Macroeconomic Effects of Commodity Booms and Busts: The Role of Financial Frictions

Job Market Paper

updates at: http://www.columbia.edu/~sfs2146/research.html

Samer Shousha*

January 25, 2016

Abstract

What are the effects of commodity price shocks on real activity for small open commodity exporters? Using both a panel VAR and an estimated open economy multi-sector model with financial frictions, this paper shows that commodity price shocks are an important source of business cycle fluctuations for small open commodity exporters, with stronger effects on emerging countries. Moreover, the main channel that accounts for the different effects among emerging and advanced economies is the response of the country interest rate to these shocks and differences in working capital constraints faced by firms. Finally, the presence of balance sheet mismatches and leverage constraints in the banking sector do not seem to contribute a lot quantitatively either to the amplification of the shocks or the heterogeneity of responses among emerging and advanced countries.

JEL classification: F31, F32, F34, F37, F41, F44

Key words: commodities, financial accelerator, balance sheet mismatch, country risk

*Department of Economics, Columbia University. Email: sfs2146@columbia.edu. I am grateful to Martin Uribe, Stephanie Schmitt-Grohe and Jose Alexandre Scheinkman for constant guidance and support. I would also like to thank, for very useful comments and suggestions, Patrick Bolton, Fernando M. Martin, Alexander Monge-Naranjo, Emi Nakamura, Christopher Otrok, Ricardo Reis, Paulina Restrepo-Echavarria, Juan M. Sanchez, John Shea, Jon Steinsson, Savitar Sundaresan and Michael Woodford and seminar participants at Columbia University and the Federal Reserve Bank of St. Louis. This paper was partly written at the Federal Reserve Bank of St. Louis, while I was a dissertation intern. I am especially grateful for their hospitality. All remaining errors are mine.

1 Introduction

Terms of trade movements are usually associated with macroeconomic fluctuations in small open economies but the effects are heterogenous among countries. For example, in the last commodity price boom, output growth in advanced commodity exporters was somewhat stable compared to the previous decade, while emerging commodity exporters growth rate more than doubled on average (see Figure 1).[1] Given the relevance that commodities have on these economies, understanding the channels by which the effect of commodity prices affect economic activity is crucial from a policy perspective.

This paper evaluates quantitatively the importance of commodity price shocks for business cycles and the different channels through which these shocks affect small open commodity producing economies, focusing on the importance of financial frictions in the transmission of these shocks. My analysis proceeds in two steps. First, I estimate a panel VAR system for two groups of countries heavily exposed to commodity goods exports, one containing only advanced and the other only emerging small open economies.[2] I show that commodity price shocks are important sources of business cycles and have stronger effects on real activity, credit, and country interest rates in emerging countries. Additionally, including commodity price shocks in a panel structural VAR makes the contribution of interest rate shocks for real activity fluctuations in emerging economies to be almost negligible, a result in contrast with what was found in Neumeyer and Perri (2005) and Uribe and Yue (2006).[3] This last result indicates that interest rate shocks capture the effects of commodity price shocks when they are omitted from the analysis, leading to a overestimation of their importance for business cycle fluctuations.

In the second part of my analysis, I build a multi-sector open economy model with a banking sector to study the mechanism by which financial frictions can amplify the effects of commodity price shocks. The key idea in the model is that a commodity price

[1]Commodities represent around 50% of exports and 10% of GDP in both countries as we can see in Table 1.

[2]I prefer to use the panel data methodology because it increases the efficiency and power of the analysis as individual countries' VARs would have too many parameters compared to the time series length.

[3]Neumeyer and Perri (2005) and Uribe and Yue (2006) find that interest rate shocks explain around 30% of movements in emerging economies aggregate activity at a business cycle frequency.

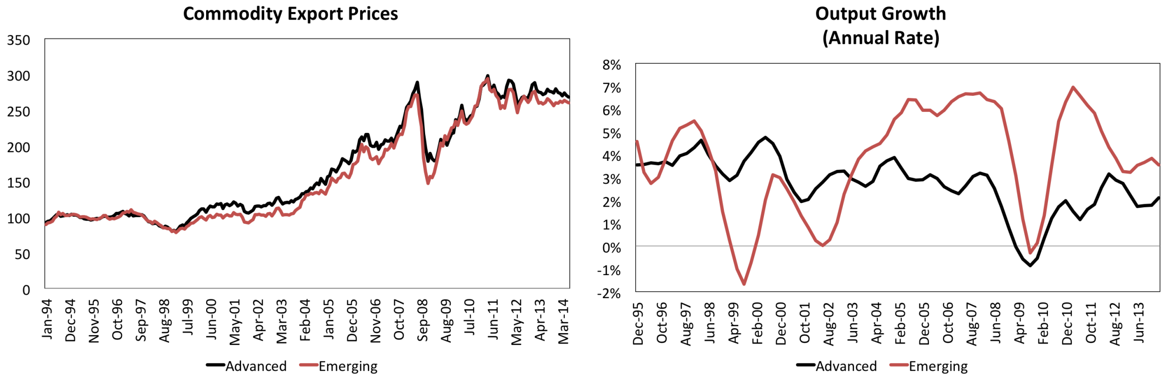

FIGURE 1: Commodity Export Prices and Output Growth in Commodity Exporters
Source: IMF Primary Commodity Price System, UN COMTRADE and National Sources.

shock triggers price movements that interact with financial constraints both at firms and banks, transmitting this shock to the rest of the economy through a change in financial conditions for all sectors. After a favorable commodity price shock, there is a currency appreciation, a rise in the price of nontradables and, especially for emerging economies, a decline in the interest rate charged by foreign lenders due to lower country risk.[4] In an environment where banks are subject to leverage constraints and finance their operation through foreign borrowing in tradable units but lend locally in nontradable units, a mismatch arises in banks' balance sheets. Consequently, the increase in the price of nontradables reduces banks' leverage and relaxes their borrowing constraint while the decrease in the country interest rate reduces their funding costs. Accordingly, bankers are able to get more funds from foreign investors and expand the supply of credit for the whole economy, leading in equilibrium to a lower lending rate. Finally, the lower interest rate reduces the costs related to working capital for firms and leads to a further boom in the commodity and non-tradable sectors while the effects in the industrial sector are ambiguous, as they have now also more costly inputs. The close relationship between commodity prices and foreign borrowing by the banking sector in small open commodity exporters can be seen in Figure 2.

I estimate the small open economy model with financial frictions using Bayesian

[4]For evidence on the negative comovement between commodity prices and country risk in emerging economies, see Bastourre, Carrera, Ibarlucia and Sardi (2013) and Fernandez, Gonzalez and Rodriguez (2015)

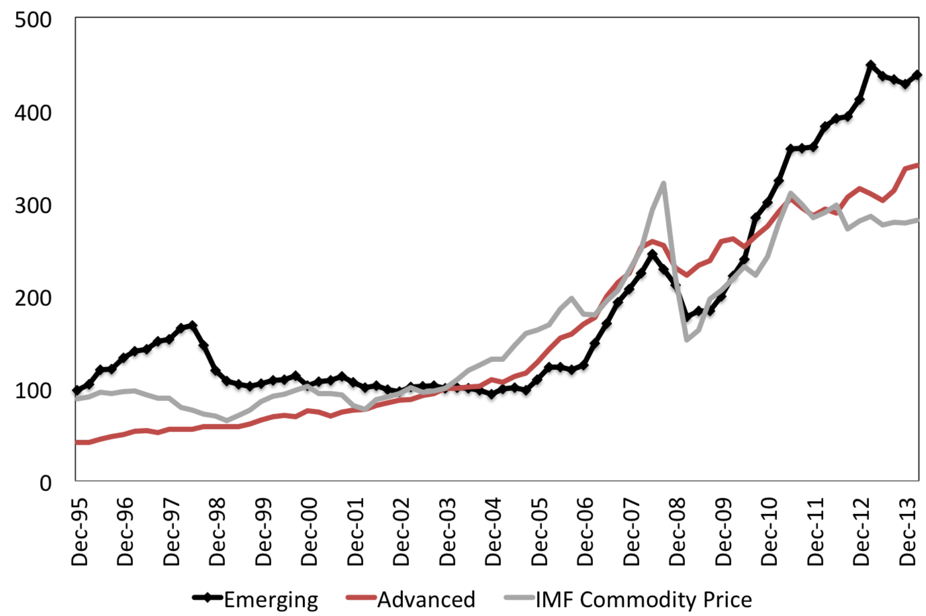

FIGURE 2: Banking Sector Foreign Financing

Note: The data are the simple average of the sum of external loans and international debt securities vis-a-vis the banking sector from 1995-2013 normalized for Dec 2003 = 100 for the Emerging (Argentina, Brazil, Chile, Colombia, Peru and South Africa) and Advanced (Australia, Canada, New Zealand and Norway) main commodity exporters. Source: BIS locational banking statistics Table 7A.

methods for both groups of economies, advanced and emerging, and I show that the model is able to account for the different effects of commodity price shocks on these two groups. This framework also allows me to evaluate the quantitative importance of four previously studied channels through which financial frictions can amplify the effects of commodity price shocks

(i) ***Working capital channel*:** the change in working capital costs when the interest rate moves due to a commodity price shock;

(ii) ***Financial accelerator channel*:** the change in credit supply when banks are subject to leverage constraints for foreign borrowing induced by fluctuations in banks' net worth due to commodity prices movements;

(iii) ***Balance sheet mismatch channel*:** the change in banks' net worth resulting from movements in the price of nontradables induced by commodity price shocks in the presence of mismatches in banks' balance sheets;

(iv) ***Country interest rate channel*:** the change in the country interest rate when commodity prices move due to a change in the country sovereign risk, especially for emerging economies.

I conduct a counterfactual analysis and find that the main transmission channel is the interaction between the working capital and country interest rate channel. Moreover, I also show that the financial accelerator and balance sheet mismatches in the banking sector don't have a relevant quantitative amplification effect.

The small role of borrowing constraints in the transmission of shocks found in this paper might seem surprising as they have received a lot of attention in the theoretical literature recently. However, there is little agreement about their quantitative relevance. On the one hand, Brunnermeier and Sannikov (2014) emphasize the role of nonlinearities and asymmetries to generate quantitatively relevant amplification arising from the financial accelerator mechanism. On the other hand, Kocherlakota (2000) argues that, although they might generate an arbitrarily high degree of amplification, this theoretical possibility is not robust because depending on the parameters of the economy prices might not respond too much to income shocks. In the same vein, Cordoba and Ripoli (2004) find that amplification is close to zero for standard values of capital shares and intertemporal elasticity of substitution. Liu, Wang and Zha (2013) confirm their findings by showing that only shocks that impact prices directly and considerably can trigger strong amplification effects. In fact, I show that the key reason for the small amplification effect in my setting is the small and short-lived effect on the spread charged by financial intermediaries to firms.

Layout. The rest of the paper is organized as follows. Section 2 discusses the relationship with the literature. Section 3 describes the data, discusses the main stylized facts, describes the panel VAR specification and discusses its results. Section 4 describes the theoretical framework and the different equilibrium concepts. Section 5 details the estimation of the model and presents its main results. Section 6 concludes.

2 Relationship with the Literature

This section discusses the contribution of this work to three strands of the literature.

Effects of External Shocks in Emerging Economies. This paper contributes to the literature that studies the effects of external shocks in small open economies. Neumeyer and Perri (2005) and Uribe and Yue (2006) analyze the effect of interest rate shocks and find that both US interest rate shocks and country spread shocks are crucial drivers of business cycle in emerging economies. Mendoza (1995) and Kose (2002) analyze the effect of terms of trade shocks by estimating a process for them and feeding it to a small open economy business cycle model to compute the variance of macroeconomic variables induced by these shocks. After that, they compare it with the actual variance of the corresponding variable and find that at least 30% of macroeconomic fluctuations should be attributed to terms of trade shocks. Lubik and Teo (2005) estimate a DSGE model for five developed and developing economies and find that world interest rate shocks are the main driving forces of business cycles in small open economies while terms of trade shocks are not relevant. However, they acknowledge that their results might be related to the importance of allowing for a richer production structure to accurately capture the contribution of terms of trade shocks to business cycle fluctuations, an issue addressed in this paper. Justiniano and Preston (2010) estimate a structural, small open-economy model of the Canadian economy and show that it cannot account for the substantial influence of foreign-sourced disturbances identified in numerous reduced form studies. They also show that these results are due to the model's inability to account for comovement without generating counter factual implications for the real exchange rate, the terms of trade and Canadian inflation, which is not true in the setup proposed in this work. Akinci (2013) uses a panel VAR methodology to show that shocks to global financial risk are an important source of business cycle fluctuations in emerging economies. Moreover, the inclusion of global financial risk makes the contribution of the global risk-free interest rate negligible, although country spread shocks are still an important source of fluctuations in emerging economies. Schmitt-Grohe and Uribe (2015) estimate both structural VARs and theoretical models for individual countries to evaluate terms of trade shocks and find that in the empirical SVAR these shocks explain around 10 percent of movements in aggregate activity. Moreover, they find that at the country level there is a disconnect between the empirical and theoretical models in the importance assigned to terms of trade shocks. I contribute to this literature by showing that commodity price shocks are relevant sources of business cycle fluctuations in emerging countries, explaining more than 20 percent of movements in output and more than 30 percent of movements in investment in these economies. Additionally, contrary to some previous studies, I find that the response of real activity to commodity price shocks is similar in the panel VAR and in the theoretical model. I also show that it is important to consider commodity prices instead of the usual terms of trade indices based on unit values, because these indices are subject to several biases and endogeneity issues that are mitigated when we use the former. Finally, I find that the inclusion of commodity price shocks dampens a lot the contribution of interest rate shocks, which were previously found to be crucial to account for emerging economies' business cycles.

There are also some works that focus specifically on commodity price shocks as I do. Cespedes and Velasco (2012), for example, provide empirical evidence using commodity price boom and bust episodes that commodity price shocks have a significant impact on output and investment dynamics and that the impact of those shocks on investment tends to be larger for economies with less developed financial markets, a result in line with what I find in this work. Charnavoki and Dolado (2014) follow Killian (2009) to identify the main global shocks driving world commodity prices using a dynamic factor model framework and find that a rise in commodity prices unambiguously generates a positive effect on external balances and commodity currency effects, but that a Dutch disease effect at business cycle frequencies in the Canadian manufacturing sector is only detected when the commodity price increase is related to a negative global commodity-specific shock. Collier and Goderis (2012) use a panel error correction methodology and show that commodity price booms have unconditional positive short-term effects on output, but non-agricultural booms in countries with poor governance have adverse long-run effects which dominate the short-term gains. Fernandez et al. (2015) embed a commodity sector into a multi-country business cycle model of small emerging market economies and find that the estimated model gives an important role to commodity prices when accounting for aggregate dynamics. Finally, Fornero, Kirchner and Yany (2014) also study the effects of commodity price shocks in small open commodity-exporting economies using both a structural VAR and a theoretical model and find expansionary effects of these shocks driven by the positive responses of commodity investment that spill over to non-commodity sectors. I contribute by showing that taking into account explicitly the role of credit frictions in small open economies helps to account for the different effects of commodity price shocks among advanced and emerging economies.

Financial Frictions in Emerging Economies. I also contribute to the literature that studies the role of financial frictions in emerging economies. Garcia-Cicco, Pancrazi and Uribe (2010) show that the presence of international financial frictions are key to account for observed aggregate dynamics in developing countries, especially the downward-sloping autocorrelation function of the trade balance-to-output ratio, the excess volatility of consumption, the high volatility of investment, and a volatility of the trade balance-to-output ratio comparable to that of output growth. Gertler, Gilchrist and Natalucci (2007) build a small open economy model with a financial accelerator mechanism and show that it accounts for roughly half of the decline in economic activity in a a quantitative exercise aimed at replicating the key features of the South Korean experience during the Asian financial crisis of 1997/98. Martins and Salles (2011) build a small open economy model with the presence of two imperfect credit markets and calibrate it to Brazilian data to assess different types of credit policies implemented during the Global Financial Crisis. They find that these policies raised GDP but their welfare effects depend on how they are funded. Finally, Fernandez and Gulan (2014) embed a financial accelerator into a business cycle model of a small open economy and estimate it on a panel dataset for emerging economies that merges macroeconomic and financial data to explain the countercyclicality of interest rates, a feature that is usually hard to match in traditional models, where the interest rate is either acyclical or procyclical.

Balance Sheet Mismatches and Cross-border Lending. I also evaluate specifically the role of balance sheet mismatches in banks in the transmission of external shocks. Eichengreen and Haussman (1999) argue that original sin, the fact that the domestic currency cannot be used to borrow abroad or borrow long term leads all domestic investments to have either a currency mismatch or a maturity mismatch. Moreover, this feature is especially important in emerging markets, where the domestic capital markets are underdeveloped. Eichengreen, Hausmann and Panizza (2006) show that distinguishing among original sin and debt intolerance with currency mismatches is important as the problems with which these approaches deal are analytically different. They also argue that although Chile's institutions are strong, its performance resembled much more that of Latin America than that of Australia, which supports the approach I use in this paper in separating the countries in emerging and advanced economies regardless of their fiscal and monetary policy frameworks. Choi and Cook (2004) examine the quantitative implications of currency mismatches in banks' balance sheets for the conduct of monetary policy in emerging economies and for the dynamic propagation of macroeconomic shocks in an open economy and find that a monetary policy that fixes the exchange rate to stabilize bank balance sheets offers greater macroeconomic stability than a floating exchange rate policy represented by an inflation-targeting interest rate rule to offset the real effects of sticky prices. Finally, Ham, Shin and Shin (2013) show that in a lending boom, when credit expansion outstrips the pool of available retail deposits, banks turn to other sources of funding to support their credit growth, typically from other banks operating as wholesale lenders in the capital market. They also find that various measures of noncore liabilities, and especially liabilities to the foreign sector, serve as a good measure of the vulnerability to a crisis. Thus, if the commodity boom leads to a strong increase in these foreign liabilities, it would make these economies more vulnerable to external shocks that could lead to a collapse in the value of the currency and a credit crisis where lending rates rise sharply.[5]

I contribute to these last two branches of the literature by developing a framework to evaluate quantitatively four commonly proposed transmission channels through which financial frictions can amplify commodity price shocks (namely the country interest rate, balance sheet mismatches, the financial accelerator and working capital constraints) and showing that the financial accelerator and balance sheet mismatches in the banking sector don't have a relevant quantitative amplification effect for commodity price shocks despite the recent attention devoted to these channels. Instead, the bulk of the differences among advanced and emerging economies are accounted for by the differences in the response of the country interest rate to these shocks and different working capital constraints faced by firms.

3 Panel VAR

I first estimate a structural panel VAR for emerging and advanced economies to evaluate the effects of commodity price shocks. The central finding of this section is that commodity price shocks are relevant sources of business cycles in small open commodity producers and have stronger effects on emerging economies with respect to real activity (output and investment), credit and country interest rates.

3.1 Data and Panel VAR Specification

My empirical model takes the form of a first-order VAR:

$$Ay_{i,t} = \eta_i + \sum_{k=1}^{p} B_k y_{i,t-k} + \epsilon_{i,t}$$

where η_i is a country fixed effect, i denotes countries and t denotes time period and

$y_{i,t} = [yf_{i,t}, yh_{i,t}]$

[5]The recent experience of several emerging and advanced small open commodity exporters seems to validate this mechanism.

$$yf_{i,t} = [r_t^{US}, pcm_{i,t}],\ yh_{i,t} = [gdp_{i,t}, inv_{i,t}, tby_{i,t}, crt_{i,t}, r_{i,t}, reer_{i,t}]$$

r^{US} denotes the real U.S. interest rate, *pcm* denotes the country specific real commodity export price, *gdp* denotes real gross domestic product, *inv* denotes real gross fixed capital formation, *tby* denotes the trade balance to output ratio, *crt* denotes real credit volume to the non-financial private sector, r denotes the country specific interest rate and *reer* denotes the real exchange rate. All variables are log deviations from a log-linear and a log-quadratic trend with the exception of the trade balance to output ratio and the interest rates, which are detrended in levels. I also remove the sample mean after detrending for each variable separately. I estimate 2 panel VARs, one for advanced economies (Australia, Canada, New Zealand and Norway) and the other for emerging economies (Argentina, Brazil, Chile, Colombia, Peru and South Africa) for the period 1994:Q1-2013:Q4. The countries selected have commodities representing more than 30% of total exports, well developed financial markets and at least 15 years of data. The data sources are listed in the Appendix.

One departure from the literature that evaluates the effects of terms of trade shocks is that I prefer to use a constructed real commodity export price instead of the ratio of export and import unit value indices, which is the usual measure of terms of trade. The reasons to do that are four. First, Silver (2009) documents several reasons for biases in unit value indices and finds that the discrepancies between unit value indices and price indices can be substantial and even have the wrong sign, especially for heterogenous products, which lead me to focus only on homogeneous commodity product exports.[6] Second, unit values that consider a broad range of products are more likely to be endogenous with respect to country-specific shocks than global commodity prices. Third, as noted by Chen and Rogoff (2003), the presence of nominal rigidities and incomplete pass-through make proper identification when we use the usual terms of trade index

[6]The sources of bias are (i) the increased product differentiation, which aggravates the bias due to compositional quality mix changes; (ii) the lack of ways for dealing with quality change, temporarily missing values, and seasonal goods with unit value indices; (iii) the increase in trade in services coupled with the lack of customs data for many sorts of service products; (iv) the impossibility of dealing appropriately with "unique" goods such as ships with customs data and unit value indices; and (v) when outlier detection and deletion is automatic and badly applied, such deletions run the risk of missing large price catch-ups due to the stickiness of many price changes.

close to impossible because these rigidities prevent these measures from adequately incorporating contemporaneous shocks that induce immediate effects on the exchange rate, which are important to account for the real effects of commodity price shocks. Fourth, I do not divide the commodity export price by a commodity import price index because commodity imports represent on average less than 3% of GDP for my sample countries. Moreover, a considerable share of these imports is related to energy products, which have their fluctuations smoothed in most of sample countries through taxes and subsidies, as we can see in Figure 3, and thus their price changes are not fully transmitted to the real economy.[7]

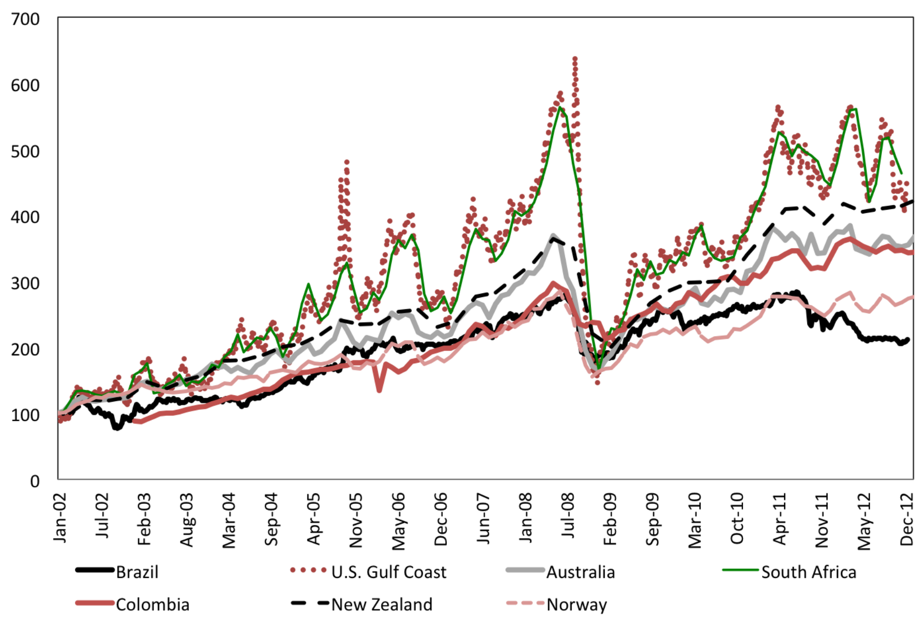

FIGURE 3: Gasoline Prices - US$/Gallon

Real commodity export prices for each country are calculated following Deaton and Miller (1996) and Chen and Rogoff (2003). See the Appendix for details about their construction. Table 1 shows the commodity exports profile for the countries in the sample and Figure 4 plots the time series for real commodity export prices. As we can see, although there is some dispersion inside the two groups, their average profile is

[7]Di Bella, Norton, Ntamatungiro, Ogawa, Samake and Santoro (2015) documents that for the Latin American countries in my sample there is either an ad hoc price-setting mechanism (Argentina and Brazil) or the presence of a stabilization fund which smooths price variations (Colombia, Chile and Peru).

Table I

Country Commodity Exports Profile

	Share of Exports	Share of GDP	Main Products
		Emerging	
Argentina	49%	6.3%	Soybeans (41%), Crude Oil (12%), Maize (8.9%)
Brazil	44%	4.4%	Soybeans (22%), Iron Ore (17%), Sugar (9%)
Chile	64%	18.0%	Copper (72%), Fish (9%), Wood (7%)
Colombia	55%	7.5%	Crude Oil (45%), Coal (19%), Coffee (18%)
Peru	60%	11.0%	Copper (34%), Gold (29%), Zinc (11%)
South Africa	30%	6.3%	Coal (23%), Platinum (21%), Iron Ore (10%)
Average	50%	8.9%	
		Advanced	
Australia	63%	10.0%	Coal (21%), Iron Ore (15%), Aluminum (10%)
Canada	30%	8.7%	Crude Oil (25%), Wood (18%), Natural Gas (16%)
New Zealand	33%	7.2%	Wood (21%), Lamb (20%), Beef (16%)
Norway	67%	21.3%	Crude Oil (59%), Natural Gas (21%), Fish (7%)
Average	49%	11.2%	

Note: The data are the simple average from annual trade data for SITC level 4 groups provided by UN COMTRADE from 1994-2013. The number in parenthesis is the share of each product in total commodity exports for each country.

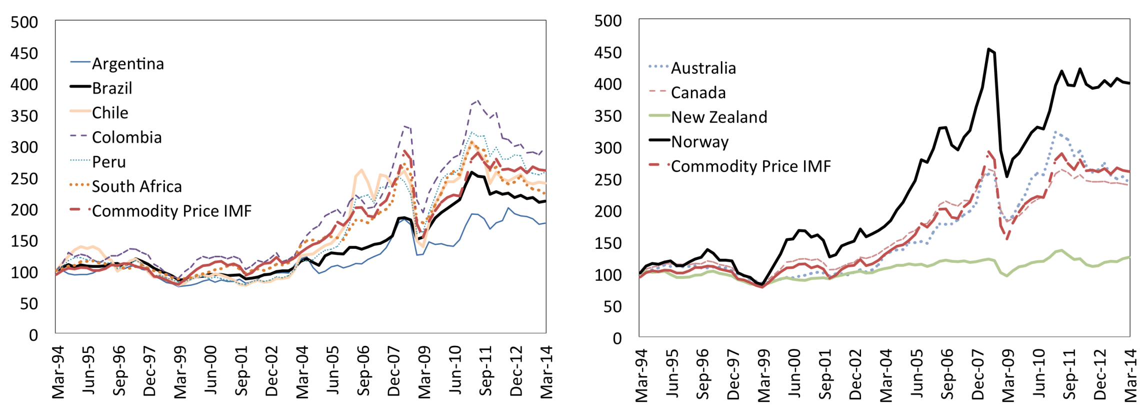

Figure 4: Real Commodity Export Prices (1994 = 100)

similar with respect to commodity exports as a share of total exports and share of GDP. Moreover, energy products are more relevant for advanced than emerging economies while the opposite is true for metals and agricultural products. Finally, all prices have an upward trend beginning in the early 2000s and are highly correlated.

Table 2 shows business cycle statistics for sample countries, averaging over country-specific moments for each of the groups. As expected, all variables are more volatile in emerging than in advanced economies. Moreover, real activity (output and invest-

TABLE II
BUSINESS CYCLE STATISTICS

	Emerging			Advanced		
	σ_X	$\rho(X_t, PCM_t)$	$\rho(X_t, Y_t)$	σ_X	$\rho(X_t, PCM_t)$	$\rho(X_t, Y_t)$
Y	0.03	0.50	1.00	0.01	0.23	1.00
I	0.11	0.44	0.82	0.07	0.41	0.68
TBY	2.4%	0.18	-0.40	1.7%	0.25	-0.06
Crt	0.13	-0.09	0.47	0.04	0.08	0.28
R_{US}	0.01	0.06	0.35	0.01	0.08	0.28
PCM	0.15	1.00	0.50	0.12	1.00	0.23
R	0.03	-0.23	-0.23	0.01	0.23	0.36
REER	0.11	0.23	0.48	0.06	0.52	0.15

Note: The data are the simple average of the indicators for the Emerging (Argentina, Brazil, Chile, Colombia, Peru and South Africa) and Advanced (Australia, Canada, New Zealand and Norway) main commodity exporters. The data sources are listed in the Appendix. The data are sampled quarterly from 1994:Q1-2013:Q4. The columns labeled Y, I, TBY, Crt, R_{US}, PCM, R and REER refer, respectively, to detrended output, investment, trade balance-to-gdp ratio, real credit, US real interest rate, real commodity export price, country real interest rate and real effective exchange rate.

ment) and real exchange rates are positively correlated with commodity prices for both groups. Consistent with previous work, the country interest rate and the trade balance-to-gdp ratio are countercyclical in emerging economies and procyclical and acyclical, respectively, for advanced economies. Finally, the country interest rate has a positive comovement with commodity prices in emerging economies and a negative comovement in advanced economies, a fact that motivates the inclusion of commodity prices in the country interest rate equation in the theoretical framework.

I identify the panel VAR by a simple recursive structure, imposing that the matrix A is lower triangular. Moreover, I assume that foreign variables are completely exogenous and that real commodity export prices have no effect on the U.S. interest rate.[8] The assumption that commodity price shocks are unrelated to home variables relies on the fact that, at least at business cycle frequencies, commodity price fluctuations are typically more sensitive to short-term demand imbalances. Moreover, with the exception of Chile, which is the world's largest copper producer, and South Africa, a big exporter of precious metals, the countries in the sample have commodity exports

[8]Relaxing this assumption does not change the main results.

distributed over a fairly diffuse set of products and, at least for their main export products, have considerable competition from other countries. Additionally, for Chile and South Africa, Chen, Rogoff and Rossi (2010) show that the exogeneity assumption holds using the Hausmann test for endogeneity.[9] Finally, innovations in the U.S. interest rate have a contemporaneous effect on the real commodity export prices to take into account the phenomenon of financialization of commodity markets (see for example Cheng and Xiong, 2014).

I use the least square dummy variable estimator to estimate the panel VAR for each group. As $T >>> N$, the LSDV strategy is preferred to GMM estimators as it has better finite sample properties and efficiency, especially if the degree of cross-section to time series variation is big. Also, with T large, Nickel's (1981) critique regarding the bias of the LSDV estimator is less important. I use the Akaike Information Criteria (AIC) to select the lag length and get p = 2 as optimal. I calculate the error bands using bootstrap methods.

3.2 Main Results

Figure 5 shows the impulse response functions for a 10% positive shock in commodity prices in both advanced and emerging economies. Commodity price shocks have a much larger effect on output, investment and real credit in emerging economies while effects on the trade balance and real exchange rate are similar. Finally, the effects on the country specific real interest rate are also significantly negative and much stronger for emerging economies.

The impulse responses for a 2% positive shock in the country-specific real interest rate are shown in Figure 6.[10] The effects on emerging and advanced economies are as expected, with the exception of output in advanced economies, which shows a small increase after the shock. Again, the effects on emerging economies are much stronger for the same size of shocks, except for the trade balance, where the effect on advanced

[9] Jacks and Stuermer (2015) also find that demand shocks strongly dominate supply shocks as the main drivers of metal and agricultural commodity prices.

[10] The standard deviation of the emerging economies' country specific interest rate is close to 2%. I use the same shock size for advanced economies to be able to compare the results.

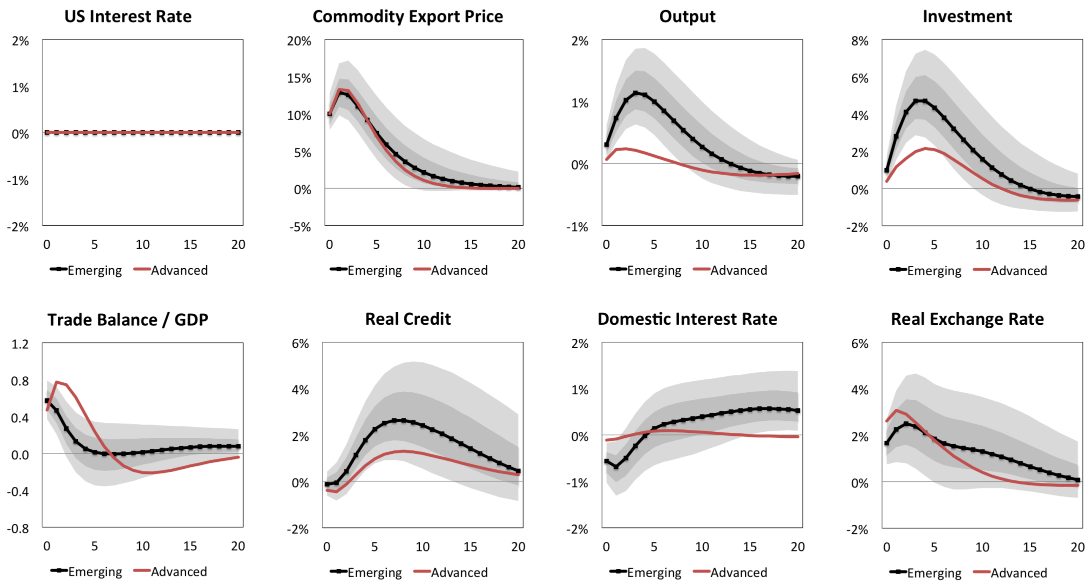

FIGURE 5: Impulse response to a 10% commodity export price shock.
Note: Marked black (solid red) lines show point estimates of impulse responses for emerging (advanced) economies; and 68% and 95% confidence bands are depicted with dark-gray and light-gray shaded areas, respectively. Bootstrap confidence bands are based on 10,000 repetitions.

economies is bigger, and the real exchange rate, where we see a depreciation in emerging economies and an appreciation in advanced economies. This last result might be related to the fact that increases in country specific interest rates in emerging economies are usually due to capital outflows, which also depreciate the exchange rate, while in advanced economies they are mainly due to monetary policy tightening, which attracts capital flows. This fact might also explain why we see an initial increase in investment and the small increase in output in these economies.

To understand the contribution of each shock for different variables, I perform a variance decomposition of the forecast errors. Figure 7 shows the results. Shocks to real commodity export prices and the country-specific real interest rate are more important for real output and investment in emerging economies. According to my estimates, innovations in real commodity export prices are responsible for about 23% of movements in aggregate output in emerging economies and about 7% in advanced economies, while shocks to the country-specific real interest rate orthogonal to commodity price shocks are responsible for about 5% of movements in emerging economies and less than 1% in advanced economies. For real fixed investment, commodity export price innovations

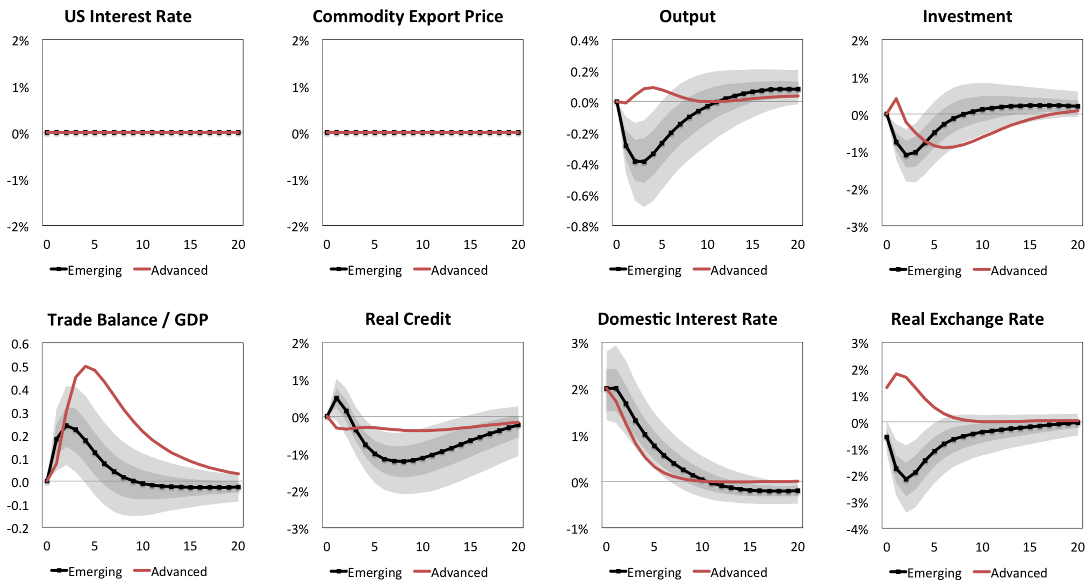

FIGURE 6: Impulse response to a 2% country-specific interest rate shock.
Note: Marked black (solid red) lines show point estimates of impulse responses for emerging (advanced) economies; and 68% and 95% confidence bands are depicted with dark-gray and light-gray shaded areas, respectively. Bootstrap confidence bands are based on 10,000 repetitions.

are responsible for around 32% of fluctuations in emerging economies and about 15% in advanced economies, while shocks to the country-specific real interest rate are responsible for about 2% of movements in emerging economies and about 1% in advanced economies. Taking these two results together, external shocks explain about 28% of output fluctuations and more than 30% of investment fluctuations in emerging economies, while about only 8% of output fluctuations and 17% of investment fluctuations in advanced economies, illustrating the much bigger importance of external shocks for the former economies. Moreover, including commodity export prices considerably reduces the contribution of country-specific interest rate shocks to fluctuations in emerging economies when compared to previous work. Neumeyer and Perri (2005) and Uribe and Yue (2006), for example, find that interest rate shocks explain around 30% of movements in emerging economies aggregate activity at a business cycle frequency. This indicates that, at least for commodity exporters, when commodity price shocks are omitted from the analysis the country interest rate shocks capture their effects, leading to an overestimation of their importance for business cycle fluctuations.

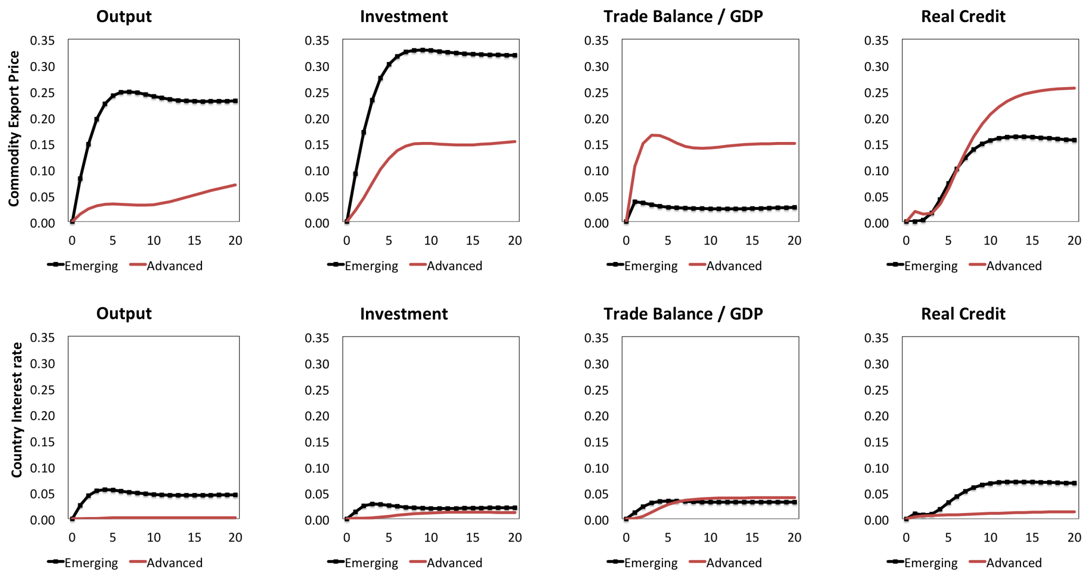

FIGURE 7: Forecast error variance decomposition at different horizons.
Note: Marked black (solid red) lines show point estimates of forecast error variance decomposition for emerging (advanced) economies for the real commodity export price (first row) and country-specific real interest rate (second row) at different horizons.

In the next section, I present the structural model to evaluate more directly the channels that can explain these results.

4 Theoretical Framework

In this section I present a model to evaluate the contribution of different financial frictions to the transmission of commodity price shocks. The theoretical framework consists of a small open economy version of a dynamic stochastic model with a financial sector similar to the one proposed in Gertler and Karadi (2011). I enrich the model in several dimensions: (i) I consider 3 different sectors (tradable final goods, nontradable goods and intermediate commodities that can be either used in the local production or exported) that are subject to independent shocks; (ii) the country interest rate can be affected by commodity prices either directly or indirectly through their effects on foreign indebtedness motivated by the results in the panel VAR analysis; (iii) I have working capital constraints for firms, which lead to a wedge in firms' decisions to hire labor and invest, and which transmit interest rate changes to the real economy; (iv) banks get funds from international lenders, subject to a leverage constraint and denominated in tradable units; and (v) banks lend to firms in nontradable units, giving rise to a mismatch in their balance sheets, which interacts with the leverage constraint to amplify the shocks. The leverage constraint arises due to an agency problem, which leads banks to be limited in their capacity to get funds from abroad. When this constraint is binding, credit to the non-financial private sector is limited. In this environment, a positive commodity price shock that might lead to a decrease in the interest rate for foreign borrowing and an increase in the relative price of nontradables would strengthen the bank's balance sheet and consequently allow them to expand borrowing from international investors and lending to the productive sector, amplifying the effect of the shock and transmitting it to the whole economy.

4.1 Households

Households are composed of a constant fraction f of workers and $(1-f)$ of bankers. Workers supply labor to firms in exchange for wages while bankers manage financial intermediaries and transfer net earnings to the household. There is perfect insurance between household members. The consumption basket is a CES aggregator with elasticity of substitution μ between tradable c_t^T and nontradable goods c_t^N:

$$c_t \equiv A(c_t^T, c_t^N) = [\chi(c_t^T)^{1-1/\mu} + (1-\chi)(c_t^N)^{1-1/\mu}]^{\frac{1}{1-1/\mu}}$$

Households have preferences described by a utility function similar to the one defined in Greenwood, Hercowitz, and Huffman (1988) with the addition of internal habit formation as can be seen below:

$$U(c_t, c_{t-1}, h_{CM,t}, h_{T,t}, h_{N,t}) = \frac{\left(c_t - bc_{t-1} - \frac{h_{CM,t}^{\omega^{CM}}}{\omega^{CM}} - \frac{h_{T,t}^{\omega^T}}{\omega^T} - \frac{h_{N,t}^{\omega^N}}{\omega^N}\right)^{1-\sigma} - 1}{1-\sigma} \tag{1}$$

where $\sigma > 0$ is the coefficient of relative risk aversion, $b \in [0, 1)$ governs the degree of internal habit and $(\omega^{CM}, \omega^T, \omega^N)$ determine the Frisch elasticity of labor supply for each sector. In the absence of habit formation, GHH preferences eliminate the wealth effect on labor supply. Consequently, if b is small, anticipated future income does not affect current labor supply, which will depend mainly on the current wage.

Households are also the owners of firms, receiving all their net profits, and can borrow directly from abroad in international markets without any frictions. Thus, the period-by-period budget constraint of households in terms of numeraire tradable final goods is given by

$$c_t^T + p_t^N c_t^N + R_{t-1}^* d_{t-1}^{*H} = d_t^{*H} + \sum_{j=\{T,N,CM\}} \left[w_{j,t} h_{j,t} + \pi_t^j\right] + \pi_t^B \tag{2}$$

where d_t^{*H} denotes the stock of one-period debt acquired in period t and due in period t+1, R_t^* is the interest rate charged for foreign borrowing, $w_{j,t}$ is the wage and π_t^j is the net cash flow received from firms on each sector j, and π_t^B are the profits sent by bankers to the household.

Households are also subject to a no-Ponzi scheme constraint:

$$\lim_{m\to\infty} E_t \frac{d_{t+m+1}^h}{\Pi_{s=0}^m R_{t+s}^*} \leq 0 \tag{3}$$

I assume that labor supply is chosen one period in advance, motivated by the fact that output barely moves initially after a commodity price shock in the panel VAR analysis. Thus, the consumption of tradables c_t^T and nontradables c_t^N, debt holdings d_t^{*H} and labor supply $h_{j,t+1}$ are given by maximizing the discounted expected future flow of utility using a subjective discount factor $\beta \in (0,1)$ subject to the budget constraint and the no-Ponzi scheme constraint. Denoting the Lagrange multiplier associated with the budget constraint (2) as λ_t, the first order conditions of the household's problem are

$$\lambda_t = U_t' A_1(c_t^T, c_t^N) - b\beta E_t[U_{t+1}' A_1(c_{t+1}^T, c_{t+1}^N)] \tag{4}$$

$$p_t^N = \frac{U_t' A_2(c_t^T, c_t^N) - b\beta E_t[U_{t+1}' A_2(c_{t+1}^T, c_{t+1}^N)]}{U_t' A_1(c_t^T, c_t^N) - b\beta E_t[U_{t+1}' A_1(c_{t+1}^T, c_{t+1}^N)]} \tag{5}$$

$$E_t[\lambda_{t+1} w_{CM,t+1}] = E_t[U_{t+1}' h_{CM,t+1}^{\omega^{CM}-1}] \tag{6}$$

$$E_t[\lambda_{t+1} w_{T,t+1}] = E_t[U'_{t+1} h_{T,t+1}^{\omega^T - 1}] \tag{7}$$

$$E_t[\lambda_{t+1} w_{N,t+1}] = E_t[U'_{t+1} h_{N,t+1}^{\omega^N - 1}] \tag{8}$$

$$\lambda_t = \beta R_t^* E_t \lambda_{t+1} \tag{9}$$

where

$$U'_t = \left(c_t - \frac{h_{CM,t}^{\omega^{CM}}}{\omega^{CM}} - \frac{h_{T,t}^{\omega^T}}{\omega^T} - \frac{h_{N,t}^{\omega^N}}{\omega^N} \right)^{-\sigma}$$

$$A_1(c_t^T, c_t^N) = \chi \left(\frac{c_t}{c_t^T} \right)^{\frac{1}{\mu}}$$

$$A_2(c_t^T, c_t^N) = (1-\chi) \left(\frac{c_t}{c_t^N} \right)^{\frac{1}{\mu}}$$

4.2 Commodity and Final Non-Tradable Goods Producers

Commodity and final non-tradable goods producers have a Cobb-Douglas production function that uses capital and labor as inputs. Following Uribe and Yue (2006), I assume that firms face a working capital constraint and thus, for each unit of wage payments and investment, firms must hold η units of a non-interest bearing asset, denoted m_t^j. Firms can borrow from banks at a rate R_t to cover working capital expenses. Firms also choose investment one-period in advance, motivated by the fact that investment barely moves initially after a commodity price shock in the panel VAR analysis. Finally, firms are subject to investment adjustment costs and a no-Ponzi scheme constraint:

$$\lim_{m \to \infty} E_t \frac{d_{t+m+1}^j}{\Pi_{s=0}^m R_{t+s}^j} \leq 0 \tag{10}$$

Firms discount their profits using the household's marginal utility of wealth because they are owned by them. The firm's problem is thus given by

$$\max_{k_{j,t+1}, i_{j,t+1}, h_{j,t}, d_t^j, m_t^j} E_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t^j \tag{11}$$

subject to

$$\pi_t^j = p_t^j y_t^j - i_{j,t} - w_{j,t}h_{j,t} - p_t^N(m_t^j - m_{t-1}^j) + p_t^N\left(d_t^j - R_{t-1}d_{t-1}^j\right) \tag{12}$$

$$y_t^j = a_{j,t}k_{j,t}^{\alpha^j}h_{j,t}^{1-\alpha^j} \tag{13}$$

$$k_{j,t+1} = (1-\delta)k_{j,t} + i_{j,t}\left(1 - \frac{\phi^j}{2}\left(\frac{i_{j,t}}{i_{j,t-1}} - 1\right)^2\right) \tag{14}$$

$$p_t^N m_t^j \geq \eta^j[w_{j,t}h_{j,t} + i_{j,t}] \tag{15}$$

where $j = \{N, CM\}$ represents the firm's sector, where N stands for the final non-tradable goods sector and CM for the commodity goods sector.

The first order conditions of the firm's problem are

$$(1-\alpha^j)\frac{p_t^j y_t^j}{h_{j,t}} = w_{j,t}(1 + \eta^j\xi_t^j) \tag{16}$$

$$\lambda_t q_{j,t} = \beta E_t\left\{\lambda_{t+1}\left[q_{j,t+1}(1-\delta) + \alpha^j\frac{p_{t+1}^j y_{t+1}^j}{k_{j,t+1}}\right]\right\} \tag{17}$$

$$E_t\left\{\lambda_{t+1}q_{j,t+1}\left[1 - \frac{\phi^j}{2}\left(\frac{i_{j,t+1}}{i_{j,t}} - 1\right)^2 - \phi^j\left(\frac{i_{j,t+1}}{i_{j,t}}\right)\left(\frac{i_{j,t+1}}{i_{j,t}} - 1\right)\right]\right\} +$$
$$\beta E_t\left\{\lambda_{t+2}q_{j,t+2}\phi^j\left(\frac{i_{j,t+2}}{i_{j,t+1}}\right)^2\left(\frac{i_{j,t+2}}{i_{j,t+1}} - 1\right)\right\} = E_t[\lambda_{t+1}(1 + \eta^j\xi_{t+1}^j)] \tag{18}$$

$$(1 - \xi_t^j) = E_t\left(\frac{\lambda_{t+1}}{\lambda_t}\frac{p_{t+1}^N}{p_t^N}\right) \tag{19}$$

$$E_t\left(\frac{\lambda_{t+1}}{\lambda_t}\frac{p_{t+1}^N}{p_t^N}R_t\right) = 1 \tag{20}$$

Combining the last two equations we get

$$\xi_t^j = \left(\frac{R_t - 1}{R_t}\right) \tag{21}$$

which shows that the working capital constraint introduces a distortion that elevates the effective cost of labor and investment for each sector and makes optimal production decisions depend on the interest rate charged by banks.

4.3 Final Tradable Goods Producers

Besides using capital and labor as inputs, final tradable goods producers also have an additional input, commodity intermediate goods. I assume again that firms have a Cobb-Douglas production function, choose investment one period in advance and face investment adjustment costs and a working capital constraint, and thus the firm's problem is given similarly by

$$\max_{k_{T,t}, i_{T,t+1}, h_{T,t}, d_t^T, m_t^T} E_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t^T \tag{22}$$

subject to

$$\pi_t^T = p_t^T y_t^T - i_{T,t} - w_t h_{T,t} - p_t^{CM} cm_t - p_t^N (m_t^T - m_{t-1}^T) + p_t^N \left(d_t^T - R_{t-1}^T d_{t-1}^T \right) \tag{23}$$

$$k_{T,t+1} = (1-\delta) k_{T,t} + i_{T,t} \left(1 - \frac{\phi^T}{2} \left(\frac{i_{T,t}}{i_{T,t-1}} - 1 \right)^2 \right) \tag{24}$$

$$y_t^T = a_{T,t} k_t^{\alpha^T} cm_t^{\gamma^T} h_t^{1-\alpha^T-\gamma^T} \tag{25}$$

$$p_t^N m_t^T \geq \eta^T [w_t h_{T,t} + p_t^{CM} cm_t + i_{T,t}] \tag{26}$$

The first order conditions of the firm's problem are then

$$(1 - \alpha^T - \gamma^T) \frac{y_t^T}{h_t^T} = w_t (1 + \eta^T \xi_t^T) \tag{27}$$

$$\gamma^T \frac{y_t^T}{cm_t^T} = p_t^{CM} (1 + \eta^T \xi_t^T) \tag{28}$$

$$\lambda_t q_{T,t} = \beta E_t \left\{ \lambda_{t+1} \left[q_{T,t+1} (1-\delta) + \alpha^T \frac{y_{t+1}^T}{k_{T,t+1}} \right] \right\} \tag{29}$$

$$E_t \left\{ \lambda_{t+1} q_{T,t+1} \left[1 - \frac{\phi^T}{2} \left(\frac{i_{T,t+1}}{i_{T,t}} - 1 \right)^2 - \phi^T \left(\frac{i_{T,t+1}}{i_{T,t}} \right) \left(\frac{i_{T,t+1}}{i_{T,t}} - 1 \right) \right] \right\} +$$

$$\beta E_t \left\{ \lambda_{t+2} q_{T,t+2} \phi^T \left(\frac{i_{T,t+2}}{i_{T,t+1}} \right)^2 \left(\frac{i_{T,t+2}}{i_{T,t+1}} - 1 \right) \right\} = E_t[\lambda_{t+1}(1 + \eta^T \xi^T_{t+1})] \quad (30)$$

$$(1 - \xi^T_t) = E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{p^N_{t+1}}{p^N_t} \right) \quad (31)$$

$$E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{p^N_{t+1}}{p^N_t} R_t \right) = 1 \quad (32)$$

and, as before, combining the two last equations shows that the working capital constraint introduces a wedge that elevates the effective cost of labor, investment and commodity inputs:

$$\xi^T_t = \left(\frac{R_t - 1}{R_t} \right) \quad (33)$$

4.4 Bankers

In addition to her accumulated net worth, n, a banker can obtain capital from foreign investors, d^{*B}, in the form of one-period non-contingent debt denominated in tradable goods units. The assets held by the banks are loans provided to firms in different sectors in the form of one-period non-contingent debt denominated in non-tradable goods units. As the bank borrows in tradable units and lends in non-tradable units, this gives rise to a mismatch in the bank's balance sheet, which is given by

$$\sum_{j=\{T,N,CM\}} p^N_t d^j_t = n_t + d^{*B}_t \quad (34)$$

Intermediaries borrowing at time t pay the non-contingent real gross return R^*_t at $t+1$. Net worth next period is given by the difference between realized returns on assets and payments promised to foreign investors:

$$n_{t+1} = \sum_{j=\{T,N,CM\}} \left(R_t p^N_{t+1} d^j_t \right) - R^*_t d^{*B}_t \quad (35)$$

where R_t is the gross return on loans.

Bankers' borrowing from abroad is limited to a multiple $\phi^B - 1$ of their net worth. Combining this borrowing limit with the bank's balance sheet equation (34), we get the following leverage constraint: [11]

$$\sum_{j=\{T,N,CM\}} p_t^N d_t^j \leq \phi^B n_t \tag{36}$$

As long as the the bank earns a risk adjusted return that is greater than its funding costs, it is optimal for the banker to keep accumulating assets until exiting the business. At any point of time, there is a probability $1-\theta$ that a banker exits the financial sector and becomes a worker, transferring all the accumulated net worth to the household.

Transfers to new bankers amount to the time invariant fraction $\nu^B/(1-\theta)$ of the value of assets of exiting bankers:

$$N_{t+1}^n = \frac{\nu^B}{(1-\theta)}(1-\theta) \sum_{j=\{H,T,N,CM\}} p_{t+1}^N D_t^j \tag{37}$$

Aggregate net worth depends on both existing bankers' net worth and the net worth of new bankers. Since a fraction θ of bankers survives each period, the net worth next period is given by

$$N_{t+1} = \theta \left\{ \sum_{j=\{T,N,CM\}} \left[\left(R_t \frac{p_{t+1}^N}{p_t^N} - R_t^* \right) p_t^N D_t^j \right] + R_t^* N_t \right\} + \nu^B \sum_{j=\{T,N,CM\}} p_{t+1}^N D_t^j \tag{38}$$

4.5 International Capital Markets and Exogenous Processes

I follow Schmitt-Grohe and Uribe (2003) and assume that the economy faces a debt-elastic interest rate premium. Moreover, to capture the effects of commodity prices on the country premium that were found in the panel VAR analysis, I also assume that

[11] This leverage constraint can be motivated by a moral hazard problem as in Gertler and Karadi (2010) where, at the beginning of each period, bankers can choose to divert a fraction λ of their assets and transfer them back to the household of which he or she is a member. This limited enforcement problem introduces an incentive constraint that requires the bank's continuation value to be higher than the value of diverted funds and leads to a leverage constraint similar to what I have here, with the difference that the parameter ϕ^B would be time varying depending on the returns that bankers' earn and the interest rate they pay for foreign lenders.

the interest rate depends on the level of the real commodity export price with respect to its steady state value as follows[12]

$$R_t^* = \bar{R}^* + \psi^D(e^{d_t^* - \bar{d}^*} - 1) + \psi^{CM}(e^{p_t^{CM} - \bar{p}^{CM}} - 1) + \epsilon_t^{r^*} \tag{39}$$

where d^* is total foreign debt from both workers and bankers and $\bar{d}^*$ is its steady state value, $\bar{p}^{CM}$ is the steady state value of the real commodity export price and $\epsilon_t^{r^*}$ is a normally distributed shock.

The productivity for each sector is assumed to follow an AR(1) process with normally distributed shocks:

$$log(a_{CM,t+1}) = \rho^{CM} log(a_{CM,t}) + \epsilon_t^{CM} \tag{40}$$

$$log(a_{T,t+1}) = \rho^{T} log(a_{T,t}) + \epsilon_t^{T} \tag{41}$$

$$log(a_{N,t+1}) = \rho^{N} log(a_{N,t}) + \epsilon_t^{N} \tag{42}$$

Finally, the real commodity export price is assumed to be completely exogenous and follows an AR(2) process around its steady state, value with normally distributed shocks:[13]

$$log(p_{t+1}^{CM}) - log(\bar{p}^{CM}) = \rho_1^{PCM} log(p_t^{CM} - log(\bar{p}^{CM})) + \rho_2^{PCM} log(p_{t-1}^{CM} - log(\bar{p}^{CM})) + \epsilon_t^{PCM} \tag{43}$$

[12]Bastourre, Carrera, Ibarlucia and Sardi (2013) and Fernandez et al. (2015) show that there is a strong negative comovement between interest rates and commodity prices in emerging economies, which motivates the inclusion of commodity prices directly in the interest rate equation. They also show that this negative association pattern is not only explained by the fact that commodity prices are one of the most relevant fundamentals for commodity exporters' bond spreads but also that reductions in international interest rates and global risk appetite, rises in quantitative global liquidity measures and equity returns, and US dollar depreciations tend to diminish spreads of emerging economies and strengthen commodity prices simultaneously. This specification captures these effects in a reduced form manner.

[13]I use an AR(2) process for the real commodity export price to be coherent with the optimal lag length found in the panel VAR analysis.

4.6 Market Clearing

To close the model, we have the following market clearing conditions:

(i) Goods Market:

$$c_t^N = y_t^N \tag{44}$$

$$i_t = i_{CM,t} + i_{T,t} + i_{N,t} \tag{45}$$

$$tb_t^T = y_t^T - c_t^T - i_t \tag{46}$$

(ii) Foreign sector

$$tb_t^{CM} = p_t^{CM}(y_t^{CM} - cm_{T,t}) \tag{47}$$

$$tb_t = tb_t^T + tb_t^{CM} \tag{48}$$

$$d_t^* = d_t^{*H} + d_t^{*B} \tag{49}$$

$$ca_t = tb_t - r_t^* d_t^* = d_{t+1}^* - d_t^* \tag{50}$$

4.7 Equilibrium Conditions and Numerical Solution

The competitive equilibrium is described by a system of nonlinear equilibrium conditions that cannot be solved analytically, so I use perturbation techniques to solve it numerically. The method consists in first solving numerically for the deterministic steady state of the economy when the leverage constraint in the banking sector is always binding, and then performing a first order approximation of the system of equations around this steady state.[14] All the equilibrium conditions and the details of the steady state calculation are shown in the Appendix.

4.8 Transmission Channels

It is now useful to describe the mechanism that ties commodity price shocks, financial frictions, and real economic activity. An increase in commodity price shocks is trans-

[14]This assumption allows me to use perturbation methods to solve the model. Otherwise, I would have to rely in other solution methods which are more time consuming and thus would make the estimation much more difficult.

mitted to the rest of the economy via four distinctive financial channels that are usually studied in the literature. First, if an increase in the price of commodities reduces the interest rate charged by financial intermediaries from firms, this reduction will lead to an increase in output and investment because the working capital constraint introduces a wedge in firms decisions to hire labor and invest which depends on the level of the interest rate. I call this channel the ***working capital channel***.

Second, as the banking sector is subject to a leverage constraint, if the net worth of the bank increases after a rise in commodity prices, banks can borrow more from foreign lenders. Consequently, the supply of credit for firms will also expand and the interest rate charged by financial intermediaries will decrease, inducing an expansion in credit and real activity. This is the ***financial accelerator channel***. Third, and related to the previous one, because the price of nontradables increases when commodity prices go up, the value of banks' assets will also rise, which generates an expansion in their net worth as the value of banks' liabilities stays constant. This increase in the net worth interacts with the leverage constraint and spurs additional borrowing from abroad, which leads again to an expansion in output and investment. This is the ***balance sheet mismatch channel***. Figure 8 illustrates the interaction between these two channels.

Fourth, a rise in the price of commodities reduces the country foreign indebtedness through the increase in exports and consequently lowers the country interest rate. Moreover, especially for emerging economies, there is an additional reduction on interest rates due to lower country risk and consequently an increase in capital flows. I call this channel the ***country interest rate channel***.

In the next section I will estimate the model to be able to evaluate which of these four channels are more relevant quantitatively for the transmission of commodity price shocks.

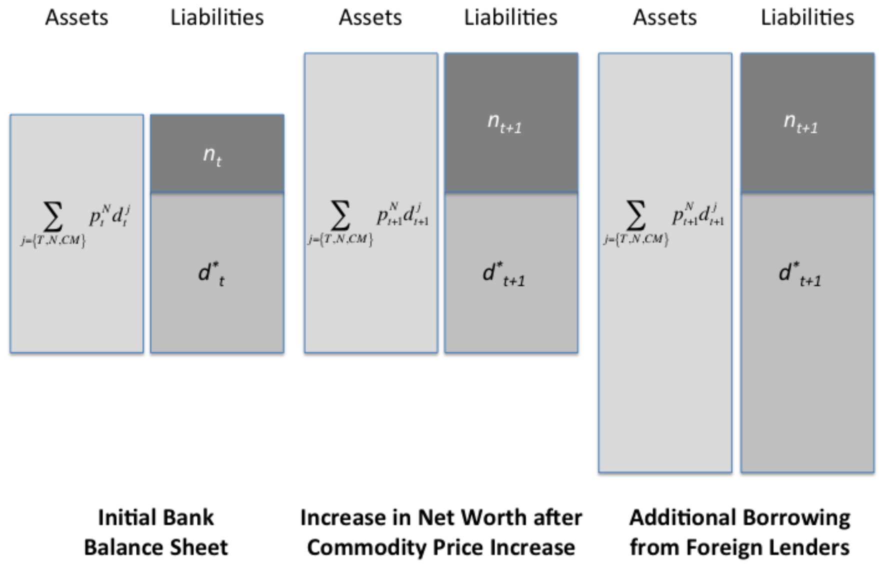

Figure 8: Balance sheet mismatch and financial accelerator channels

5 Quantitative Analysis

The model is estimated using the same dataset used in section 2 and Bayesian methods. Section 5.1 describes the estimation strategy. Section 5.2 presents diagnostics regarding model fit and evaluates the estimated model, comparing its properties with the panel VAR estimated for each group of countries and analyzing the transmission mechanism.

5.1 Model Estimation

I denote the vector of model parameters by $\theta \in \Theta$. It is useful to partition the parameter vector into $\theta = [\theta_1, \theta_2]$, where θ_1 represents the set of parameters that are calibrated while θ_2 represents the set of parameters that are estimated.

$$\theta_1 = [\bar{d}^*, \bar{p}^{CM}, \bar{r}^*, \beta, \mu, \delta, \chi, \sigma, \alpha^{CM}, \alpha^T, \alpha^N, \gamma^T, \omega^{CM}, \omega^T, \omega^N, \nu^B]$$

$$\theta_2 = [\psi^D, \psi^{CM}, \eta^{CM}, \eta^T, \eta^N, \phi^B, \theta^B, b, \phi^{CM}, \phi^T, \phi^N]$$

I choose the calibrated parameters using both long-run data relations from emerging and advanced economies and parameter values that are standard in related business cycle studies. Table 3 shows the calibrated parameter values. I set the parameter $\bar{d}^*$ to induce a steady-state value of the trade balance-to-output ratio of 1% for emerging economies and 0% for advanced economies. I set $\bar{p}^{CM}$ to get a steady-state value of the commodity exports-to-output ratio of 10%. I set the steady-state interest rate to 1% for advanced economies and 2% for emerging economies and β accordingly as $1/(1+\bar{r}^*)$ for each group of economies. I set the elasticity of substitution between tradable and nontradable final goods to 0.5, which is in the range found by Akinci (2011). I set the depreciation rate δ at 2.5%, which implies an annual depreciation rate around 10%. I set χ to 0.35 to have a nontradable final goods production-to-output ratio around 50%. The intertemporal elasticity of substitution σ is set to 2 and the labor curvature parameters ω^{CM}, ω^T and ω^N are set to 1.455, which are fairly standard values. Using the results from Na (2015) and Uribe (1997), the capital share ratios α^{CM} and α^T are set to 0.35 while α^N is set to 0.25 to get the labor share of income close to 70% in the first two sectors and 75% in the latter, and γ^T is set to 0.05. Finally, I set ν^B to 1% to make new bankers start with a small share of total assets.[15]

The parameters in θ_2 are estimated using as observables the same set of home variables used in the panel VAR, namely real gross domestic product, real gross fixed capital formation, the trade balance to output ratio, real credit concessions to the non-financial private sector, the country-specific real interest rate and the real effective exchange rate, using the same detrending method. I prefer to use exactly the same data used in Section 2 to check how closely the model can replicate the results from the panel VAR analysis. I also add measurement errors to all observables.

I use the Bayesian methods surveyed in An and Schorfheide (2007) to estimate the vector θ_2, the persistence and standard deviations of the shocks and the standard deviations of the measurement errors. Conditional on the distribution of the exogenous shocks and after computing the first order approximation of the model around the

[15] I don't estimate this parameter because it is not well identified when it is estimated together with the other banking sector parameters.

Table III
Calibrated Parameter Values

Parameter	Value	Source/target
Steady-state foreign debt	$\bar{d^*} = 0.12$ (0.0)	TB-to-output ratio = 1% (0%)
Steady-state pcm	$\bar{p}^{CM} = 0.69$	TBCM-to-output ratio = 10%
Interest rate	$\bar{r^*} = 0.02$ (0.01)	Average value
Discount factor	$\beta = 0.98(0.99)$	$\beta = 1/(1 + r^*)$
At. elasticity of substitution	$\mu = 0.5$	Akinci (2011)
Weight on tradables in CES	$\chi = 0.35$	Share of nontradable output = 50%
In. elasticity of substitution	$\sigma = 2$	Standard value
Labor curvature	$\omega^{CM} = \omega^T = \omega^N = 1.455$	Standard value
Depreciation rate	$\delta = 2.5\%$	Standard value
Capital share ratio	$\alpha^N = 0.25$	Labor share of income = 75%
Capital share ratio	$\alpha^T = \alpha^{CM} = 0.35$	Labor share of income = 70%
Commodity input share	$\gamma^T = 0.05$	Commodity inputs = 5%
Transfer rate	$\nu^B = 0.01$	Small share of total assets
AR1 coefficient *pcm*	$\rho_1 = 1.29(1.32)$	Panel VAR
AR2 coefficient *pcm*	$\rho_2 = -0.40(-0.45)$	Panel VAR
Std *pcm* shock	$\sigma^{pcm} = 0.067(0.053)$	Panel VAR

steady state assuming that the banking sector leverage constraint is always binding, the model defines a state space system which generates a likelihood function that can be used to transform prior distributions for the structural parameters into a posterior distribution using the Bayes Theorem. As it is not feasible to characterize the posterior distribution analytically, we have to use computational techniques to generate draws from the posterior and then approximate posterior expectations by Monte Carlo averages. I use a Random Walk Metropolis Hastings algorithm implemented in Schorfheide (2000) to compute the posterior distribution and evaluate the marginal likelihood of the model. I use priors that are standard in the literature for most of the parameters while for the parameters related to the financial frictions I choose very loose and uninformative prior.

Particularly, the coefficients of the country interest rate process (ψ^D, ψ^{CM}) are assumed to follow uniform distributions, with the first ranging from 0.00001 to 0.5, and the second ranging from -0.05 to 0; the working capital constraint parameters $(\eta^{CM}, \eta^T, \eta^N)$, a gamma distribution with mean 2 and standard deviation of 1; the leverage constraint parameter (ϕ^B), an uniform distribution ranging from 2 to 20; the parameter that governs the survival rate of bankers (θ^B), a beta distribution with mean 0.7 and standard deviation of 0.1; the parameter that governs internal habit formation (b), a beta distribution with mean 0.75 and standard deviation of 0.1; the sectoral investment adjustment costs parameters ($\phi^{CM}, \phi^T, \phi^N$), a gamma distribution with mean 10 and standard deviation of 5; the persistence of the autoregressive processes ($\rho^{CM}, \rho^T, \rho^N$), a beta distribution with mean 0.5 and standard deviation of 0.2; and the standard errors of the innovations ($\sigma^{r^*}, \sigma^{CM}, \sigma^T, \sigma^N$), an inverse-gamma distribution with mean 0.1 and a standard deviation of 2. Finally, uniform prior distributions were chosen for the innovations of the measurement errors, restricted to account for at most 10% of the average variance of each corresponding observable time series. Table 4 reports the priors with the average of the posterior means for θ_2 for each group of countries and all the prior and posterior plots are in a separate Computational Appendix. Comparing the posterior distributions with the prior distributions we can conclude that the data are informative about all estimated parameters.

5.2 Model Fit and Analysis

This subsection analyzes the properties of the model. First, I compare the impulse response functions of the baseline estimation with the ones obtained from the Panel VARs. In general, the impulse responses generated by the model are close to the ones generated by the VARs. Then, I do some counterfactual exercises to evaluate the key channels through which the results are obtained, especially the different responses of emerging and advanced economies to commodity price shocks.

5.2.1 Impulse Respones

Figures 9-11 show the results for the impulse responses for a 10% positive shock to commodity prices comparing, respectively, the model and the panel VAR results for emerging and advanced economies, and the model results for both groups of countries. Model estimates are computed in two steps: first, I compute the mean posterior IRF

Table IV
Prior and Posterior Distribution of θ_2

Parameter	Prior	Para 1	Para 2	Advanced Posterior Mean	Emerging Posterior Mean
ψ^D	Uniform	0.00001	0.50	0.016	0.077
ψ^{CM}	Uniform	-0.05	0	-0.006	-0.014
η^{CM}	Gamma	2.0	1.0	2.9	2.5
η^T	Gamma	2.0	1.0	1.7	1.9
η^N	Gamma	2.0	1.0	1.2	2.1
ϕ^B	Uniform	2.0	20	2.06	2.04
θ^B	Beta	0.70	0.10	0.72	0.75
b	Beta	0.75	0.10	0.46	0.45
ϕ^{CM}	Gamma	10	5	10.6	10.3
ϕ^T	Gamma	10	5	1.8	4.6
ϕ^N	Gamma	10	5	11.3	9.3
ρ^{CM}	Beta	0.50	0.20	0.73	0.88
ρ^T	Beta	0.50	0.20	0.89	0.87
ρ^N	Beta	0.50	0.20	0.82	0.84
σ^{r^*}	Inverse Gamma	0.10	2.0	0.01	0.02
σ^{CM}	Inverse Gamma	0.10	2.0	0.16	0.57
σ^T	Inverse Gamma	0.10	2.0	0.03	0.05
σ^N	Inverse Gamma	0.10	2.0	0.01	0.02

Note: Para 1 and Para 2 are the extreme values for the Uniform distribution; and mean and standard deviation for Beta, Gamma and Inverse Gamma distributions. Posterior statistics are computed using 400,000 draws from the posterior distribution of model's parameters.

for each country; then I take the average across countries for each group.

The model matches well the behavior of most of the variables after the commodity price shock when compared with the results obtained in the panel VAR analysis for both group of countries. Both in the panel VAR and the theoretical model we have stronger responses of output, investment, credit and country interest rate in emerging economies. The key difference between the model and the panel VAR is the behavior of the trade balance in emerging economies, which increases more in the model than in the data; and the real exchange rate in advanced economies, which appreciates more in the panel VAR than in the model. Moreover, output and investment are more persistent in the model than in the data. Finally, credit increases more rapidly in the model than in the panel VAR, which might indicate some type of time-to-lending feature in reality.

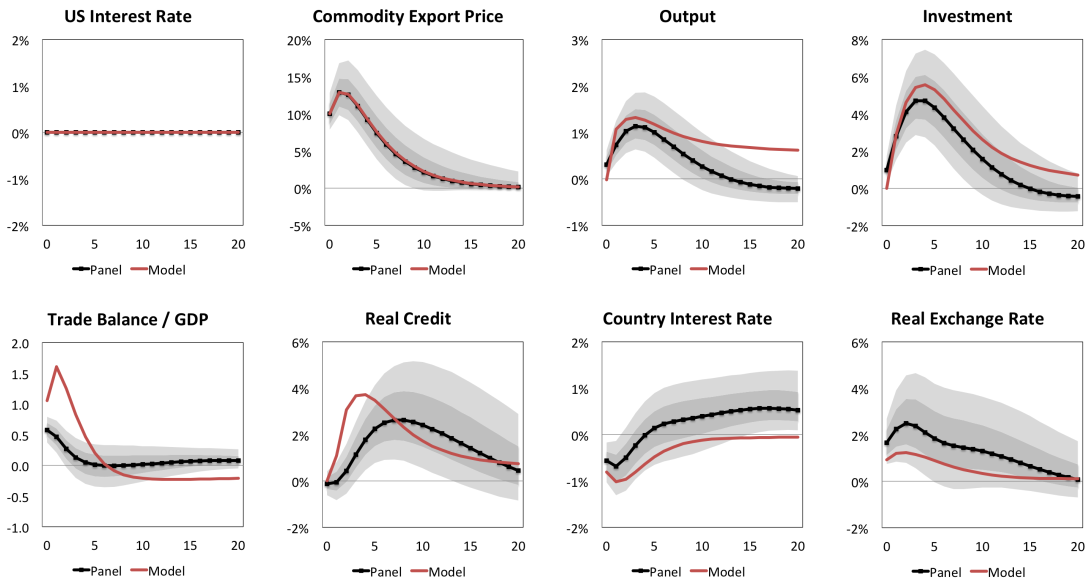

FIGURE 9: Impulse response to a 10% commodity export price shock - Emerging Economies. Note: Marked black (solid red) lines show point estimates of impulse responses for emerging economies for the panel VAR (model); and 68% and 95% confidence bands for the panel VAR estimates are depicted with dark-gray and light-gray shaded areas, respectively. Bootstrap confidence bands are based on 10,000 repetitions. Model estimates are the average of impulse responses across countries.

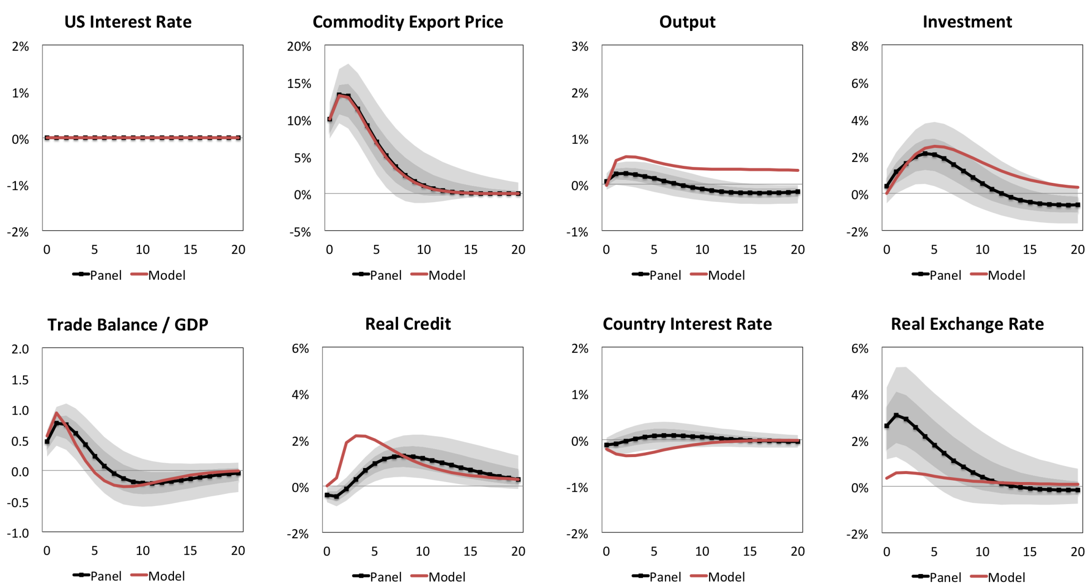

FIGURE 10: Impulse response to a 10% commodity export price shock - Advanced Economies. Note: Marked black (solid red) lines show point estimates of impulse responses for advanced economies for the panel VAR (model); and 68% and 95% confidence bands for the panel VAR estimates are depicted with dark-gray and light-gray shaded areas, respectively. Bootstrap confidence bands are based on 10,000 repetitions. Model estimates are the average of impulse responses across countries.

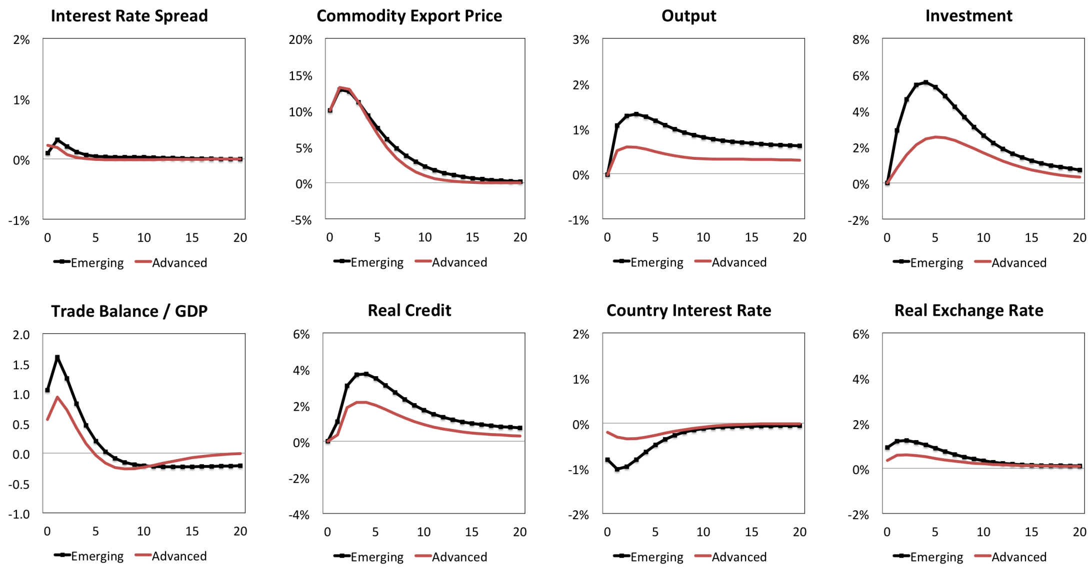

FIGURE 11: Impulse response to a 10% commodity export price shock - Model Comparison. Note: Marked black (solid red) lines show point estimates of impulse responses for emerging (advanced) economies for the model. Model estimates are the average of impulse responses across countries. Model estimates are the average of impulse responses across countries.

5.2.2 Inspecting the Mechanism

The estimated model can be used to ask which channel is responsible for the different results between emerging and advanced economies. I will analyze what happens if (i) there isn't any mismatch in banks balance sheets in emerging countries; (ii) the financial accelerator is not present in the banking sector in emerging economies; and (iii) emerging economies have the same working capital constraints and interest rate processes as the average of the estimates for advanced economies.

Balance sheet mismatch channel. I first recompute the impulse responses eliminating the mismatch in banks' balance sheets by making them lend in tradable units to firms. The results can be seen in figure 12. The impulse responses are almost identical to the baseline scenario, with the exception of the interest rate spread, which increases on impact. Consequently, we can conclude that quantitatively the role of balance sheet mismatches is minor in this environment.

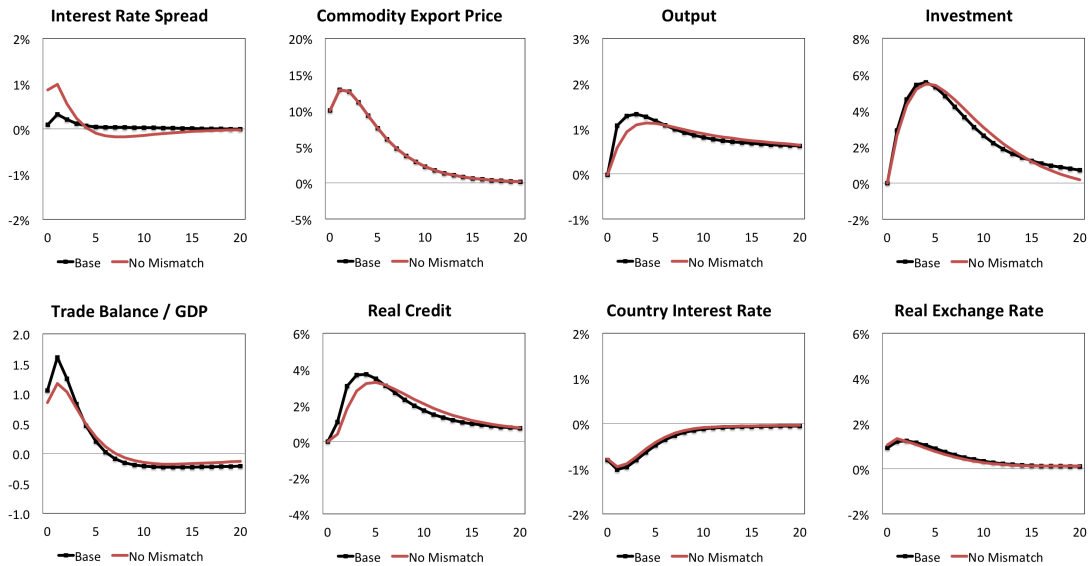

FIGURE 12: Impulse response to a 10% commodity export price shock - No Mismatch.
Note: Marked black (solid red) lines show point estimates of impulse responses for emerging economies for the model in the baseline (alternative) scenario. Model estimates are the average of impulse responses across countries.

Financial accelerator channel. Now I eliminate the leverage constraint and consequently the entire banking sector, as without the constraint the model is equivalent to one where firms borrow directly from abroad. The impulse responses can be seen in figure 13. The results are again very similar to the baseline scenario, with actually a stronger growth in credit when we don't have the financial accelerator in place. Moreover, the increase on investment is also stronger but less persistence. Thus, we can also conclude that, on top of the minor role of balance sheet mismatches, the whole banking sector is not important quantitatively for the transmission of commodity price shocks in the setup of this paper.

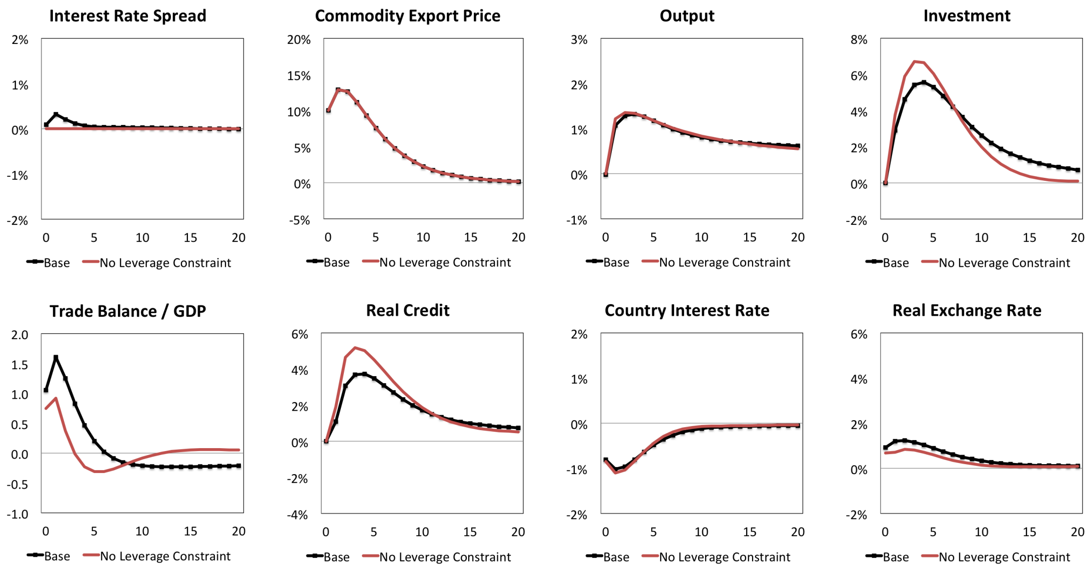

FIGURE 13: Impulse response to a 10% commodity export price shock - No Leverage Constraint. Note: Marked black (solid red) lines show point estimates of impulse responses for emerging economies for the model in the baseline (alternative) scenario. Model estimates are the average of impulse responses across countries.

Country interest rate and working capital channels. Finally, I evaluate if the country interest and working capital channels can explain the different effects in emerging and advanced economies. To do that, I calibrate the firms' working capital parameters and country interest rate process for each emerging country using the average obtained in the advanced countries and I keep all the other estimated parameters equal to the baseline estimation. The results can be see in figure 14. It shows that the bulk of the difference in impulse responses to commodity price shocks is explained by the interaction between the working capital and the interest rate channel.

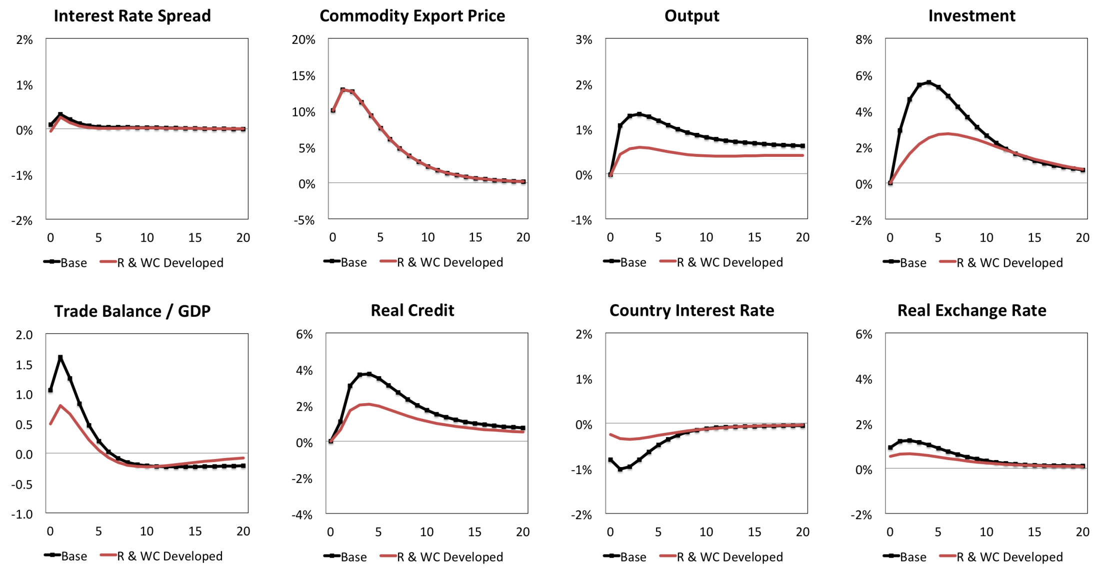

FIGURE 14: Impulse response to a 10% commodity export price shock - Working Capital Constraint parameters and R^* process for Advanced Economies.
Note: Marked black (solid red) lines show point estimates of impulse responses for emerging economies for the model in the baseline (alternative) scenario. Model estimates are the average of impulse responses across countries.

It is clear from the results that the most relevant channels for the transmission of commodity price shocks are the interest rate and working capital channels. Moreover, turning off the balance sheet mismatch and the financial accelerator channels almost do not change the impulse responses, which leads to the conclusion that although theoretically plausible and heavily explored after the recent financial crisis, these frictions do not have relevant quantitative implications in the environment proposed in this paper. This result is related to the response of interest rate spreads, which are small and temporary. Consequently, most of the effects stem from the country interest rate, which experiences a strong and persistent reduction after a commodity price shock; and from differences in working capital constraints, which are how changes in interest rates are transmitted to the real economy through the wedge that they create in firms' hiring and investment decisions.

6 Conclusion and Future Research

This paper uses two different methodologies to evaluate the effects of commodity price shocks on small open commodity exporters. First, I estimate a panel VAR and show that commodity price shocks are important sources of business cycles in small open commodity exporters and their effect on real activity, credit and country interest rate is stronger on emerging than on advanced economies. After that, I propose a theoretical framework to evaluate the contribution of different financial frictions to the amplification of commodity price shocks. The model is a three-sector small open economy model with financial intermediaries to be able to account for the dynamics of small open commodity producers. I estimate the model using Bayesian methods and show that it is able to account for the different behavior of emerging and advanced economies, generating impulse responses that are similar to the ones generated by the panel VAR. Moreover, using the estimated model to evaluate the most important financial friction for the amplification of commodity price shocks, I find that the interaction between their effect on the country interest rate through a lower country risk and the presence of different working capital constraints explains the bulk of the difference in the effects on real activity and credit among emerging and advanced economies. Additionally, the presence of balance sheet mismatches and leverage constraints for foreign borrowing in the banking sector do not play a significant role in the transmission of commodity price shocks to the real economy.

The quantitative small role of the financial accelerator is coherent with previous works that have evaluated this issue (Kocherlakota (2000) and Cordoba and Ripoli (2004) for example). More recently, Brunnermeier and Sannikov (2014) argued that nonlinearities and asymmetries are crucial to generate quantitatively relevant amplification and thus a full characterization of system dynamics far away from the steady state is needed to get accurate results because in that case prices would move more strongly. However, the rich environment proposed in this paper makes it impracticable to work with higher order approximations if we want to perform Bayesian estimation. On the other hand, other features that might lead to a stronger and more persistent effect on spreads such as shocks to net worth, a maturity mismatch in banks' balance sheets or a time-varying leverage constraint might also make the financial accelerator more important quantitatively. These are planned for future research.

There are other dimensions in which the model could be extended. First, I do not consider any countercyclical policies that might be implemented by governments. Understanding how different monetary and fiscal policy measures could interact with the channels studied in this work would allow a more complete evaluation of the transmission mechanism of commodity price shocks. Moreover, I would be able to study optimal monetary and fiscal policies in countries where this particular shocks are very important. Second, the fact that the main transmission channel is the effect on the interest rate for foreign borrowing might give additional support to countercyclical capital control policies as the ones advocated recently by the IMF and several authors (see for example Ostry, Ghosh, Chamon and Qureshi (2011), Costinot, Lorenzoni and Werning (2014), Schmitt-Grohe and Uribe (2015) and many others). In fact, Shousha and Sundaresan (2015) show that the imposition of countercyclical capital controls in Brazil had real effects, especially in investment, a result in line with my findings. However, a welfare analysis of the effects of capital controls is beyond the scope of this work and would depend also on which sectors are the most affected by these policies and the externalities generated by them. While all these issues would require an even more comprehensive framework, they represent exciting opportunities for future research.

References

Akinci, Ozge. 2011. "A Note on the Estimation of the Atemporal Elasticity of Substitution Between Tradable and Nontradable Goods." Manuscript.

Akinci, Ozge. 2013. "Global Financial Conditions, Country Spreads and Macroeconomic Fluctuations in Emerging Countries" *Journal of International Economics*, 91(2): 358-71.

An, Sungbae, and Frank Schorfheide. 2007. "Bayesian Analysis of DSGE Models." *Econometric Reviews*, 26(2-4): 113-72.

Bastourre, Diego, Jorge Carrera, Javier Ibarlucia, and Mariano Sardi. 2013. "Common Drivers in Emerging Market Spreads and Commodity Prices." Manuscript.

Cespedes, Luis Felipe, and Andres Velasco. 2012. "Macroeconomic Performance During Commodity Price Booms and Busts." *IMF Economic Review*, 60(4): 570-99.

Charnavoki, Valery, and Juan J. Dolado. 2014. "The Effects of Global Shocks on Small Commodity-Exporting Economies: Lessons from Canada." *American Economic Journal: Macroeconomics*, 6(2): 207-37.

Chen, Yu-chin, and Kenneth S. Rogoff. 2003. "Commodity Currencies." *Journal of International Economics*, 60(1): 133-60.

Chen, Yu-chin, Kenneth S. Rogoff, and Barbara Rossi. 2010. "Can Exchange Rates Forecast Commodity Prices?" *Quarterly Journal of Economics*, 125(3): 1145-94.

Cheng, Ing-Haw, and Wei Xiong. 2014. "Financialization of Commodity Markets." *Annual Review of Financial Economics*, 6: 419-41.

Choi, Woon Guy, and David Cook. 2004. "Liability Dollarization and the Bank Balance Sheet Channel." *Journal of International Economics*, 64(2): 247-75.

Collier, Paul, and Benedikt Goderis. 2012. "Commodity Prices and Growth: An Empirical Investigation." *European Economic Review*, 56: 1241-60.

Cordoba, Juan-Carlos, and Marla Ripoll. 2004. "Credit Cycles Redux." *International Economic Review*, 45(4): 1011-46.

Costinot, Arnaud, Guido Lorenzoni, and Ivan Werning. 2014. "A Theory of Capital Controls as Dynamic Terms-of-Trade Manipulation." *Journal of Political Economy*, 122(1): 77-128.

Deaton, Angus, and Ronald Miller. 1996. "International Commodity Prices, Macroeconomic Performance, and Policies in Sub-Saharan Africa." *Journal of African Economies*, 5(3): 99-191.

Di Bella, Gabriel, Lawrence Norton, Joseph Ntamatungiro, Sumiko Ogawa, Issouf Samake, and Marika Santoro. 2015. "Energy Subsidies in Latin America and the Caribbean: Stocktaking and Policy Challenges." *IMF Working paper* No. 15/30.

Eichengreen, Barry, and Ricardo Hausmann. 1999. "Exchange rates and financial fragility," Proceedings - Economic Policy Symposium - Jackson Hole, Federal Reserve Bank of Kansas City, pgs 329-368.

Eichengree, Barry, Ricardo hausmann, and Ugo Panizza. 2007. "Currency Mismatches, Debt Intolerance and Original Sin: Why They Are Not the Same and Why it Matters." in Sebastian Edwards, *Capital Controls and Capital Flows in Emerging Economies*, University of Chicago Press.

Fernandez, Andres, and Adam Gulan. 2014. "Interest Rates and Business Cycles in Emerging Economies: The Role of Financial Frictions." *American Economic Journal: Macroeconomics*, 7(3): 153-88.

Fernandez, Andres, Andres Gonzalez, and Diego Rodriguez. 2015. "Sharing a Ride on the Commodities Roller Coaster: Common Factors in Business Cycles of Emerging Economies." Manuscript.

Fornero, Jorge, Markus Kirchner, and Andres Yany. 2014. "Terms of Trade Shocks and Investment in Commodity-Exporting Economies." Manuscript.

Garca-Cicco, Javier, Roberto Pancrazi, and Martn Uribe. 2010. ”Real Business Cycles in Emerging Countries?” *American Economic Review*, 100(5): 2510-31.

Gertler, Mark, Simon Gilchrist, and Fabio Natalucci. 2007. ”External Constraints on Monetary Policy and the Financial Accelerator.” *Journal of Money, Credit and Banking*, 39(2-3): 295-330.

Gertler, Mark, and Peter Karadi. 2011. ”A Model of Unconventional Monetary Policy.” *Journal of Monetary Economics*, 58(1): 17-34.

Greenwood, Jeremy, Zvi Hercowitz, and Gregory W. Huffman. 1988. ”Investment, Capacity Utilization, and the Real Business Cycle.” *American Economic Review*, 78(3): 402-17.

Jacks, Davis S., and Martin Stuermer. 2015. ”What Drives Commodity Prices in the Long Run?” Manuscript.

Justiniano, Alejandro, and Bruce Preston. 2010. ”Can Structural Small Open Economy Models Account for the Influence of Foreign Disturbances?” *Journal of International Economics*, 81(1): 61-74.

Kocherlakota, Narayana R. 2000. ”Creating Business Cycles Through Credit Constraints.” *Federal Reserve Bank of Minneapolis Quarterly Review*, 24(3):2-10.

Kose, M. Ayhan. 2002. ”Explaining business cycles in small open economies ?How much do world prices matter??” *Journal of International Economics*, 56(2): 299-327.

Liu, Zheng, Pengfei Wang, and Tao Zha. 2013. ”Land-Price Dynamics and Macroeconomic Fluctuations.” *Econometrica* 81(3): 1147-84.

Lubik, Thomas A., and Wing Leong Teo. 2005. ”Do World Shocks Drive Domestic Business Cycles? Some Evidence from Structural Estimation.” Manuscript.

Martins, Guilherme B., and Joao M. Salles. 2011. ”The Credit Dimension of Monetary Policy: Lessons from Developing Economies under Sudden Stops.” Manuscript, Columbia University.

Mendoza, Enrique. 1995. "The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations." *International Economic Review*, 36(1): 101-37.

Na, Seunghoon. 2015. "Business Cycles and Labor Income Shares in Emerging Economies." Manuscript.

Neumeyer, Pablo A., and Fabrizio Perri. 2005. "Business cycles in emerging economies: the role of interest rates." *Journal of Monetary Economics*, 52(2): 345-80.

Nickel, Stephen J. 1981. "Biases in Dynamic Models with Fixed Effects.", *Econometrica*, 49(6): 1417-26.

Ostry, Jonathan D., Atish Ghosh, Marcos Chamon, and Mahvash Qureshi. 2011. "Capital Controls: When and Why?" *IMF Economic Review*, 59(3): 562-580.

Schmitt-Grohe, Stephanie, and Martin Uribe. 2003. "Closing small open economy models." *Journal of International Economics*, 61(1): 163-85.

Schmitt-Grohe, Stephanie, and Martin Uribe. 2015. "Downward Nominal Wage Rigidity, Currency Pegs, and Involuntary Unemployment." *Journal of Political Economy*, forthcoming.

Schmitt-Grohe, Stephanie, and Martin Uribe. 2015. "How Important are Terms of Trade Shocks?" NBER Working Paper 21253.

Schorfheide, Frank. 2000. "Loss function-based evaluation of DSGE models." *Journal of Applied Econometrics*, 15(6):645?670.

Shousha, Samer, and Savitar Sundaresan. 2015. "The Real Consequences of Countercyclical Capital Controls." Manuscript.

Uribe, Martin. 1997. "Exchange-Rate-Based Inflation Stabilization: The Initial Real Effects of Credible Plans." *Journal of Monetary Economics*, 39(2): 197-221.

Uribe, Martin, and Vivian Z. Yue. 2006. "Country Spreads And Emerging Countries: Who Drives Whom?" *Journal of International Economics*, 69(1): 6-36.

A Data

The dataset includes quarterly data for Argentina, Brazil, Chile, Colombia, Peru and South Africa for Emerging Economies and Australia, Canada, New Zealand and Norway for Advanced Economies. The sample periods vary across countries.They are: Argentina, Australia, Canada, New Zealand and Norway 1994Q1-2013Q4, Brazil 1994Q2-2013Q4, South Africa 1995Q1-2013Q4, Colombia and Peru 1997Q1-2013Q4 and Chile 1999Q2-2011Q3.

Real Output and Real Investment: all the data are from national sources, deflated by each own deflator and seasonally adjusted using ARIMA X-12.

Trade Balance to GDP ratio: all the data are from national sources, dividing nominal trade balance by nominal GDP.

Real Credit: obtained by dividing nominal credit to non-financial sector by the CPI and seasonally adjusted using ARIMA X-12. For Argentina, Australia, Brazil, Canada, Norway and South Africa, nominal credit to non-financial sector is obtained from the BIS in http://www.bis.org/statistics/totcredit.htm. For Chile, Colombia, Peru and New Zealand, nominal credit to non-financial sector is obtained from each country's Central Bank. CPI is obtained from national statistical agencies.

Real Interest Rate: for emerging economies, the country specific interest rate in the international financial markets, R, is measured as the sum of J. P. Morgan's EMBI+ sovereign spread and the U.S. real interest rate. The U.S. real interest rate is measured by the interest rate on the three-month U.S. Treasury bill minus a measure of the U.S. expected inflation. EMBI+ is a composite index of different U.S. dollar-denominated bonds on four markets: Brady bonds, Eurobonds, U.S. dollar local markets and loans. The spreads are computed as an arithmetic, market-capitalization-weighted average of bond spreads over the U.S. Treasury bonds of comparable duration. For advanced economies, the country interest rate is measured by the interest rate on the three-month bill (Central Bank policy rate when this is not available) minus expected inflation (12-month accumulated inflation when this is not available).

Real Exchange Rates: obtained from the BIS effective exchange rate indices database, particularly the quarterly average of the broad indices. Nominal EERs are calculated as geometric weighted averages of bilateral exchange rates. Real EERs are the same weighted averages of bilateral exchange rates adjusted by relative consumer prices. The weighting pattern is time-varying, and the most recent weights are based on trade in the 2008-10 period (see broad and narrow weights in http://www.bis.org/statistics/eer.htm). An increase in the index indicates an appreciation.

Real Commodity Export Price: calculated following Deaton and Miller (1996) and Chen and Rogoff (2003) through 5 steps: (i) I find the equivalence between SITC level 4 groups and the IMF commodities database (composed by 51 commodities); (ii) I calculate for each country the value of each primary commodity exports using the UN COMTRADE database, which provides annual trade data for SITC level 4 groups, and take the average; (iii) I calculate the weights for each commodity by dividing its average value of exports for each commodity by the average total value of primary commodity exports; (iv) I use the weights to compute a geometric weighted-average of (US-dollar based) monthly nominal commodity export prices; and (v) I calculate the real commodity price index by dividing the nominal price index by the U.S. import price of manufactured articles from industrialized countries.

Figure A.1 shows the average time series of all detrended variables for each group of countries and the IMF real commodity price.

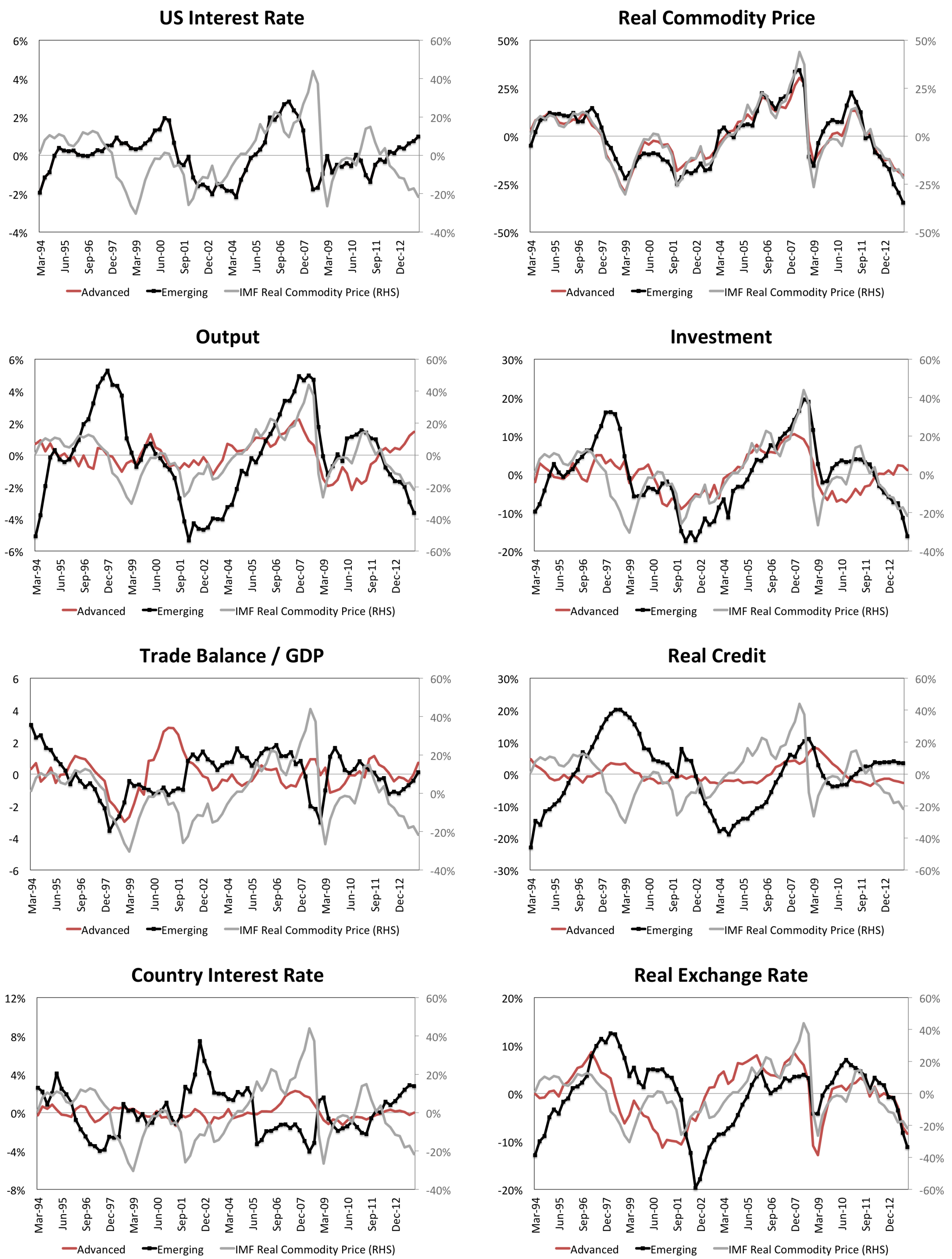

FIGURE A.1: Business Cycles and Commodity Prices.

Note: The data are the simple average of the indicators for the Emerging (Argentina, Brazil, Chile, Colombia, Peru and South Africa) and Advanced (Australia, Canada, New Zealand and Norway) main commodity exporters. The data are sampled quarterly from 1994:Q1-2013:Q4.

B Equilibrium Conditions

- Lagrange multiplier

$$\lambda_t = U'_t A_1(c_t^T, c_t^N) - b\beta U'_{t+1} A_1(c_{t+1}^T, c_{t+1}^N) \tag{B.1}$$

where

$$U'_t = \left(c_t - \frac{h_{CM,t}^{\omega^{CM}}}{\omega^{CM}} - \frac{h_{T,t}^{\omega^T}}{\omega^T} - \frac{h_{N,t}^{\omega^N}}{\omega^N} \right)^{-\sigma} \tag{B.2}$$

- Labor supply

$$E_t[\lambda_{t+1} w_{CM,t+1}] = E_t[U'_{t+1} h_{CM,t+1}^{\omega^{CM}-1}] \tag{B.3}$$

$$E_t[\lambda_{t+1} w_{T,t+1}] = E_t[U'_{t+1} h_{T,t+1}^{\omega^T-1}] \tag{B.4}$$

$$E_t[\lambda_{t+1} w_{N,t+1}] = E_t[U'_{t+1} h_{N,t+1}^{\omega^N-1}] \tag{B.5}$$

- Price of nontradables

$$p_t^N = \frac{U'_t A_2(c_t^T, c_t^N) - b\beta U'_{t+1} A_2(c_{t+1}^T, c_{t+1}^N)}{U'_t A_1(c_t^T, c_t^N) - b\beta U'_{t+1} A_1(c_{t+1}^T, c_{t+1}^N)} \tag{B.6}$$

- Euler equation for household debt

$$\lambda_t = \beta R_t^* E_t \lambda_{t+1} \tag{B.7}$$

- Capital accumulation and investment demand

$$k_{j,t+1} = (1-\delta) k_{j,t} + i_{j,t} \left(1 - \frac{\phi^j}{2} \left(\frac{i_{j,t}}{i_{j,t-1}} - 1 \right)^2 \right) \tag{B.8}$$

$$\lambda_t q_{j,t} = \beta E_t \left\{ \lambda_{t+1} \left[q_{j,t+1}(1-\delta) + \alpha^j \frac{p_{t+1}^j y_{t+1}^j}{k_{j,t+1}} \right] \right\} \tag{B.9}$$

$$E_t\left\{\lambda_{t+1}q_{j,t+1}\left[1-\frac{\phi^j}{2}\left(\frac{i_{j,t+1}}{i_{j,t}}-1\right)^2-\phi^j\left(\frac{i_{j,t+1}}{i_{j,t}}\right)\left(\frac{i_{j,t+1}}{i_{j,t}}-1\right)\right]\right\}+$$

$$\beta E_t\left\{\lambda_{t+2}q_{j,t+2}\phi^j\left(\frac{i_{j,t+2}}{i_{j,t+1}}\right)^2\left(\frac{i_{j,t+2}}{i_{j,t+1}}-1\right)\right\}=E_t[\lambda_{t+1}(1+\eta^j\xi^j_{t+1})] \quad \text{(B.10)}$$

for $j=CM,T,N$

- Production function

$$y_t^{CM}=a_{CM,t}k_{CM,t}^{\alpha^{CM}}h_{CM,t}^{1-\alpha^{CM}} \quad \text{(B.11)}$$

$$y_t^{T}=a_{T,t}k_{T,t}^{\alpha^{T}}cm_{T,t}^{\gamma^T}h_{T,t}^{1-\alpha^{T}-\gamma^T} \quad \text{(B.12)}$$

$$y_t^{N}=a_{N,t}k_{N,t}^{\alpha^{N}}h_{N,t}^{1-\alpha^{N}} \quad \text{(B.13)}$$

- Commodities domestic demand

$$\left(1+\eta^T\frac{R_t-1}{R_t}\right)p_t^{CM}=\gamma^T\frac{y_t^T}{cm_{T,t}} \quad \text{(B.14)}$$

- Labor demand

$$\left(1+\eta^{CM}\frac{R_t-1}{R_t}\right)w_{CM,t}=(1-\alpha^{CM})\frac{p_t^{CM}y_t^{CM}}{h_{CM,t}} \quad \text{(B.15)}$$

$$\left(1+\eta^{T}\frac{R_t-1}{R_t}\right)w_{T,t}=(1-\alpha^{T}-\gamma^T)\frac{y_t^{T}}{h_{T,t}} \quad \text{(B.16)}$$

$$\left(1+\eta^{N}\frac{R_t-1}{R_t}\right)w_{N,t}=(1-\alpha^{N})\frac{p_t^{N}y_t^{N}}{h_{N,t}} \quad \text{(B.17)}$$

- Working capital

$$p_t^N(d_t^{CM}-R_{t-1}d_{t-1}^{CM})=\eta^{CM}\left(\frac{i_{CM,t}+w_{CM,t}h_{CM,t}}{R_t}-(i_{CM,t-1}+w_{CM,t-1}h_{CM,t-1})\right) \quad \text{(B.18)}$$

$$p_t^N(d_t^{T}-R_{t-1}d_{t-1}^{T})=\eta^{T}\left(\frac{p_t^{CM}cm_{T,t}+i_{T,t}+w_{T,t}h_{T,t}}{R_t}-(p_{t-1}^{CM}cm_{T,t-1}+i_{T,t-1}+w_{T,t-1}h_{T,t-1})\right) \quad \text{(B.19)}$$

$$p_t^N(d_t^N - R_{t-1}d_{t-1}^N) = \eta^N \left(\frac{i_{N,t} + w_{N,t}h_{N,t}}{R_t} - (i_{N,t-1} + w_{N,t-1}h_{N,t-1}) \right) \quad \text{(B.20)}$$

- Tradables market clearing

$$y_t^T = c_t^T + i_t + tb_t^T \quad \text{(B.21)}$$

- Commodities trade balance

$$tb_t^{CM} = p_t^{CM}(y_t^{CM} - cm_{T,t}) \quad \text{(B.22)}$$

- Trade balance

$$tb_t = tb_t^T + tb_t^{CM} \quad \text{(B.23)}$$

- Country interest rate

$$r_t^* = \bar{r^*} + \psi^D(e^{d_t^* - \bar{d}^*} - 1) + \psi^{CM}(e^{p_t^{CM} - \bar{p}^{CM}} - 1) + \epsilon_t^{r^*} \quad \text{(B.24)}$$

- Total net foreign assets

$$d_t^* = d_t^{*H} + d_t^{*B} \quad \text{(B.25)}$$

- Current account

$$ca_t = tb_t - r_t^* d_t^* \quad \text{(B.26)}$$

- Net foreign assets evolution

$$ca_t = d_{t+1}^* - d_t^* \quad \text{(B.27)}$$

- Banking sector balance sheet

$$n_t + d_t^{*B} = p_t^N d_t \quad \text{(B.28)}$$

- Total debt

$$d_t = d_t^{CM} + d_t^T + d_t^N \quad \text{(B.29)}$$

- Net worth evolution

$$n_t = \theta^B \left\{ \left(R_t \frac{p_t^N}{p_{t-1}^N} - R_{t-1}^* \right) p_{t-1}^N d_{t-1} + R_{t-1}^* n_{t-1} \right\} + \nu^B p_t^N d_{t-1} \tag{B.30}$$

- Leverage constraint

$$p_t^N d_t = \phi^B n_t \tag{B.31}$$

- Market clearing nontradables

$$y_t^N = c_t^N \tag{B.32}$$

- Market clearing labor

$$h_t = h_{CM,t} + h_{T,t} + h_{N,t} \tag{B.33}$$

- Total investment

$$i_t = i_{CM,t} + i_{T,t} + i_{N,t} \tag{B.34}$$

- Total output

$$y_t = tb_t^{CM} + y_t^T + p_t^N y_t^N \tag{B.35}$$

- Exogenous shocks

$$log(p_{t+1}^{CM}) - log(\bar{p}^{CM}) = \rho_1^{PCM} log(p_t^{CM} - log(\bar{p}^{CM})) + \rho_2^{PCM} log(p_{t-1}^{CM} - log(\bar{p}^{CM})) + \epsilon_t^{PCM} \tag{B.36}$$

$$log(a_{CM,t+1}) = \rho^{CM} log(a_{CM,t}) + \epsilon_t^{CM} \tag{B.37}$$

$$log(a_{T,t+1}) = \rho^T log(a_{T,t}) + \epsilon_t^T \tag{B.38}$$

$$log(a_{N,t+1}) = \rho^N log(a_{N,t}) + \epsilon_t^N \tag{B.39}$$

C Steady State Calculation

First, normalize r^* to the calibrated value. Using the foreign sector equation and household euler equation we can get

$$d^* = \bar{d^*} \tag{C.1}$$

$$ca = 0 \tag{C.2}$$

$$tb = r^* d^* \tag{C.3}$$

$$\beta = \frac{1}{R^*} \tag{C.4}$$

From the net worth evolution equation we then get

$$R = \frac{1 - \theta^B R^* - \nu^B \phi^B}{\phi^B \theta^B} + R^* \tag{C.5}$$

From the investment demand equations we obtain

$$q_{CM} = \left(1 + \eta^{CM} \frac{R_t - 1}{R_t}\right) \tag{C.6}$$

$$q_T = \left(1 + \eta^T \frac{R_t - 1}{R_t}\right) \tag{C.7}$$

$$q_N = \left(1 + \eta^N \frac{R_t - 1}{R_t}\right) \tag{C.8}$$

and the auxiliary variables representing the shadow rent of capital

$$u_{CM} \equiv \alpha^{CM} \frac{p^{CM} y^{CM}}{k_{CM}} = q_{CM}(R^* - 1 + \delta) \tag{C.9}$$

$$u_T \equiv \alpha^T \frac{y^T}{k_T} = q_T(R^* - 1 + \delta) \tag{C.10}$$

$$u_N \equiv \alpha^N \frac{p^N y^N}{k_N} = q_N(R^* - 1 + \delta) \tag{C.11}$$

Using the output equation and the definition of the shadow rental rate of capital we get the capital to hours ratio for the commodity sector

$$\frac{k_{CM}}{h_{CM}} = \left(\frac{\left(1+\eta^{CM}\frac{R_t-1}{R_t}\right) u_{CM}}{\alpha^{CM} p^{CM} a_{CM}} \right)^{\frac{1}{\alpha^{CM}-1}} \tag{C.12}$$

From the labor demand by firms in the commodity sector we then get

$$w_{CM} = \frac{(1-\alpha^{CM}) p^{CM} a_{CM}}{\left(1+\eta^{CM}\frac{R_t-1}{R_t}\right)} \left(\frac{k_{CM}}{h_{CM}}\right)^{\alpha^{CM}} \tag{C.13}$$

Using the definition of the shadow rental rate of capital and the demand for commodities in the final tradable goods sector, its output can be rewritten as

$$y^T = \theta^T a_T k_T^{\alpha^T+\gamma^T} h_T^{1-\alpha^T-\gamma^T} \tag{C.14}$$

where $\theta^T = \left(\frac{\gamma^T u_T}{\alpha_T p^{CM}}\right)^{\gamma^T}$

Using the previous equation and the definition of the shadow rental rate of capital we get the capital to hours ratio for the final tradable goods sector

$$\frac{k_T}{h_T} = \left(\frac{\left(1+\eta^{T}\frac{R-1}{R}\right) u_{T}}{\alpha^{T} \theta^{T} a_{T}} \right)^{\frac{1}{\alpha^{T}+\gamma^T-1}} \tag{C.15}$$

From the labor demand by firms in the final tradable goods sector sector

$$w_T = \frac{(1-\alpha^T-\gamma^T)\theta^T a_T}{\left(1+\eta^{T}\frac{R-1}{R}\right)} \left(\frac{k_T}{h_T}\right)^{\alpha^T+\gamma^T} \tag{C.16}$$

Then we have to solve numerically the following system of equations to obtain p^N, $\left(\frac{k_N}{h_N}\right)$, h_N and $reer$

$$u_N = p^N \alpha^N a_N \left(\frac{k_N}{h_N}\right)^{\alpha^N-1} \tag{C.17}$$

$$\left(1+\eta^N\frac{R-1}{R}\right)\left(\frac{reer}{1-\beta b} h_N^{\omega^N-1}\right) = p^N(1-\alpha^N)a_N\left(\frac{k_N}{h_N}\right)^{\alpha^N} \tag{C.18}$$

$$reer = (\chi^\mu + (1-\chi)^\mu((p^N)^{1-\mu}))^{1/(1-\mu)} \tag{C.19}$$

$$p^N = \left(\frac{1-\chi}{\chi}\right)\left(\frac{a_T\theta^T\left(\frac{k_T}{h_T}\right)^{\alpha^T+\gamma^T}\left(\frac{w_T(1-\beta b)}{reer}\right)^{\omega^T-1} - i_T - i_{CM} - \delta\left(\frac{k_N}{h_N}\right)h_N - tb + tb^{CM}}{a_N\left(\frac{k_N}{h_N}\right)^{\alpha^N} h_N}\right)^{\frac{1}{\mu}} \tag{C.20}$$

where $i_T = \delta\left(\frac{k_T}{h_T}\right)\left(\frac{w_T(1-\beta b)}{reer}\right)^{\omega^T-1}$, $i_{CM} = -\delta\left(\frac{k_{CM}}{h_{CM}}\right)\left(\frac{w_{CM}(1-\beta b)}{reer}\right)^{\omega^{CM}-1}$,

$$tb^{CM} = p^{CM}\left(a_{CM}\left(\frac{k_{CM}}{h_{CM}}\right)^{\alpha^{CM}}\left(\frac{w_{CM}(1-\beta b)}{reer}\right)^{\omega^{CM}-1} - \left(\frac{\gamma^T u_T}{\alpha^T p^{CM}\left(1+\eta^T\frac{R_t-1}{R_t}\right)}\right)\left(\frac{k_T}{h_T}\right)\left(\frac{w_T(1-\beta b)}{reer}\right)^{\omega^T-1}\right)$$

Using the labor supply equilibrium conditions

$$h_{CM} = \left(\frac{(1-\beta b)w_{CM}}{rer}\right)^{\frac{1}{\omega^{CM}-1}} \tag{C.21}$$

$$h_T = \left(\frac{(1-\beta b)w_T}{rer}\right)^{\frac{1}{\omega^T-1}} \tag{C.22}$$

$$w_N = \frac{rer}{1-\beta b}h_N^{\omega^N-1} \tag{C.23}$$

Using the previous equations

$$k_{CM} = \left(\frac{k_{CM}}{h_{CM}}\right)h_{CM} \tag{C.24}$$

$$k_T = \left(\frac{k_T}{h_T}\right)h_T \tag{C.25}$$

$$k_N = \left(\frac{k_N}{h_N}\right)h_N \tag{C.26}$$

Combining the definition of the shadow rental rate of capital and the demand for commodities in the tradable final goods sector

$$cm_T = \left(\frac{\gamma^T u_T}{\alpha^T p^{CM}\left(1+\eta^T\frac{R_t-1}{R_t}\right)}\right)k_T \tag{C.27}$$

$$tb^{CM} = p^{CM}(y^{CM} - cm_T) \tag{C.28}$$

From the trade balance equation

$$tb^T = tb - tb^{CM} \tag{C.29}$$

From the capital accumulation equations we get

$$i_{CM} = \delta k_{CM} \tag{C.30}$$

$$i_T = \delta k_T \tag{C.31}$$

$$i_N = \delta k_N \tag{C.32}$$

Sectoral outputs are given by

$$y^{CM} = a_{CM} k_{CM}^{\alpha^{CM}} h_{CM}^{1-\alpha^{CM}} \tag{C.33}$$

$$y^T = a_T k_T^{\alpha^T} cm_T^{\gamma^T} h_T^{1-\alpha^T-\gamma^T} \tag{C.34}$$

$$y^N = a_N k_N^{\alpha^N} h_N^{1-\alpha^N} \tag{C.35}$$

Using the equilibrium equation for the price of nontradables

$$c^T = \left(\frac{\chi}{1-\chi} p^N \right)^{\mu} y^N \tag{C.36}$$

Nontradable market clearing yields

$$c^N = y^N \tag{C.37}$$

Using the working capital constraints we can get firms' borrowing from the banking sector

$$d^{CM} = \eta^{CM} \left(\frac{i_{CM} + w_{CM} h_{CM}}{p^N R} \right) \tag{C.38}$$

$$d^T = \eta^T \left(\frac{p^{CM} cm_T + i_T + w_T h_T}{p^N R} \right) \tag{C.39}$$

$$d^N = \eta^N \left(\frac{i_N + w_N h_N}{p^N R} \right) \tag{C.40}$$

$$d = d^{CM} + d^T + d^N \tag{C.41}$$

Banks' foreign borrowing and net worth are then given by

$$d^{*B} = \frac{(\phi^B - 1)}{\phi^B} p^N d \tag{C.42}$$

$$n = p^N d - d^{*B} \tag{C.43}$$

Using the equation for total foreign borrowing

$$d^{*H} = d^* - d^{*B} \tag{C.44}$$

Aggregate hours, investment and GDP are given by

$$h = h_{CM} + h_T + h_N \tag{C.45}$$

$$i = i_{CM} + i_T + i_N \tag{C.46}$$

$$y = tb^{CM} + y^T + p^N y^N \tag{C.47}$$

Using the definition of the consumption basket

$$c = [\chi (c^T)^{1-1/\mu} + (1-\chi)(c^N)^{1-1/\mu}]^{\frac{1}{1-1/\mu}} \tag{C.48}$$

Using the optimality conditions from the households problem we then get

$$U' = \left(c - \frac{h_{CM}^{\omega^{CM}}}{\omega^{CM}} - \frac{h_T^{\omega^T}}{\omega^T} - \frac{h_N^{\omega^N}}{\omega^N} \right)^{-\sigma} \tag{C.49}$$

$$A_1(c^T, c^N) = \chi \left(\frac{c}{c^T} \right)^{\frac{1}{\mu}} \tag{C.50}$$

$$A_2(c^T, c^N) = (1-\chi) \left(\frac{c}{c^N} \right)^{\frac{1}{\mu}} \tag{C.51}$$

$$\lambda_t = (1 - b\beta)U' A_1(c^T, c^N) \tag{C.52}$$