>
<tr>
<td>Total</td>
<td>873.19</td>
<td>13.02</td>
<td>205.20</td>
</tr>
</tbody>
</table>

Table 3.4: The Effects of Relaxed Hukou Restrictions

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>Migration Cost ↓</th>
<th>Wage Gap ↓</th>
<th>Both ↓</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Share</td>
<td>Wage Educ</td>
<td>Share</td>
<td>Wage Educ</td>
</tr>
<tr>
<td>Rural</td>
<td>11.97</td>
<td>2.1277</td>
<td>5.04</td>
<td>11.79</td>
</tr>
<tr>
<td>Migrant</td>
<td>14.29</td>
<td>2.1818</td>
<td>3.99</td>
<td>14.46</td>
</tr>
<tr>
<td>Urban</td>
<td>73.74</td>
<td>3.4761</td>
<td>9.02</td>
<td>73.74</td>
</tr>
</tbody>
</table>

Table 3.5: Output Gain or Loss from the Relaxed Hukou Restrictions (Unit: %)

<table>
<thead>
<tr>
<th></th>
<th>Migration Cost ↓</th>
<th>Wage Gap ↓</th>
<th>Both ↓</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital Labor Output</td>
<td>Capital Labor Output</td>
<td>Capital Labor Output</td>
</tr>
<tr>
<td>Urban</td>
<td>+0.30 +0.70 +0.50 +1.35 +5.63 +2.01 +4.95 +17.09 +6.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>+0.07 -0.08 +0.28 -0.26 -1.08 +0.40 -0.11 -4.30 +1.41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.6: Welfare Gain or Loss (Unit: Per-Period Consumption)

<table>
<thead>
<tr>
<th></th>
<th>Rural</th>
<th>Migrant</th>
<th>Urban</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migration Cost ↓</td>
<td>-2.50%</td>
<td>+2.33%</td>
<td>+0.14%</td>
<td>+0.43%</td>
</tr>
<tr>
<td>Wage Gap ↓</td>
<td>-22.40%</td>
<td>+25.97%</td>
<td>+0.31%</td>
<td>+0.89%</td>
</tr>
<tr>
<td>Both ↓</td>
<td>-71.28%</td>
<td>+69.68%</td>
<td>+1.82%</td>
<td>+2.54%</td>
</tr>
</tbody>
</table>
Bibliography


