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ABSTRACT

Essays in Macroeconomics

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The goal of this dissertation is to improve our understanding of the driving forces behind short-term movements in important aggregate variables such as exports, imports, the trade balance, output, investment, and employment. The first chapter contrasts the cyclical behavior of the trade balance and trade flows in a group of emerging and a group of developed economies. I find that: (i) unlike developed open economies, emerging economies import a substantial part of their equipment and export few or only a selective set of capital goods, (ii) capital good imports display large procyclical business cycle swings, and (iii) unlike developed countries, exports are acyclical in emerging economies. Previous work has shown that emerging economy business cycles are also characterized by strongly countercyclical trade balances, countercyclical real interest rates, and real interest rates that are negatively correlated with future output. I present a small open economy business cycle model that is consistent with these empirical regularities. The key model feature is a two-sector set-up that incorporates the stylized facts that emerging economies import capital goods and exports are acyclical.

The second chapter of the dissertation examines the business cycle properties of aggregate job and worker flows variables and asks how different kind of shocks (such as technology, monetary and demand shocks) affect the job finding probability of an unemployed person, the job separation probability of an employed person and the number of jobs created and destroyed in a given quarter. We identify the demand and supply shocks by restricting the short-run responses of output and the price level. On the demand side we disentangle a monetary and non-monetary shock by restricting the response of the interest rate. The responses of labor market variables are similar across shocks: expansionary shocks increase job creation, the hiring rate, vacancies, and hours. They decrease job destruction and the separation rate. Supply shocks have more persistent effects than demand shocks. Demand and supply shocks are equally important in driving business cycle fluctuations of labor market variables. Our findings for demand shocks are robust to alternative identification schemes involving the response of labor productivity at different horizons and an alternative specification of the VAR. However, supply shocks identified by restricting the medium-run or long-run response of labor productivity do not have a clear cut response on the labor market variables.

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CHAPTER 1

Introduction

The goal of this dissertation is to improve the profession's understanding of the business cycle. The innovation of the first chapter is to explore the composition and cyclicality of exports and imports of emerging economies and highlight differences with a group of developed economies. From the trade data I observe that in a typical emerging economy capital good imports are very volatile and procyclical (similar to what is observe in developed economies), whereas exports are acyclical (unlike the procyclical exports observed in developed economies). The chapter then studies the dynamics of savings and investment in a model environment where countries import part of the capital stock.

The second chapter of the dissertation examines the statistical properties of aggregate job and worker flows variables and asks how different kind of shocks (such as technology, monetary and demand shocks) affect the job finding probability of an unemployed person, the job separation probability of an employed person and the number of jobs created and destroyed in a given quarter.

CHAPTER 2

The Composition and Cyclicality of Trade Flows and Emerging Economy Business Cycles

2.1. Introduction

Business cycles differ across emerging and developed economies.[1] Trade balances are strongly countercyclical in emerging economies but display little cyclicality in developed economies.[2] General equilibrium models of a small open economy with incomplete markets and optimizing agents that have been successful in replicating the dynamics of the trade balance in developed economies cannot account for these observations. In the intertemporal equilibrium approach to business cycle analysis, consumer optimization endogenously determines the correlation between external accounts and output.[3] For the trade balance to be countercyclical the pro-borrowing effect induced by for example an expansionary positive productivity shock must dominate the pro-saving effect. Standard small-open economy business cycle models do not give rise to strongly countercyclical trade balances. Even the small open economy model with the type of preferences proposed in Greenwood,

[1]Aside from the people thanked in the Acknowledgements, this chapter has also benefitted from the remarks of Jon Heathcote and workshop participants at the Society for Economic Dynamics in Vancouver, Northwestern University, the Board of Governors of the Federal Reserve, Lehman Brothers, Bowling Green University, Georgetown University, the Bank for International Settlements, the Bank of Norway, the Bank of Portugal and the University of Amsterdam.

[2]Also, real interest rates are more negatively correlated with current and future output in emerging economies.

[3]An older literature focuses on models with strong income effects on imports to generate a countercyclical trade balance.

Hercowitz, and Huffman (1988)- which remove wealth effects and have been a popular shortcut to generate a less procyclical trade balance- gives rise to at most a moderately countercyclical trade balance.[4]

This paper takes a different approach from earlier work. The motivation stems from the fact that emerging economies export few or only a selective set of capital goods and import a considerable amount of capital goods, both in terms of overall imports and gross domestic product (GDP). This stands in sharp contrast to the trade structure of developed economies. In those countries, exports and imports of capital goods are roughly equal. I subsequently examine the role this asymmetry plays for business cycles in small open economies. This paper has therefore two objectives. First, I compare the size and business cycle properties of capital goods trade between emerging and developed economies. The second objective is to incorporate this trade structure in a standard small open economy models and show that such a model can more successfully replicate the business cycle properties of emerging economies.

In the first part of the paper I use disaggregate UN-NBER trade data to examine the components and cyclical behavior of capital goods trade. The following facts stand out. For both the set of emerging and developed economies, more than a third of all imports are capital goods. Capital good imports are also relatively large as a fraction of GDP. For both emerging and developed economies, the value of capital good imports corresponds to the portion of equipment investment in GDP. When looking at exports, however, the data reveals a striking difference between emerging and developed economies. In the case

[4]See Mendoza (1991), Correia, Neves, and Rebelo (1995) and Schmitt-Grohe and Uribe (2003).

of emerging countries, capital good exports are typically less than a tenth of total exports, compared to a third for industrialized economies.

Turning to the cyclical behavior of capital goods trade, I find that capital good imports and exports in both developed and emerging economies are about twice as volatile as investment measured as gross fixed capital formation from national accounts data. This is remarkable as investment is generally considered the most volatile component of GDP. More important for understanding the cyclical behavior of the trade balance is that capital good imports are very procyclical in both emerging and developed economies whereas total exports are procyclical in developed economies but acyclical in emerging economies. In fact, countries that were net capital good importers over the period 1980-2000, i.e. the emerging economies, have strongly countercyclical trade balances.

In the second part of the paper I propose a small open-economy business cycle model for an emerging economy. The key feature of the model is a two-sector set-up that incorporates the facts that emerging economies import equipment from abroad and capital goods play a limited role in exports. The model is otherwise similar to the standard small open economy model used in the literature. It has preferences and adjustment costs in line with those surveyed in Schmitt-Grohe and Uribe (2003). Unlike in their one-sector models, however, the productivity shock in the home sector does not make imported capital goods cheaper. Funding the same amount of aggregate investment in the two-sector model is hence relatively more expensive and the economy borrows more compared to the one-sector model. The trade balance therefore becomes countercyclical.

Literature review. This paper relates to a number of recent papers on emerging economy business cycles. Neumeyer and Perri (2005) focus on an extension of the small open economy model where firms must borrow to pay for a fraction of intermediate inputs before production takes place and interest rate shocks generate a big fraction of the output volatility.[5] Oviedo (2005), however, shows that interest-rate shocks cause business cycles only when the the level and volatility of the interest rate are high and when the interest rate is negatively correlated with output. Rather than concentrating on a particular deviation from the frictionless neoclassical model, Aguiar and Gopinath (2007) argue that the parameterization of the income process is different for emerging markets. In emerging economies, shocks to trend growth rather than transitory fluctuations around a stable trend are the primary source of business cycle fluctuations. The authors argue this is in sharp contrast with developed economies where the income process is primarily driven by transitory shocks. They show that the trade balance is countercyclical in a small open economy model where output fluctuations are mainly driven by permanent shocks. Following the permanent technology shock, savings goes down in anticipation of higher permanent income in the future. Garcia-Cicco, Pancrazi, and Uribe (2006) estimate the stochastic process of the unit root and transitory shocks over a longer sample period. Contrary to Aguiar and Gopinath (2007), they find that the small open economy real business cycle model does a poor job when the model is simulated with the shock processes estimated from a longer sample period.

The paper is organized as follows. Section 2.2 describes the data sources. Section 2.3 reproduces some of the earlier observations on business cycle fluctuations and presents the new facts. Section 2.4 presents small open economy models of developed and emerging economies. Section 2.5 calibrates the model. Section 2.6 studies the implications of the

[5] In Neumeyer and Perri (2005) firms must borrow to pay for a fraction of the wage bill; the crucial friction is that firms are required to put these funds in a non-interest-bearing escrow account.

two-sector model and makes a comparison with standard small open economy models. Section 2.7 concludes.

2.2. Description of Data

This section describes the different data sources. Table 3.1 summarizes all countries studied, together with the data sources and available sample periods of the different time series data. The first part of the section discusses the data sources, the second section describes the construction of capital good imports and exports from the trade data.

2.2.1. Data Sources

2.2.1.1. National Accounts Data. National accounts data are from the IMF International Financial Statistics (IFS). The emerging market classification follows the International Finance Corporation (IFC).[6] As in Neumeyer and Perri (2005), real variables for gross domestic product, consumption, gross fixed capital formation, imports and exports, are obtained by dividing nominal components of GDP by the GDP deflator.[7]

2.2.1.2. Trade Data. Feenstra, Lipsey, Deng, Ma, and Mo (2005) construct a set of bilateral trade data by commodity for the period 1962-2000.[8] These data are constructed

[6]The IFC continues to include new markets as they open their doors to foreign investment. Current IFC markets are: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela; China, Korea, Philippines, and Taiwan, China; India, Indonesia, Malaysia, Pakistan, Sri Lanka, and Thailand; Czech Republic, Egypt, Greece, Hungary, Israel, Jordan, Morocco, Nigeria, Poland, Portugal, Portugal, Russia, Saudi Arabia, Slovakia, Turkey, South Africa, Zimbabwe. See Standard and Poor report.

[7]Alternatively, import and export price indexes can be used to convert import and export values into real terms, or, in the case where the IFS does not offer import and exports prices, unit values indices (UVIs) are used. UVIs are computed as the ratio of the local currency value of exports or imports to volume (weight or quantity). A price index is calculated as an average of the proportionate changes in the prices of a specified set of items. UVIs, on the other hand, measure the change in the value of items regardless of whether the items are homogenous and can be affected by changes in the composition of the trade balance as well as changes in prices.

[8]See www.nber.org/data.

from United Nations trade data over two periods: (i) 1962-1983, where the data covers all trading partners and classification follows the Standard International Trade Classification (SITC) Rev.1 and (ii) UN comtrade data for 1984-2000, covering trade flows above \$100,000 dollar per year from 72 reporter countries classified by SITC Rev. 2. The dataset updates the Statistics Canada World Trade Database with that difference that Feenstra, Lipsey, Deng, Ma, and Mo (2005) give priority to the trade flows reported by the importing country. These are arguably more accurate than reports by the exporters. If the importer report is not available then the corresponding exporter report is used instead.

2.2.1.3. Interest Rates. The interest rate studied in the literature is a measure for the expected real interest rate at which governments in a country can borrow. Neumeyer and Perri (2005) and Uribe and Yue (2005) use secondary market prices of emerging market bonds to recover nominal U.S. dollar interest rates. Nominal rates are constructed as the 90-day U.S. T-bill rate plus the J.P. Morgan Emerging Markets Bond Index Plus (EMBI+). This index is the most comprehensive emerging markets debt benchmark index and the best representative of the full range of relatively liquid global fixed income investment opportunities. It tracks total returns for U.S. dollar-denominated debt instruments for 16 emerging market countries. As in Neumeyer and Perri (2005), I subtract U.S. GDP deflator inflation to get the real rates. For Argentina, there exists earlier data on prices of Argentine government dollar denominated bonds that allows the construction of a real interest rate series back to 1983:Q2. For a number of developed countries I use the lending rate published by the IFS. The lending rate is the bank rate that usually meets the short- and medium-term financing needs of the private sector. The real lending rate is then obtained by subtracting the country's GDP deflator inflation from the nominal rate.

2.2.2. Capital Good Imports and Exports constructed from Trade Data

The UN-NBER trade data are available by type of product but do not distinguish by use as intermediate, consumption, or investment good. Eaton and Kortum (2001) approximate trade in capital equipment by trade in goods associated with major equipment producing industries. They identify equipment-producing industries after consulting input-output tables and capital flows tables of domestic transactions for each of the three major capital-good producers (Germany, Japan, and the United States). The three industries identified as major capital goods producers are: (i) electrical machinery, (ii) nonelectrical machinery, and (iii) instruments. The output of these three industries is much more likely to be produced for investment, though about half of the output of equipment-producing countries is used as intermediate inputs.[9] For the three major equipment producing countries, the three industries cover at least 60% of the manufacturing sector's total output of investment goods and the equipment-producing industries generate about 80% of the investment goods used by the manufacturing sector.

For each country I construct two variables measuring total capital good imports ($M^{K,\$}$) and exports ($X^{K,\$}$) of machinery and transport equipment in a given year. In the SITC Rev. 2, this corresponds to category 7, machinery and transport equipment. This category includes: power-generating machinery and equipment (71), machinery specialized

[9]See page 1231 in Eaton and Kortum (2001). An important caveat to this classification is that investment goods are also produced by the textile products industry, wood processing, paper products, and metal processing.

for particular industries (72), metalworking machinery (73), general industrial machinery and equipment (74), office machines and automatic data processing (75), telecommunications (76), electrical machinery, apparatus and appliance (77), road vehicles (78), and transport equipment (79).

Deflator series for imported and exported equipment are not available for most countries and an equipment deflator for a given country corresponds to the price of equipment used in that country and could be different from the price of equipment produced in and exported from that country.[10] Despite these data limitations a number of researchers have argued equipment is a highly tradable good and suggested the price of capital goods is the same across countries. Hsieh and Klenow (2003) find that capital goods tend to be no more expensive in poor countries than in rich countries. The relative price of capital in poor countries is high because consumption goods are much cheaper, not because investment goods are more expensive. This empirical regularity suggests the high relative price of investment in poor countries is driven by the denominator rather than the numerator.[11] Purchasing power parity investment rates are lower in poor countries largely because the price of investment goods *relative* to consumption goods is higher in these countries. This motivates the use of a world price of capital to obtain real import and export values. The U.N. International Comparison Program (ICP) collects data on the prices of between 500 and 1500 individual goods and services. Unfortunately these data only exist for selected

[10]Navaretti, Soloaga, and Takacs (2000) find that poorer countries tend to import a higher share of used equipment.

[11]De Long and Summers (1993) present evidence that the price of investment goods relative to the GDP deflator as a whole is much greater in poor than in rich countries. The relative price of equipment is close to the inverse of the national product deflator. Eaton and Kortum (2001) also point out that price measures from the ICP show no systematic differences in capital goods prices among rich and poor countries.

countries and years.[12] The countries in the ICP are benchmark countries for the Penn World Tables. For non-benchmark years country-years, prices and PPP values are then inferred from fitted values of price regressions on the benchmark data. Hsieh and Klenow (2003) also point out that PPP prices provided by the Penn World Tables are effectively the prices prevailing in the rich countries.[13]

Given these data issues, I proceed by converting the dollar value of capital good imports $M^{K,\$}$ and capital good exports $X^{K,\$}$ in the national currency, $M^{K,DOM}$ using the spot exchange rate (domestic currency in terms of foreign currency) S_t. Under the assumption of freely traded capital goods, absolute purchasing power holds:

$$P_t^K = P_t^{K,\$} \cdot S_t^{DOM/\$},$$

where P^K ($P_t^{K,\$}$) is the imported equipment price (foreign equipment price). As with the national accounts variables, real quantities in domestic currency are calculated by dividing the nominal domestic currency values by the GDP deflator $Defl_t^{GDP}$. For example, real capital good imports M_t^K are calculated as follows:

$$M_t^K = \frac{M_t^{K,\$} \cdot S_t^{DOM/\$}}{Defl_t^{GDP}}.$$

[12]Benchmark data exist for 1970 (16 countries), 1975 (34 countries), 1980 (61 countries), 1985 (64 countries), 1990 (24 countries), and 1996 (115 countries).

[13]Hsieh and Klenow (2003): "The Penn World Tables use a Gheary-Kamis procedure to calculate PPP prices. The PPP price of a good, say consumption (individual goods are finer than this) would be defined as $P_c = \sum_j \frac{P_c^j}{E^j} \frac{C^j}{C^w}$, where P_c^j is the domestic currency price of consumption in country j, $C^w = \sum_j C^j$ is world consumption and $E^j = \frac{P^j{}_c C^j + P_i^j I^j}{P_c C^j + P_i I^j}$ is the PPP exchange rate of country j. In addition, E^{US} is typically normalized to 1 so that the units are US dollars. Because the weights used to aggregate country prices are aggregate quantities, rich country prices are over-weighted relative to poor country prices."

2.3. Composition and Cyclical Behavior of Trade Data

This section documents the magnitude and the business cycle behavior of capital goods imports and exports for 17 emerging economies. To stress the distinct features of emerging economies, I also report statistics for 6 developed economies and 3 G-7 countries. The sample has an annual frequency (the frequency of the UN-NBER trade data), starts in 1980 and ends in 2000, the last year available in Feenstra, Lipsey, Deng, Ma, and Mo (2005).[14]

2.3.1. Magnitude of Capital Good Exports and Imports

Observation 1 : *According to trade data, capital good imports represent more than a third of the total imports in both emerging and developed economies. Unlike developed economies, emerging countries export few or only a selective set of capital goods.*

The first two columns of table 3.2 display the median shares of capital good exports and imports in total good exports and imports over the period 1980-2000. The table shows that there is a stark group difference between the emerging and developed countries. Whereas the median country share of capital goods imports $M^{K,\$}$ in total goods imports $M^{\$}$ is similar (37.24 in the group of emerging economies versus 36.59 in the group of developed economies), the median share of capital goods $X^{K,\$}$ in total exports $X^{\$}$ is only 8.77 per cent for the emerging market group compared with 31.66 for the group of the developed economies. In fact, a non-parametric Wilcoxon rank-sum test rejects the null

[14]Quarterly data starting in the early or mid nineties are only available for countries such as South Korea, Argentina, and Brazil.

hypothesis at the 5% level that the median capital good export shares for the developed and emerging economies come from the same distribution. It does not reject the same distribution hypothesis for the capital good import shares.

Table 3.2 can be interpreted as the time series version of Eaton and Kortum (2001). Using a cross-section of 34 countries in the year 1985, Eaton and Kortum (2001) show that innovative activity is highly concentrated in a handful of advanced countries. As a consequence, these countries also produce most of the world's capital goods and the rest of the world typically imports capital goods from these countries.

> **Observation 2 :** *According to trade and national accounts data, capital good imports are a sizable fraction of Gross Domestic Product (GDP).*

The last two columns of table 3.2 present the median shares of capital goods imports $M^{K,\$}$ and capital goods exports $X^{K,\$}$ in GDP over the 1980-2000 period. The median share of exported capital goods as a fraction of GDP in the emerging market group is less than two per cent, whereas the median share of capital good imports in GDP is 6.98 per cent in this group. In both emerging and developed economies the share of capital goods imports in GDP is about the same as the share of equipment investment in GDP.

The above observations are not set in stone as countries move from emerging to developed status. For a number of emerging countries such as Brazil, the Philippines, and South Korea, capital goods exports amount to more than a third of total exports by the end of the year 2000. Figure 3.1 shows the evolution of capital good import and export shares over the 1975-2000 period for a set of emerging economies. The gray shades are the official liberalization dates of Bekaert and Harvey (2000). In the case of Argentina, Chile or South Africa, capital good exports remain a small fraction of overall exports.

The situation is different for Korea, the Philippines or Thailand. Indeed, these economies are well known for an industralization process heavily focused on manufacturing. Digging a bit deeper in the UN-NBER data one can observe that the nineties saw a sharp increase in the export share of road vehicles and semiconductors in these countries (subcategories 78 and 776 respectively, also shown in figure 3.1).

For comparison, figure 3.2 shows the evolution of capital good shares in imports and exports for eight developed economies.

2.3.2. Business Cycle Properties

I now turn to the business cycle observations emphasized in this paper. Figure 3.3 shows the business cycle behavior of output Y (GDP), the trade balance over output ratio TB/Y, investment I, capital good imports M, the share of capital goods in imports and the real interest rate R for Argentina. Argentina is a widely studied emerging economy, and is the emerging economy with the longest available time series for the real interest rate. In what follows, series are filtered using the Hodrick-Prescott (HP) filter with a smoothing parameter of 6.25 proposed for annual data by Ravn and Uhlig (2002).[15] The gray shade in 3.3 is the official liberalization date of Bekaert and Harvey (2000). The upper panel of the figure plots logged output together with trade balance over output and the real interest rate for Argentina. The panel shows a negative comovement of output with both the trade balance and the real interest rate. The lower panel of figure 3.3 plots the deviation from trend of both logged investment, capital goods imports, M, and the share of capital goods in imports. These three variables are procyclical. Furthermore,

[15]I have also calculated the statistics using a bandpass filter at frequencies between 2 and 8 years and found no substantial differences.

booms and busts in output seem to coincide with big jumps and drops in capital goods imports, up to forty per cent above and below trend. In fact, the standard deviation of filtered capital goods imports is an order of magnitude bigger than the standard deviation of investment.

The remainder of this subsection argues that these observations hold more generally within the emerging market group.

> **Observation 3 :** *According to trade and national accounts data, emerging economies have countercyclical trade balances whereas trade balances in developed economies are acyclical.*

The first two columns of table 3.3 print the correlation of real GDP with the trade balance over output ratio TB/Y and the goods trade balance over output ratio TB^G/Y. The table confirms the findings on the cyclicality of the trade balance in emerging markets documented in earlier work by Prasad, Rogoff, Wei, and Kose (2004), Neumeyer and Perri (2005), and Aguiar and Gopinath (2007).

The trade balance is strongly countercyclical in emerging economies (a median correlation of -0.66), whereas there is no clear pattern in the group of developed economies (median correlation of -0.16). A non-parametric Wilcoxon rank-sum test rejects the null hypothesis at the 1% level that the correlations for the developed and emerging economies are drawn from a single population. The second column of table 3.3 shows these conclusions also hold for the more narrowly defined goods trade balance.

> **Observation 4:** *According to trade and national accounts data, emerging economies have acyclical exports and capital goods exports and procyclical capital goods imports.*

Table 3.4 presents the correlation of real GDP with exports X, capital good exports X^K, the share of X^K in total exports, imports M, capital good imports M^K, and the share of M^K in total imports. Imports are procyclical in both groups, whereas exports are only procyclical in the developed countries. A number of emerging economies have countercylical to strongly countercyclical exports (correlation between exports and GDP is -0.60 for Argentina, -0.70 for Mexico), but this pattern does not hold for the group of emerging countries as a whole. The median correlation of output with exports in the emerging market group is -0.03.

Table 3.4 contains a key observation of this paper; equipment imports M^K are procyclical to strongly procyclical in emerging economies. The emerging market group median for the correlation of equipment imports with output is 0.59. The correlations of capital good exports with output, on the other hand, are low for most emerging economies (a median value around zero). In any case, the subsection above shows that capital good exports are a small fraction of overall exports for most emerging economies. In developed economies, on the other hand, both capital good imports and exports are procylical (a median correlation with output of 0.62 and 0.43 respectively).

Figure 3.4 is a scatter plot of the correlation between trade balance over output ratio and output and the median level of the capital goods trade balance (capital good exports X^K minus capital good imports M^K over output) over the period 1980-2000. The figure shows that countries that are net capital good importers tend to have countercyclical trade balances (the group can be found in the lower left quadrant of figure 3.4). The linear regression line shown in figure 3.4 is:[16]

$$a = -0.36 + \underset{(5.14)}{0.044} \cdot b, \tag{2.1}$$

where a is the cyclicality of the goods trade balance, b the median of the capital goods trade balance and the number in parentheses is the t statistic. Equation (2.1) shows the median level of the net capital good imports and the cyclicality of the trade balance have a statistically significant relationship. The correlation coefficient between the two variables is 0.61.

Taking into account that equipment imports make up more than a third of total imports and emerging economies have acyclical exports (see table 3.4), the above observations suggests that understanding the cyclical behavior of capital good imports is key for understanding the countercyclicality of the trade balance in emerging economies.

Observation 5 : *At business cycle frequencies, capital good imports and exports measured using trade data are more volatile than investment measured using national accounts data.*

The standard deviation of equipment imports $M^{K,\$}$ relative to the standard deviation of output Y is reported in the last column of table 3.5. For a number of countries the relative standard deviation of this variable is double the relative standard deviation of investment measured from national accounts data (displayed in the fourth column of table 3.5). The relative standard deviations of total exports and imports, on the other hand, are in the same range of those of investment.

[16] The linear regression is used to summarize the information in the scatter plot. The correlation is a bounded measure so alternatives like the logistic regression could also have been used.

Observation 6: *Interest rates are countercyclical in emerging economies.*

Table 3.6 shows that interest rates are strongly countercyclical in emerging economies. The median group correlation is -0.83. This is consistent with Neumeyer and Perri (2005) and Uribe and Yue (2005).

To conclude this section, table 3.5 reports key business cycle moments for both developed and emerging economies. Standard deviations for GDP (Y) and trade balance over output (TB/Y) are higher in the group of emerging economies than in the group of developed countries. Turning to relative volatilities, the relative volatility of detrended consumption (C) to GDP is higher than one in most emerging economies.[17] The relative volatility of investment (I), on the other hand, is similar in both groups.

2.4. The Model

This section lays out an extended small open economy model with two sectors. The economy is populated by a large number of identical agents who are price takers. All variables are in per capita terms.

2.4.1. Production and Investment Technology

2.4.1.1. Home Sector. Firms in the home sector produce a non-tradable commodity Y_t^H with a Cobb-Douglas production function:

[17]As stressed in Bergoeing and Soto (2005), this apparent excess volatility of consumption is at least in part the result of using total consumption data. For Chile, the volatility of durable goods is 8.5 times higher than that of nondurable goods and the volatility of the purchases of nondurable consumption goods is smaller than that of GDP. This higher volatility of the consumption of durable goods does not arise primarily from the changes in relative prices, as the price deflator of durable goods exhibits the same volatility as the deflator for nondurable goods.

$$Y_t^H = A_t \left(K_t^H\right)^{\alpha} \left(N_t^H\right)^{1-\alpha}.$$

A_t is the level of random productivity in the domestic sector. K_t^H is the capital stock. N_t^H is the number of hours worked in the domestic sector. The remainder of hours worked N_t^E is allocated to the export sector. Total hours worked N_t is the sum of the two:

$$N_t = N_t^H + N_t^E.$$

2.4.1.2. Export Sector. Firms in the export sector of the economy produce an export good with a Cobb-Douglas production technology:

$$Y_t^E = B_t \left(K_t^E\right)^{\alpha} \left(N_t^E\right)^{1-\alpha},$$

where K_t^E is the capital stock, and N_t^E labor services. B_t is productivity in the export sector.

2.4.1.3. Resource Constraints and Trade Balance. The resource constraints for the home and export sector are respectively:

$$\begin{aligned} C_t + I_t^H &\leq Y_t^H \\ I_t^F + \left[(1+R^*)\, D_{t-1} + \Psi(D_t)\right] &\leq D_t + Y_t^E. \end{aligned}$$

The output in the domestic sector Y_t^H can be used either for consumption C_t or investment I_t^H. In the traded sector, the country imports investment goods I_t^F and exports Y_t^E. The difference between Y_t^E and I_t^F is the trade balance. D_t are the outstanding foreign assets, and R^* is the exogenously determined interest rate charged on foreign assets. $R^* D_{t-1}$ is the interest due on previously acquired assets.

The current account balance ca_t is defined as the change in the value of the economy's net foreign asset:

$$ca_t \equiv D_{t-1} - D_t \equiv nx_t - R^* D_{t-1},$$

where nx_t is net exports. The trade balance TB_t is defined as:

$$TB_t \equiv nx_t \equiv (1 + R^*)\, D_{t-1} - D_t$$

2.4.1.4. Final Investment Good. A constant elasticity of substitution aggregator $G(I_t^H, I_t^F)$ describes the production of new investment goods:

$$G(I_t^H, I_t^F) = \left[\omega_H^{1-\xi} \left(I_t^H\right)^{\xi} + \omega_F^{1-\xi} \left(I_t^F\right)^{\xi}\right]^{\frac{1}{\xi}}. \tag{2.2}$$

The aggregate investment good $G(I_t^H, I_t^F)$ is a composite of domestically produced investment goods I_t^H and imported investment good I_t^F. The elasticity of substitution between foreign and domestic investment goods is $\frac{1}{1-\xi}$. Different production functions are nested in equation (2.2), e.g. for $\xi = 1$ the function is linear. ω_H is the share of domestic, nontradable goods and $\omega_H = 1 - \omega_N$ the share of imported investment goods. Depending on the parameter value ξ (2.2) can take on a variety of shapes. In what follows σ_I denotes the elasticity of substitution and:

$$\sigma_I = 1/(1 - \xi).$$

As ξ approaches zero the isoquants of the CES function approach those of a Cobb-Douglas functional form, $\xi = 1$ corresponds to the linear function. As ξ approaches $-\infty$ the CES approaches the Leontief; under $\sigma_I \to 0$, equation (2.2) can be rewritten as:

$$G(I_t^H, I_t^F) = \min\left\{\omega_H I_t^H, (1-\omega_H) I_t^F\right\}.$$

Firms buy domestic investment goods at price P_t^H. As the imported investment good is the numeraire, total investment expenditures are:

$$P_t^H I_t^H + I_t^F. \tag{2.3}$$

To obtain the relation between I_t^H and I_t^F in equilibrium, I solve the following minimization problem:

$$\min_{I_t^H, I_t^F} \quad P_t^I \cdot G(I_t^H, I_t^F), \tag{2.4}$$

subject to the CES aggregator (2.2) and (2.3). The first-order conditions of the minimization problem (2.4) are:

$$\begin{aligned} P_t^I \cdot G_{I_t^H}(I_t^H, I_t^F) &= P_t^H \\ P_t^I \cdot G_{I_t^F}(I_t^H, I_t^F) &= 1. \end{aligned}$$

In equilibrium the relationship between $I_{N,t}$ and $I_{F,t}$ can be written as:

$$P_{H,t} = \left(\frac{1-\omega_H}{\omega_H}\frac{I_{H,t}}{I_{F,t}}\right)^{-1/\sigma_I}. \tag{2.5}$$

The investment price index is then:[18]

$$P_t^I = \left[\omega_H \left(P_t^H\right)^{\frac{\xi}{\xi-1}} + (1-\omega_H)\right]^{\frac{\xi-1}{\xi}} . \tag{2.6}$$

Aggregate investment I_t in the model is defined as:

$$I_t \equiv P_t^I \cdot G(I_t^H, I_t^F)$$

To study the case of a Cobb-Douglas aggregator, I set $\xi = 0$ such that $\sigma_I = 1$ and $G(I_t^H, I_t^F)$ becomes:

$$G(I_t^H, I_t^F) = \left(I_t^H\right)^{\omega_H} \left(I_t^F\right)^{1-\omega_H}$$

The first-order conditions in this case are:

$$\begin{aligned} P_t^I \cdot \omega_H \left(I_t^H\right)^{\omega_H - 1} \left(I_t^F\right)^{(1-\omega_H)} &= P_t^H \\ P_t^I \cdot (1-\omega_H) \left(I_t^H\right)^{\omega_H} \left(I_t^F\right)^{(-\omega_H)} &= 1. \end{aligned}$$

[18]The total value of investment is: $P_t^I G_t = P_t^H I_t^H + I_t^F$. Substituting in I_t^F gives $P_t^I G_t = \left[P_t^H + \left(P_t^H\right)^{1/(1-\xi)} \frac{(1-\omega_H)}{\omega_H}\right] I_t^H$, or in function of P_t^I : $P_t^I = \left[P_t^H + \left(P_t^H\right)^{1/(1-\xi)} \frac{(1-\omega_H)}{\omega_H}\right] \frac{I_t^H}{I_t}$. Get $\frac{I_t^H}{G_t}$ from the equilibrium condition:

$$P_t^I = \left[P_t^H + (P_H)^{1/(1-\xi)} \frac{(1-\omega_H)}{\omega_H}\right] \left[\omega_H^{1-\xi} + (1-\omega_H) \left[\frac{\left(P_t^H\right)^{1/(1-\xi)}}{\omega_H}\right]^{\xi}\right]^{-1/\xi},$$

this simplifies to (2.6).

The Cobb-Douglas specification imposes constant investment expenditure shares on traded and nontraded goods. Bems (2005) argues constant shares is indeed what is found in the data.

2.4.2. Preferences and Budget Constraint

The representative household maximizes expected lifetime utility:

$$U(C_t, N_t) = \mathbf{E}_t \left(\sum \beta^t u(C_t, N_t) \right), \quad 0 < \beta < 1, \tag{2.7}$$

where β is the discount factor, and C_t and N_t are random sequences of period t consumption and hours worked, respectively. $\mathbf{E}_t$ is the expectation based on the information set available at time t.

Two specifications for $u(\cdot)$, Cobb-Douglas and Greenwood, Hercowitz, and Huffman (1988) (GHH) preferences, have been widely used in the small open economy literature. Before discussing the difference between the specifications, I turn to the budget constraint.

2.4.2.1. Budget Constraint. The per-period budget constraint is:

$$P_t^H C_t + P_t^I \cdot G(I_t^H, I_t^F) + \Psi(D_t) + \Phi(K_{t+1}, K_{t+1}^E, K_t, K_t^E) \tag{2.8}$$

$$\leq \; r_t^K K_t + w_t N_t + \left[D_t - (1 + R^*) \, D_{t-1} \right]. \tag{2.9}$$

C_t and P_t^H represent domestic consumption and price of home goods. $G(I_t^H, I_t^F)$ is a new investment good, which can be purchased at price P_t^I. The exported good Y_t^E is the numeraire. $\Phi(K_{t+1}, K_{t+1}^E, K_t, K_t^E)$ are the costs associated with adjusting the aggregate capital stock K and the sector-specific capital stock K^E. Households own the capital stock and rent it to firms at rental rate r_t^K. They receive a wage w_t.

$\Psi(D_t)$ is the function that determines the magnitude of costs of adjusting the portfolio. This function induces stationarity in the model by assuming that agents face convex costs of holding assets in quantities different from a long-run level $\bar{D}$. The functional form for $\Psi(\cdot)$ is:

$$\Psi(D_t) = \frac{\psi}{2}\left[D_t - \bar{D}\right]^2. \tag{2.10}$$

The first-order condition associated with holding assets is:

$$\lambda_t\left[1 - \psi(D_t - \bar{D})\right] = \beta \mathbf{E}_t\left[\lambda_{t+1}(1 + R^*)\right] \tag{2.11}$$

$$\lambda_t = \beta \mathbf{E}_t\left[\lambda_{t+1}\right] \cdot \frac{(1 + R^*)}{\left[1 - \psi(D_t - \bar{D})\right]} \tag{2.12}$$

Equation (2.11) states the marginal benefit of a unit debt increase equals the marginal cost of a unit debt increase. The loglinearized version is:

$$\hat{\lambda}_t - \psi D \hat{D}_t = \hat{\lambda}_{t+1} + \frac{R}{1+R}\hat{R}^*.$$

Uribe and Yue (2005) show equation (2.10) can be decentralized fairly easy if one assumes that financial intermediaries work in a competitive sector and capture funds from foreign investors at rate R^*, lending to domestic residents at rate R^d. The volume of intermediation is D, chosen to maximize profits Π^{Fin}:

$$\Pi^{Fin} = (1 + R_t^d)(D_t - \Psi(D_t)) - (1 + R^*)D_t.$$

The first-order condition is:

$$(1 + R_t^d)(1 - \Psi'(D_t)) - (1 + R^*) = 0$$

The expression for the interest rate in the domestic economy R_t^d is:

$$1 + R_t^d = \frac{1 + R^*}{1 - \Psi'(D_t)},$$

the same interest rate as applied in equation (2.11).

2.4.2.2. Cobb-Douglas Specification. The Cobb-Douglas specification for utility is:

$$u(C_t, N_t) = \frac{(C_t^\theta (1 - N_t)^{1-\theta})^{1-\sigma}}{1 - \sigma}. \tag{2.13}$$

This specification is the most commonly used preference in the small open economy literature.[19] θ determines the fraction of labor in steady state. Labor is determined by:

$$w_t = -\frac{U_N}{U_c} = \frac{C_t}{1 - N_t}\frac{(1 - \theta)}{\theta}.$$

In a standard small open economy model these preferences are associated with two properties. First, the preferences make consumption in the model not very volatile. To get some intuition for this, consider the case where $\sigma = 1$. In that case, the Euler condition

[19]Studied in Correia, Neves, and Rebelo (1995), Neumeyer and Perri (2005), Aguiar and Gopinath (2007), and Lucca (2006).

for consumption is given by:

$$\frac{1}{C_t} = \beta \mathbf{E}_t \left(\frac{1}{C_{t+1}} \right),$$

and the process for consumption $\{C_t\}_{t=0}^{\infty}$ will be very smooth. If one calibrates $\sigma > 1$ smoothing the marginal utility of consumption does not imply consumption has to be smooth but that movements in consumption should be proportional to movements in labor $\epsilon \hat{C}_t = \hat{N}_t$.[20] Calibrating N at a high value will then correspond to lower values of ϵ. This is not problematic if the goal is match the volatility of consumption observed in the data. The drawback, however, is that a high steady state value of N reduces the Frish elasticity of labor supply ε^{λ}:[21]

$$\varepsilon^{\lambda} = \frac{1-N}{N} \frac{(1-\theta(1-\sigma))}{\sigma}.$$

A low value for ε^{λ} will in turn lower the variation in labor effort. Consequently a small open economy model with Cobb-Douglas preferences is not able to simultaneously match the volatility of consumption and hours worked.

A second property associated with Cobb-Douglas preferences is that they generate a procyclical trade balance.[22] As the optimal response of consumption is smooth for a reasonable model calibration (compared to the case of the GHH preferences discussed

[20] See page 1099 in Correia, Neves, and Rebelo (1995).

[21] The general formula for the Frish elasticity implied by a class of momentary utility functions $U(C, N)$ is:

$$\varepsilon^{\lambda} \equiv \frac{dN}{dw} \frac{w}{N} |_{\lambda} = \frac{1}{N} \frac{\lambda w}{-U_{NN} + \frac{U_{CN}^2}{U_{CC}}} = \frac{1}{N} \frac{U_N}{U_{NN} - \frac{U_{CN}^2}{U_{CC}}}.$$

The elasticity shows how labor supply responds to an intertemporal reallocation of wages that leaves the marginal utility of wealth unaffected.

[22] See Schmitt-Grohe and Uribe (2003).

below), there is less incentive to borrow after, for example, an expansionary productivity shock, and the trade balance will be procyclical.

2.4.2.3. GHH Specification. Another specification for the momentary utility function widely used in open economy models is the GHH-preference proposed in Greenwood, Hercowitz, and Huffman (1988):[23]

$$u(C_t, N_t) = \frac{(C_t - \omega \frac{N_t^{1+\theta}}{1+\theta})^{1-\sigma} - 1}{1-\sigma}. \tag{2.14}$$

These preferences imply that there is no intertemporal substitution associated with leisure and undoes income effects on labor supply that are present under Cobb-Douglas preferences. This can be observed from the first-order condition for labor supply. In equilibrium the marginal product of labor is equal to the marginal rate of substitution between consumption and leisure:

$$w_t = -\frac{U_N}{U_c} = \omega N_t^{\theta}, \tag{2.15}$$

so there is no intertemporal substitution associated with leisure. Labor supply at time t is entirely determined by the current real wage (no C-term on right-hand side in equation 2.15). The uncompensated labor supply elasticity $1/\theta$ equals the Frisch elasticity ε^{λ}.

[23] If one allows for a trend γ in productivity growth, these preferences need to be made consistent with long-run growth. One could assume technological progress increases the utility of leisure. Then:

$$\frac{(C_t - \omega(1+\gamma)^t \frac{N^{1+\theta}}{1+\theta})^{1-\sigma} - 1}{1-\sigma}.$$

A number of papers have demonstrated that models with GHH preferences capture business cycle dynamics of small open economies much better than models with Cobb-Douglas preferences.[24] As these preferences are not separable across consumption and labor, even when $\sigma = 1$, $\epsilon \hat{C}_t = \hat{N}_t$ can be smooth over time. In the context of a multi-country model, for example, Raffo (2006) has shown GHH preferences improve the empirical performance of two-country models by generating sufficient volatility in consumption compared to Cobb-Douglas preferences.

2.4.3. Factor-market Inflexibilities

2.4.3.1. Capital Adjustment Costs. The stock of capital evolves according to:

$$K_{t+1} = (1 - \delta)K_t + G(I_t^H, I_t^F),$$

where δ is the rate of depreciation.

Unlike closed-economy models, adjustment costs to capital are needed in open-economy models to avoid excessive responses in aggregate investment I_t to domestic-foreign interest rate differentials. Small capital adjustment costs suffice to bring the volatility of investment in the model in line with the volatility of investment observed in the data.

The two-sector structure poses an additional problem. Empirically we observe that capital is not very mobile across sectors and comoves (see for example Boldrin, Christiano, and Fisher (2001)), so I need to impose adjustment costs $\Phi(K_{t+1}, K_{t+1}^E, K_t, K_t^E)$ on both the aggregate capital stock and sector-specific capital stock. The functional form for these

[24]Schmitt-Grohe and Uribe (2003) for example find that these preferences match data much better than the Cobb-Douglas specification in small open economy models. To cite Mendoza (1991) these preferences "...allows the model to focus expressly on the interaction of foreign assets and domestic capital as alternative vehicles of savings, at the cost of eliminating the wealth effect on labor supply."

costs is:

$$\Phi(K_{t+1}, K_{t+1}^E, K_t, K_t^E) = \frac{\phi}{2}(K_{t+1} - K_t)^2 + \frac{\phi}{2}(K_{t+1}^E - K_t^E)^2.$$

The bulk of the literature has also worked with quadratic capital adjustment costs. The restrictions on $\Phi(K_{t+1}, K_{t+1}^E, K_t, K_t^E)$ are such that non-stochastic steady-state adjustment costs are zero and the domestic interest rate equals the marginal product of capital net of depreciation.

2.4.3.2. Labor Adjustment Costs. One-sector business cycle models do not typically have labor adjustment costs. Because of the two-sector set-up described above, however, I introduce adjustment costs on sectoral hours worked, N_t^E and N_t^H to generate comovement of labor across the two sectors.[25] The adjustment costs take a quadratic form. In the export sector, for example, the present value of profits is:

$$\Pi^E = \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[Y_t^E - r_t^K K_t - w_t N_t^E - \frac{\theta}{2}(N_t^E - N_{t-1}^E)^2 \right]$$

The first-order condition for N_t^E is:

$$(1-\alpha)\left(K_t^E/N_t^E\right)^{\alpha} = w_t - \theta(N_t^E - N_{t-1}^E) - \frac{\beta\lambda_{t+1}}{\lambda_t}\theta(N_{t+1}^E - N_t^E).$$

2.4.3.3. Investment Adjustment Costs. I will also study a variant of the model with the investment adjustment costs introduced by Christiano, Eichenbaum, and Evans (2005). In that case, the stock of capital evolves according to:

$$K_{t+1} = (1-\delta)K_t + G(I_t^H, I_t^F) - S\left(\frac{I_t}{I_{t-1}}\right).$$

[25] See Christiano and Fitzgerald (1998) on the comovement of factor inputs in two-sector models.

Under investment adjustment costs, current and past investment determines the installed capital for the following period:

$$
\begin{aligned}
K_{t+1} &= (1-\delta)K_t + F(I_t, I_{t-1}) \\
F(I_t, I_{t-1}) &= (1 - S(\frac{I_t}{I_{t-1}}))I_t,
\end{aligned}
\tag{2.16}
$$

As in Christiano, Eichenbaum, and Evans (2005) restrictions on $S(\cdot)$ are that $S(1) = S\prime(1) = 0$ (so that in steady-state there are no investment adjustment costs) and $S\prime\prime = \eta$ and $\eta > 0$. Equation (2.16) implies the marginal cost of installed capital corresponds to the change in the slope of investment; the increase from yesterday to today minus the increase from today to tomorrow. Adjusting investment is cheaper at the margin if that slope is very smooth. This formulation is different from the classic capital adjustment formulation discussed above where marginal cost is a function of the *level of investment*. With the cost of change formulation it is a function of the *second derivative*.

The loglinearized optimality condition for investment is:

$$
\hat{\lambda}_t = \hat{\mu}_t - \eta\left(\hat{I}_t - \hat{I}_{t-1}\right) + \beta\hat{\mu}_{t+1} + \beta\eta\left(\hat{I}_{t+1} - \hat{I}_t\right)
\tag{2.17}
$$

This equation is closely related to time-to-build models (TTB). In fact, Lucca (2006) develops a TTB model that is identical up to a first-order approximation to the model of Christiano, Eichenbaum, and Evans (2005). So for an adjustment cost function as given above it is possible to find projects durations and investment goods' substitution elasticities implying identical local dynamics in both models.

Equation (2.17) can also be rewritten to include Tobin's Q term (price of capital in terms of units of consumption). As μ_t is the marginal utility of K_{t+1} or loosely, dU/dK_{t+1} and λ_t is the marginal utility of C_t, loosely dU/dC_t, Tobin's Q corresponds to the ratio $\frac{\mu_t}{\lambda_t}$,.[26] Given $F_2 = 0$:

$$\begin{aligned}\eta\left(\hat{I}_t - \hat{I}_{t-1}\right) &= \hat{\mu}_t - \hat{\lambda}_t + \beta\eta\left(\hat{I}_{t+1} - \hat{I}_t\right)\\ \eta\left(\hat{I}_t - \hat{I}_{t-1}\right) &= \hat{Q}_t + \beta\eta\left(\hat{I}_{t+1} - \hat{I}_t\right)\end{aligned}$$

The first-order condition for K_{t+1} is:

$$\mu_t = \beta\lambda_{t+1}\left[\frac{\mu_{t+1}}{\lambda_{t+1}}(1-\delta) + r^K_{t+1}\right] \tag{2.18}$$

The steady-state conditions for these two equations are: $\lambda = \mu$ and $\mu = \beta\lambda\left[(1-\delta) + r^K\right]$ so $1 = \beta\left[(1-\delta) + r^K\right]$.

2.4.3.4. Risk-free Rate. As in Jermann (1998) or Boldrin, Christiano, and Fisher (2001), the risk-free rate is defined from:

$$\lambda_t = \beta\mathbf{E}_t\left[\lambda_{t+1}(1 + r^f_t)\right].$$

[26] $\frac{\mu_t}{\lambda_t} = \frac{dU/dK_{t+1}}{dU/dC_t} = \frac{dC_t}{dK_{t+1}}$

The risk-free rate is:

$$r_t^f = \frac{\lambda_t}{\beta \mathbf{E}_t \left[\lambda_{t+1}\right]} - 1, \tag{2.19}$$

the time subscript convention used in r_t^f indicates the date on which the payoff is revealed.

2.4.4. Equilibrium

A competitive equilibrium is a set of allocations

$\left\{Y_t^E, Y_t^H, C_t, I_t^H, I_t^F, K_{t+1}^E, K_{t+1}^F, N_t^H, N_t^F, D_t\right\}_{t=0}^{\infty}$ and prices $\left\{P_t^H, P_t^I, r_t^K, r_t^f, \lambda_t, w_t\right\}_{t=0}^{\infty}$ such that given exogenously determined process for $\{A_t, B_t\}_{t=0}^{\infty}$:

- given prices the households maximize utility (2.7) subject to the budget constraint (2.8) and the capital accumulation technology.
- Factor markets clear. Firms choose to maximize the profit functions given prices.
- Markets clear.

2.5. Parameterization

The model is calibrated at quarterly frequency on Argentina, a widely studies country in the literature.[27] Table 3.7 summarizes the benchmark parameter values.

2.5.1. Preferences and Labor Supply

The parameter values of the model are chosen in line with earlier work. The quarterly discount rate β is set to match the average real interest rate on Argentine foreign debt.

[27]Most calibrated parameter values (capital share, depreciation rate, Frisch elasticity) are similar across the emerging and developed economies.

The depreciation rate is set to match an average investment to GDP ratio of 20 percent (the average in the 1980-2000 period). The capital exponent in the production functions α is set to 0.6.

The labor exponent in the GHH specification for the utility function, $1+\theta$, is set to 1.45 in Mendoza (1991) and Schmitt-Grohe and Uribe (2003), 1.66 in Neumeyer and Perri (2005), and 1.7 in Correia, Neves, and Rebelo (1995). In the baseline calibration I set $\theta = 0.60$, implying a Frisch elasticity of $1/\theta = 1.66$. The calibration for the labor weight ω corresponds to a steady state supply of labor of 0.30.[28] As in Mendoza (1991) and Schmitt-Grohe and Uribe (2003), I set the utility curvature $\sigma = 2$.

2.5.2. Investment Aggregator and Adjustment Costs

The share ω_H of home investment in the aggregator $G(I_t^H, I_t^F)$ is set at 0.50. I set $\sigma_I = 1$, corresponding to Cobb-Douglas. The adjustment cost parameters for aggregate and sector-specific capital are set to match the observed volatility of aggregate investment and the capital stock.

2.5.3. Asset Market and the Trade Balance

As in Schmitt-Grohe and Uribe (2003) and Neumeyer and Perri (2005), the coefficient Ψ on the interest rate premium takes a small value. The steady-state level of debt D is chosen such that the steady-state average trade balance-to-output ratio equals about one percent. For Argentina, the average trade balance-to-output ratio was 0.77 percent,

[28]Mendoza (1991) and Schmitt-Grohe and Uribe (2003) set $\omega = 1$.

whereas the average goods trade balance-to-output ratio was 1.68 percent over the period 1980-2000.

2.5.4. Productivity Shocks

The logarithm of the productivity shock in the domestic sector follows an $AR(1)$ process with coefficient ρ_a :

$$\log(A_t) = \rho_a \log(A_{t-1}) + \varepsilon_{A,t} \tag{2.20}$$

$$\varepsilon_{A,t} \sim N(0, \sigma_A) \tag{2.21}$$

The estimation of the process for shocks to total factor productivity is not possible in the case of emerging economies as hours worked are not available, so the parameters of the $AR(1)$ process are calibrated as in Kydland and Prescott (1982). Persistence ρ_a is chosen so that the model generates a persistence of output of about 0.70, about the serial correlation that is typically observed in the emerging economy group. The standard deviation σ_a of the innovation ε_A is set such that the model matches the volatility of output.

The logarithm of the productivity shock in the export sector follows an $AR(1)$ process with coefficient ρ_B :

$$\log(B_t) = \rho_B \log(B_{t-1}) + \varepsilon_{B,t}.$$

In what follows, the only exogenous driving forces in the two-sector model are productivity shocks to the home sector, according to the AR(1) process in equation (2.20). For the model discussed in the section below to generate volatility in exports in line of what is observed in the data, shocks to B_t need to be added. If these shocks are uncorrelated with A_t, then exports are volatile and acyclical, in line of observation 4 from the data section above. More importantly, when B_t is uncorrelated with A_t, the conclusions with respect to the trade balance discussed below are not affected.

2.6. Implications of the Model

This section compares the performance of the two-sector model with the standard small open economy models along three dimensions. The two-sector model referred to in this section is the model described in section 2.4, with GHH preferences, and quadratic portfolio, capital and labor adjustment costs.

First I show that this two-sector model produces a countercyclical trade balance. Then I evaluate the implications for the second moments of the other variables. Finally, I show how the model could be made consistent with asset return observations.

2.6.1. Cyclicality of the Trade Balance

Before discussing the two-sector model in detail, I re-examine a variant of the standard one-sector small open economy model described in Mendoza (1991) or Schmitt-Grohe and Uribe (2003). A summary of this model with quadratic capital and portfolio adjustment costs, can be found in the appendix.

As emphasized in Mendoza (1991), the defining feature of a small open economy model is the separation between savings and investment.[29] After a serially correlated

[29]Savings in the model is defined as $S_t \equiv Y_t - C_t$. Remember that the trade balance can also be defined as:

$$TB_t \equiv S_t - I_t.$$

productivity shock, two opposing forces determine if and for how long the economy will borrow abroad. On the one hand, agents can invest some of the windfall abroad and receive the exogenous world interest rate R^* as return. In this case, savings go up in anticipation of lower income in the future. On the other hand, agents can borrow internationally and build more domestic capital to benefit from the temporarily higher level of productivity. Savings decrease in the latter case.

Figure 3.5 shows the impulse responses of output, labor effort, consumption, investment and the trade balance to output ratio to a one standard deviation productivity shock. The figure displays the response of these variables in the standard one-sector small open economy model with Cobb-Douglas and GHH preferences described in the appendix. The models are calibrated so that they have the same persistence of output and volatility of output and investment.

The first column of table 3.8 summarizes the models' implications for the cyclicality of the trade balance. In the standard one-sector model with Cobb-Douglas preferences, the trade balance is procyclical. The correlation between output and the trade balance over output ratio is 0.58. In the model with GHH preferences, on the other hand, the trade balance is acyclical. The correlation of output with the trade balance over output ratio is 0.01. Figure 3.5 shows the difference in cyclicality of the trade balance can be traced down to the response of consumption. The responses of output and investment are similar in both models (remember the models are calibrated to have the same persistence and volatility of output and investment). The response of consumption to a productivity shock, on the other hand, is much larger with GHH preferences than with standard preferences. As discussed in section 2.4, in a model with Cobb-Douglas preferences consumption is very smooth and the savings effect dominates. GHH preferences in an otherwise similar model imply a stronger response of consumption, and the economy will borrow from abroad.

I now turn to the two-sector model with imported capital goods. The first column of table 3.8 shows the model is consistent with a countercyclical trade balance. Figure 3.6 shows the impulse response of real output, real consumption, real aggregate investment, the real price of investment and the trade balance to output ratio to a one standard deviation productivity shock.[30] The real price of investment is defined as the price of investment P_t^I over the price of domestically produced goods P_t^H.

Figure 3.6 depicts the mechanism underlying the countercyclicality of the trade balance in the two-sector model. Following the one standard deviation shock to productivity in the home sector, the price of domestically produced goods P_t^H falls. The production of domestically produced real consumption C_t and investment I_t^F increases. On the other hand, the small open economy is a price taker for the export good Y_t^E and the imported investment good I_t^F. As I_t^F is needed to produce aggregate investment I_t, the price of investment P_t^I will decrease proportionaly less than the price of domestically produced goods P_t^H (see equation 2.6 defining the investment price index P_t^I). Consequently, the real price of investment increases following the productivity shock. Compared to a one-sector model with the same preferences and calibrated to generate the same persistence and volatility of output and investment, the economy will need to borrow more to fund investment and the trade balance becomes countercyclical.

---

[30]Real variables were obtained by scaling by P_t^H.

2.6.2. Second Moments

Table 3.5 reports unconditional second moments observed in the data and implied by the different models. The first row reports the median of the second moments observed in the emerging economy group.[31] Numbers for the standard small open economy models are similar to what has been found in previous work. The table confirms that in the standard model with Cobb-Douglas preferences the volatility of consumption relative to the volatilty of output is low compared to the case of the standard model with GHH preferences and GHH preferences allow for more volatility in the hours worked series. In the one-sector models investment is more volatile than output and output is in turn more volatile than consumption. The table shows that the two-sector model is also consistent with these observations.

2.6.3. Cross-Correlation of Returns

Table 3.10 shows the cross-correlation between quarterly GDP and interest rates in Argentina generated by the different models.[32] In the standard small-open economy model there is a positive correlation between output and risk-free interest rates r_t^f, at leads and lags. This is the case with both GHH and Cobb-Douglas preferences. In a one-sector model, the positive technology shock increases output and consumption on impact. Interest rates, on the other hand, start falling when consumption growth decreases. This explains why interest rates do not move on impact as consumption does not move much

[31]The data is annual, whereas the model statistics are quarterly. Model statistics are about the same when annualized. For hours worked, the hours worked series from Argentina used in Neumeyer and Perri (2005) is reported.

[32]There is an inverted leading indicator property of interest rates also observed in developed economies (see Boldrin, Christiano, and Fisher (2001)).

from period one to period two (the marginal utility of consumption λ_t does not vary much). As consumption falls gradually later on, interest rates will decrease but this occurs when output is shrinking. Hence there is no predictive power of low interest rates for high future output in these models.

The table shows that the two-sector model discussed earlier in the section also does not generate a negative cross-correlation. Two modifications of this model, however, lead to both countercyclical real interest rates, and real interest rates that are negatively correlated with future levels of output. These frictions are the investment adjustment costs discussed in section 2.4 and portfolio costs that are formulated with a similar adjustment cost specification.[33] In this extended two-sector model, marginal utility of consumption and the interest rate falls when output peaks on impact, implying a negative correlation between the interest rate and output. Unlike the standard model, the marginal utility of consumption is then hump-shaped and increasing. There is a gradual increase in the interest rate as output returns to steady state.

2.7. Conclusion

This chapter focuses on emerging economy business cycles. A number of authors have shown emerging economies are characterized by a strongly countercyclical trade balance. The innovation of the chapter is to explore the role of capital goods in the composition and cyclicality of exports and imports of emerging economies and highlight differences with a group of developed economies. From the trade data I observe that in a typical emerging economy capital good imports are very volatile and procyclical, whereas exports

[33]So agents not only care about the deviation of debt from its long-run level, but also the speed at which they adjust borrow.

are acyclical. The chapter then studies the dynamics of savings and investment in a model environment where countries import part of the capital stock. In contrast to earlier work on standard small open economy models, this model is able to generate a countercyclical trade balance.

This research could be extended in several dimensions. From an empirical point of view, explaining why the cyclicality of exports differs across emerging and developed countries is a line of research worth pursuing. From a model point of view, one could develop models documenting the transition of emerging economy to developed economy status, and study the implications of this transition for the behavior of the trade balance and interest rates.

CHAPTER 3

Supply Shocks, Demand Shocks, and Labor Market Fluctuations

(joint with Helge Braun and Riccardo DiCecio)

3.1. Introduction

Hall (2005) and Shimer (2004) argue that the model of Galì (1999) is unable to reproduce the volatility of the job-finding rate, unemployment, and vacancies observed in the data.[1] A growing literature has attempted to augment the basic Mortensen-Pissarides model in order to match these business cycle facts.[2] Although most of this literature considers shocks to labor productivity as the source of fluctuations, some authors invoke the responses to other shocks as a potential resolution (see Silva and Toledo, 2005). These analyses are based on the assumption that either the unconditional moments are driven to a large extent by a particular shock, or the responses of the labor market to different shocks are similar. In this paper, we take a step back and ask what the contributions of different aggregate shocks to labor market fluctuations are and to what extent the labor market responds differentially to shocks. The labor market variables we analyze are worker flows, job flows, vacancies, and hours. Including both worker and job flows allows us to

[1]Aside from people thanked in the Acknowledgements, this chapter has also benefited from comments by Paul Beaudry, Luca Dedola, Daniel Levy, Éva Nagypál, Dale Mortensen, Frank Smets and seminar participants at the European Central Bank, Ghent University, 2006 Midwest Macroeconomics Meetings, WEAI 81st Annual Conference, University of British Columbia, and the Board of Governors. We thank Steven Davis, and Robert Shimer for sharing their data. Helge Braun and Reinout De Bock thank the research department at the St. Louis FRB and the ECB, respectively, for their hospitality.

[2]See, for example, Hagedorn and Manovskii (2006) and Mortensen and Nagypal (2005).

analyze the different conclusions authors have reached with respect to the importance of the hiring versus separation margin in driving changes in employment and unemployment. Including aggregate hours relates our work to the literature on the response of hours to technology shocks.

We identify three aggregate shocks – supply shocks, monetary, and non-monetary demand shocks – using a structural vector autoregression. We place restrictions on the signs of the dynamic responses of aggregate variables as in Uhlig (2005) and Peersman (2005). The first identification scheme we consider places restrictions on the short-run responses of output, the price level, and the interest rate. We require that supply shocks move output and the price level in opposite directions, while demand shocks generate price and output responses of the same sign. Monetary shocks additionally lower the interest rate on impact; other demand shocks do not. These restrictions are motivated by a basic IS-LM-AD-AS framework or by new-Keynesian models. We leave the responses of job flows, worker flows, hours and vacancies unrestricted.

The main results for the labor market variables are as follows: The responses of hours, job flows, worker flows, and vacancies are at least qualitatively similar across shocks. A positive demand or supply shock increases vacancies, the job-finding and creation rates, and decreases the separation and job-destruction rates. As in Fujita (2004), the responses of vacancies and the job-finding rate are persistent and hump shaped. Furthermore, the responses induced by demand shocks are less persistent than those induced by supply shocks. Across shocks, changes in the job-finding rate are responsible for the bulk of changes in unemployment, although separations contribute up to one half on impact. Changes in employment, on the other had, are mostly driven by the job destruction rate. As in Davis and Haltiwanger (1999), we find that job reallocation falls following expansionary shocks, especially for demand-side shocks. We find no evidence of differences in the matching process of unemployed workers and vacancies in response to different shocks. Finally, each of the demand side-shocks is at least as important as the supply side shock in explaining fluctuations in labor market variables.

There is mild evidence in support of a technological interpretation of the supply shocks identified by these restrictions. The response of labor productivity is positive for supply shocks at medium-term horizons, whereas insignificantly different from zero for the demand shocks. To check the robustness of our results, we modify our identification scheme by restricting the medium-run response of labor productivity to identify the supply-side shock, while leaving the short-run responses of output and the price level unrestricted. This identification scheme is akin to a long-run restriction on the response of labor productivity used in the literature. Consistent with the first identification scheme, technology shocks tend to raise output and decrease the price level in the short run.

Interestingly, the labor market responses to supply shocks under this identification scheme are less clear cut. In particular, the responses of vacancies, worker and job flows to supply shocks are not significantly different from zero. Again, the demand side shocks are at least as important in explaining fluctuations in the labor market variables as the supply shock. We also identify a technology shock, using a long-run restriction on labor productivity, and a monetary shock, via the recursiveness assumption used by Christiano, Eichenbaum, and Evans (1999). Again, we find that the responses to the technology shock are not significantly different from zero. The responses to the monetary shock are consistent with the ones identified above. The contribution of the monetary shock to the variance of labor-market variables exceeds that of the technology shock.

We also analyze the subsample stability of our results. We find a reduction in the volatility of shocks, consistent with the Great Moderation literature, for the post-1984 subsample. The main conclusions from the analysis above apply to both subsamples.

Furthermore, we use a small VAR including only non-labor market variables and hours to identify the shocks. We then uncover the responses of the labor market variables by regressing them on distributed lags of the shocks. Our findings are robust to this alternative empirical strategy.

Our results suggest that a reconciliation of the Mortensen-Pissarides model should equally apply to the response of labor market variables to demand side shocks. Furthermore, the response to supply side shocks is much less clear cut than implicitly assumed in the bulk of the literature. In a related paper, Braun, De Bock, and DiCecio (2006) further explore the labor market responses to differentiated supply shocks (see also Lopez-Salido and Michelacci, 2005).

Also, our findings suggest that the "hours debate" spawned by Galì (1999) is relevant for business cycle models with a Mortensen-Pissarides labor market. In trying to uncover the source of business cycle fluctuations, several authors have argued that a negative response of hours worked to supply shocks is inconsistent with the standard real business cycle (RBC) model. These results are often interpreted as suggesting that demand-side shocks must play an important role in driving the cycle and used as empirical support for models that depart from the RBC standard by incorporating nominal rigidities and other frictions. We provide empirical evidence on the response of job flows, worker flows, and vacancies. This is a necessary step to evaluate the empirical soundness of business cycle models with a labor market structure richer than the competitive structure typical of the RBC models or the stylized sticky-wages structure often adopted in new-Keynesian models. The importance of demand shocks in driving labor-market variables and the atypical responses to supply shocks can be interpreted as a milder version of the "negative response of hours" findings.

The chapter is organized as follows. Section 2 describes the data used in the analysis. Section 3 describes the identification procedure. Results are presented and discussed in Section 4. Section 5 contains the robustness analysis. Section 6 concludes.

3.2. Worker Flows and Job Flows Data

For worker flows data, we use the separation and job-finding rates constructed by Shimer (2005b). We briefly discuss their construction in Section 3.2.1. For job flows data, we take the job creation and destruction series recently constructed by Faberman (2004) and Davis, Faberman, and Haltiwanger (2005), as discussed in Section 3.2.2. Section 3.2.3 presents business cycle statistics of the data.

3.2.1. Separation and Job-Finding Rates

The separation rate measures the rate at which workers leave employment and enter the unemployment pool. The job-finding rate measures the rate at which unemployed workers exit the unemployment pool. Although the rates are constructed and interpreted while omitting flows between labor market participation and non-participation, Shimer (2005b) shows that they capture the most important cyclical determinants of the behavior of both the unemployment and employment pools over the business cycle. The advantage of using these data lies in its availability for a long time span. The data constructed by Shimer are available from 1947, whereas worker flow data including non-participation flows from the Current Population Survey (CPS) are available only from 1967 onward.

The separation and job-finding rates are constructed using data on the short-term unemployment rate as a measure of separations and the law of motion for the unemployment rate to back out a measure of the job-finding rate. The size of the unemployment pool is observed at discrete dates t, $t+1$, $t+2$.... Hirings and separations occur continuously between these dates. To identify the relevant rates within a time period, assume that between dates t and $t+1$, separations and job-finding occur with constant Poisson arrival rates s_t and f_t, respectively. For some $\tau \in (0,1)$, the law of motion for the unemployment pool $U_{t+\tau}$ is

$$\dot{U}_{t+\tau} = E_{t+\tau} s_t - U_{t+\tau} f_t,$$

where $E_{t+\tau}$ is the pool of employed workers. Here, $E_{t+\tau} s_t$ are simply the inflows and $U_{t+\tau} f_t$ the outflows from the unemployment pool at $t+\tau$. The analogous expression for the pool of short-term unemployed $U^s_{t+\tau}$ (i.e., those workers who have entered the unemployment pool after date t) is:

$$\dot{U}^s_{t+\tau} = E_{t+\tau} s_t - U^s_{t+\tau} f_t.$$

Combining these expressions leads to

$$\dot{U}_{t+\tau} = \dot{U}^s_{t+\tau} - (U_{t+\tau} - U^s_{t+\tau}) f_t.$$

Solving the differential equation using $U_t^s = 0$ yields

$$U_{t+1} = U_t e^{-f_t} + U_{t+1}^s.$$

Given data on U_t, U_{t+1}, and U_{t+1}^s, the last expression can be used to construct the job-finding rate f_t. The separation rate then follows from

$$U_{t+1} = (1 - e^{-f_t - s_t}) \frac{s_t}{f_t + s_t} L_t + e^{-f_t - s_t} U_t, \tag{3.1}$$

where $L_t \equiv U_t + E_t$. Given the job-finding rate, f_t, and labor force data, L_t and U_t, equation 3.1 uniquely defines the separation rate, s_t. Note that the rates s_t and f_t are time-aggregation adjusted versions of $\frac{U_{t+1}^s}{E_{t+1}}$ and $\frac{U_t - U_{t+1} + U_{t+1}^s}{U_{t+1}}$, respectively. The construction of s_t and f_t takes into account that workers may experience multiple transitions between dates t and $t+1$. Note also that these rates are continuous time arrival rates. The corresponding probabilities are $S_t = (1 - \exp(-s_t))$ and $F_t = (1 - \exp(-f_t))$.

Using equation 3.1, observe that if $f_t + s_t$ is large, the unemployment rate, $\frac{U_{t+1}}{L_t}$, can be approximated by the steady-state relationship $\frac{s_t}{f_t + s_t}$. As shown by Shimer (2005b), this turns out to be a very accurate approximation to the true unemployment rate. We use it to infer changes in unemployment from the responses of f_t and s_t in the SVAR. To gauge the importance of the job finding and separation rates in determining unemployment, we follow Shimer (2005b) and construct the following variables:

- $\frac{s_t}{s_t + f_t}$ is the approximated unemployment rate;
- $\frac{\bar{s}}{\bar{s} + f_t}$ is the hypothetical unemployment rate computed with the actual job-finding rate, f_t, and the average separation rate, $\bar{s}$;

- $\frac{s_t}{s_t+\overline{f}}$ is the hypothetical unemployment rate computed with the average job-finding rate, $\overline{f}$, and the actual separation rate, s_t.

These measures allow us to disentangle the contributions of the job-finding and separation rates to changes in the unemployment rate.

Note that we measure the inflow side of the employment pool using the job-finding rate and not the hiring rate. The hiring rate sums all worker flows into the employment pool and scales them by current employment (see Fujita (2004)). Its construction is analogous to the job-creation rate defined for job flows. The response of this rate to shocks is in general not very persistent, as opposed to that of the job-finding rate. This difference is due to the scaling. We return to this point below.

3.2.2. Job Creation and Job Destruction

The job flows literature focuses on job-creation (JC) and destruction (JD) rates.[3] Gross job creation sums up employment gains at all plants that expand or start up between $t-1$ and t. Gross job destruction, on the other hand, sums up employment losses at all plants that contract or shut down between $t-1$ and t. To obtain the creation and destruction rates, both measures are divided by the averages of employment at $t-1$ and t. Davis, Haltiwanger, and Schuh (1996) constructed measures for both series from the Longitudinal Research Database (LRD) and the monthly Current Employment Statistics (CES) survey from the Bureau of Labor Statistics (BLS).[4] A number of researchers work only with the

[3] See Davis and Haltiwanger (1992), Davis, Haltiwanger, and Schuh (1996), Davis and Haltiwanger (1999), Caballero and Hammour (2005), and Lopez-Salido and Michelacci (2005).

[4] As pointed out in Blanchard and Diamond (1990) these job creation and destruction measures differ from true job creation and destruction as (i) they ignore gross job creation and destruction within firms, (ii) the point-in-time observations do not take into account job creation and destruction offsets within the quarter, and (iii) they fail to account for newly created jobs that are not filled with workers yet.

quarterly job creation and job destruction series from the LRD.[5] Unfortunately this series is available only for the 1972:Q1-1993:Q4 period.

In this paper we work with the quarterly job flows constructed by Faberman (2004), and Davis, Faberman, and Haltiwanger (2005) from three sources. These authors splice together data from the (i) BLS manufacturing Turnover Survey (MTD) from 1947 to 1982, (ii) the LRD from 1972 to 1998, and (iii) the Business Employment Dynamics (BED) from 1990 to 2004. The MTD-LRD data are spliced as in Davis and Haltiwanger (1999), whereas the LRD-BED splice follows Faberman (2004).

A fundamental accounting identity relates the net employment change between any two points in time to the difference between job creation and destruction. We define $g_{E,t}^{JC,JD}$ as the growth rate of employment implied by job flows:

$$g_{E,t}^{JC,JD} \equiv \frac{E_t - E_{t-1}}{(E_t + E_{t-1})/2} \equiv JC_t - JD_t. \tag{3.2}$$

The data spliced from the MTD and LRD of the job-creation and -destruction rates constructed by Davis, Faberman, and Haltiwanger (2005) pertain to the manufacturing sector. However, over the period 1954:Q2-2004:Q2, the implied growth rate of employment from these job flows data, $g_{E,t}^{JC,JD} \equiv (JC_t - JD_t)$, is highly correlated with the growth rate of total non-farm payroll employment, $g_{E,t} \equiv \left[\frac{E_t - E_{t-1}}{0.5(E_t + E_{t-1})}\right]$: $Corr\left(g_{E,t}^{JC,JD}, g_{E,t}\right) = 0.89$.[6]

[5]Davis and Haltiwanger (1999) extend the series back to 1948. Some authors report that this extended series is (i) somewhat less accurate and (ii) only tracks aggregate employment in the 1972:Q1-1993:Q4 period (see Caballero and Hammour (2005)).

[6]The correlation of $g_{E,t}^{JC,JD}$ with the growth rate of employment in manufacturing is 0.93.

As in Davis, Haltiwanger, and Schuh (1996), we also define gross job reallocation r_t as

$$r_t \equiv JC_t + JD_t. \tag{3.3}$$

Using this definition we examine the reallocation effects of a particular shock in the SVARs. We also look at cumulative reallocation.

3.2.3. Business Cycle Properties

Table 3.11 reports correlations and standard deviations (relative to output) for the business cycle component[7] of worker flows, job flows, the unemployment rate (u), vacancies (v), and output (y).[8] The job-finding rate and vacancies are strongly procyclical. Job creation is moderately procyclical. The separation rate, job destruction and the unemployment rate are countercyclical. Job destruction is one-and-a-half times more volatile than job creation. The job-finding rate is twice as volatile as the separation rate. Notice that job destruction and the separation rate are positively correlated, whereas job creation and the job-finding rate are orthogonal to each other.

In Table 3.12 we report correlations of the three unemployment approximations described in Section 3.2.1 with actual unemployment, and standard deviations (relative to

[7]We used the band-pass filter described in Christiano and Fitzgerald (2003) for frequencies between 8 and 32 quarters to extract the business-cycle component of the data.
[8]See Appendix A for data sources.

actual unemployment). The steady-state approximation to unemployment is very accurate, and the job-finding rate plays a bigger role in determining unemployment. The contribution of the job-finding rate is even larger at cyclical frequencies.[9]

3.3. Structural VAR Analysis

In this section, we describe the reduced-form VAR specification and provide an outline of the Bayesian implementation of sign restrictions. The variables included in the SVAR analysis are the growth rate of average labor productivity ($\Delta \ln Y/H$), the inflation rate ($\Delta \ln p$), hours ($\ln H$), worker flows (job-finding and separation rates), job flows (job creation and destruction), a measure of vacancies ($\ln v$), and the federal funds rate ($\ln(1+R)$). Worker flows are the job-finding and separation rates constructed in Shimer (2005b). Job flows are the job-creation and destruction series from Faberman (2004) and Davis, Faberman, and Haltiwanger (2005). Sources for the other data are given in Appendix A. The sample covers the period 1954:Q2-2004:Q2. The variables are required to be covariance stationary. To achieve stationarity, we linearly detrend the logarithms of the job flows variables. The estimated VAR coefficients corroborate the stationarity assumption.

Consider the following reduced-form VAR:[10]

$$Z_t = \mu + \textstyle\sum_{j=1}^{p} B_j Z_{t-j} + u_t, \;\; E u_t u_t' = V, \tag{3.4}$$

[9]Shimer (2005a) uses an HP filter with smoothing parameter 10^5. His choice of an unusual filter to detrend the data further magnifies the contribution of the job-finding rate to unemployment with respect to the figures we report.

[10]Based on information criteria, we estimate a reduced form VAR including 2 lags, i.e., $p = 2$.

where Z_t is defined as:

$$Z_t = \begin{bmatrix} \Delta \ln \left(\frac{Y_t}{H_t} \right), \Delta \ln (p_t), \ln (H_t), \ln (f_t), \\ \ln (s_t), \ln (JC_t), \ln (JD_t), \ln (v_t), \ln (1 + R_t) \end{bmatrix}'.$$

The reduced-form residuals (u_t) are mapped into the structural shocks (ϵ_t) by the structural matrix (A_0) as follows:

$$\epsilon_t = A_0 u_t.$$

The structural shocks are orthogonal to each other, i.e., $E(\epsilon_t \epsilon_t') = I$.

We employ identification schemes of the structural shocks that use prior information about the signs of the responses of certain variables. First we use short-run output and price responses to distinguish between demand and supply shocks. Then, we alternatively identify supply-side technology shocks by restricting the medium-run response of labor productivity.[11]

3.3.1. Implementing Sign-Restrictions

The identification schemes we consider are implemented following a Bayesian procedure. We impose a Jeffreys (1961) prior on the reduced-form VAR parameters:

$$p(B, V) \propto \|V\|^{-\frac{n+1}{2}},$$

where $B = [\mu, B_1, ..., B_p]'$ and n is the number of variables in the VAR. The posterior distribution of the reduced-form VAR parameters belongs to the inverse Wishart-Normal

[11]As a robustness check, we also combine long-run and short-run restrictions more commonly used in the literature (see Section 5)

family:

$$(3.5) \qquad (V|Z_{t=1,...,T}) \sim IW\left(T\hat{V}, T-k\right),$$

$$(3.6) \qquad (B|V, Z_{t=1,..,T}) \sim N\left(\hat{B}, V\left(X'X\right)^{-1}\right),$$

where $\hat{B}$ and $\hat{V}$ are the OLS estimates of B and V, T is the sample length, $k = (np+1)$, and X is defined as

$$X = \left[x_1', ..., x_T'\right]',$$
$$x_t' = \left[1, Z_{t-1}', ..., Z_{t-p}'\right]'.$$

Consider a possible orthogonal decomposition of the covariance matrix, i.e., a matrix C such that $V = CC'$. Then CQ, where Q is a rotation matrix, is also an admissible decomposition. The posterior distribution on the reduced-form VAR parameters, a uniform distribution over rotation matrices, and an indicator function equal to zero on the set of IRFs that violate the identification restrictions induce a posterior distribution over the IRFs that satisfy the sign restrictions.

The sign restrictions are implemented as follows:

(1) For each draw from the inverse Wishart-Normal family for (V, B) in (3.5) and (3.6) we take an orthogonal decomposition matrix, C, and draw one possible rotation, Q.[12]

[12] We obtain Q by generating a matrix X with independent standard normal entries, taking the QR factorization of X, and normalizing so that the diagonal elements of R are positive.

(2) We check the signs of the impulse responses for each structural shock. If we find a set of structural shocks that satisfy the restrictions, we keep the draw. Otherwise we discard it.

(3) We continue until we have 1,000 draws from the posterior distribution of the IRFs that satisfy the identifying restrictions.

3.4. Price and Output Restrictions

The basic IS-LM-AD-AS model can be used to motivate the following restrictions to distinguish demand and supply shocks. Demand shocks move the price level and output in the same direction in the short run. Supply shocks, on the other hand, move output and the price level in opposite directions. On the demand side, we further distinguish between monetary and non-monetary shocks: Monetary shocks lower the interest rate on impact whereas non-monetary demand shocks do not. The price level and interest rate responses are restricted for one quarter, the output response is restricted for four quarters. These restrictions are similar to the ones used by Peersman (2005).[13] The identifying restrictions are summarized in Table 3.13.

Figures 3.8 and 3.9 report the median, 16th, and 84th percentiles of 1,000 draws from the posterior distribution of acceptable IRFs to the structural shocks of non-labor market variables, labor market variables, and other variables of interest. Recall that labor market variables are left unrestricted. Note that the response of output is hump-shaped across shocks and more persistent for supply shocks. Furthermore, the response of hours is positive for all shocks and the response of labor productivity is positive for supply shocks.

[13] Peersman (2005) additionally restricts the response of the interest rate for supply shocks and the response of the oil price to further disentangle supply shocks.

For the response of the labor market variables displayed in Figure 3.9, the following main observations emerge:

Similarity Across Shocks. The labor market variable responses are qualitatively similar across shocks. However, supply shocks generate more persistent responses than demand shocks. Also, the IRFs of the labor market variables to supply shocks are less pronounced. A larger fraction of responses involve atypical responses of the labor market variables, such as an increase in job destruction on impact.

Worker Flows, Unemployment, and Vacancies. The job-finding rate and vacancies respond in a persistent, hump-shaped manner. Separations are less persistent. The unemployment rate decreases for ten quarters in response to demand shocks and overshoots its steady-state value. In response to supply shocks, the unemployment rate decreases in a U-shaped way, displaying a more persistent response and no overshooting. The response of the unemployment rate to all shocks is mostly determined by the effect on the job-finding rate. However, the separation rate contributes up to one half of the total effect on impact. The largest effect on unemployment is reached earlier for the separation rate than for the job-finding rate.

Job Flows, Employment Dynamics, and Job Reallocation. The response of employment growth is largely driven by job destruction. The responses of the job-destruction rate are similar in shape to those of the separation rate, but larger in magnitude. The responses of the job-creation rate are the mirror image of the IRFs of the job-destruction rate. Job destruction responds to shocks twice as much as job creation does. Note that a sizable number of the responses of job flows to supply shocks involve a decrease in job creation and an increase in job destruction. All shocks increase the growth rate of employment and reduce reallocation. The drop in reallocation is more pronounced for demand shocks. We do not find a significant permanent effect on cumulative reallocation.

The similarity across shocks may support the one-shock approach taken in the literature studying the business cycle properties of the Mortensen-Pissarides model. Although the persistence of the effects differs, all shocks raise job finding, vacancies, and job creation; they lower separations and job destruction in a similar fashion. The difference in persistence across shocks casts doubts on a reconciliation of the Mortensen-Pissarides model with the observed labor market behavior that is specific to a particular shock. The considerable fraction of atypical responses to supply shocks suggests that a further analysis of shocks different from the one we consider is necessary (see Braun, De Bock, and DiCecio, 2006; Lopez-Salido and Michelacci, 2005).

The hump-shaped response of the job-finding rate and vacancies to shocks is not consistent with the Mortensen-Pissarides model and with most of the literature. This finding is in line with Fujita (2004), who identifies a unique aggregate shock in a trivariate VAR including worker flows variables, scaled by employment, and vacancies. This aggregate shock is identified by restricting the responses of employment growth (non-negative for four quarters), the separation rate (non-positive on impact), and the hiring rate (non-negative on impact). Our identification strategy confirms these findings without restricting worker flow variables. Note that where we use the job finding probability in our VAR, Fujita (2004) includes the hiring rate to measure worker flows into employment. The hiring rate measures worker flows into employment, scaled by the size of the employment pool. The job-finding rate measures the probability of exiting the unemployment pool. Although both arguably reflect movements of workers into employment (see Shimer, 2005b), the difference in scaling leads to a different qualitative behavior of the two series in response to an aggregate shock. The response of the job-finding rate shows a persistent increase. Fujita's hiring rate initially increases but quickly drops below zero because of the swelling employment pool.

The mildly negative effect on cumulative reallocation is at odds with Caballero and Hammour (2005), who find that expansionary aggregate shocks have positive effects on cumulative reallocation.

For monetary policy shocks, the IRFs of aggregate variables are consistent with Christiano, Eichenbaum, and Evans (1999), who use a recursiveness restriction to identify a monetary policy shock. However, Christiano, Eichenbaum, and Evans (1999) obtain a more persistent interest rate response and inflation exhibits a price puzzle. The latter difference is forced by our identification scheme. The job flows responses are consistent with estimates in Trigari (2004) and the worker flows and vacancies responses with those in Braun (2005).

The last row of Figure 3.8 shows the IRFs of labor productivity for 100 quarters. Average labor productivity, which is unrestricted, displays a persistent yet weak increase in response to supply shocks. On the other hand, productivity shows no persistent response to demand and monetary shocks. The medium-run response of labor productivity to supply shocks is consistent with a "technology shocks" interpretation.

Table 3.15 reports the median of the posterior distribution of variance decompositions, i.e., the percentage of the j-periods-ahead forecast error accounted for by the identified shocks. The forecast errors of output and labor productivity are mostly driven by supply shocks. Interestingly, demand shocks seem to play a more important role for the labor market variables than the supply shock. The greater importance of demand shocks suggests that more attention should be paid to other shocks in the evaluation of the basic labor market search model.

A growing literature is analyzing the response of hours worked to technology shocks in VARs. Shea (1999), Galì (1999, 2004), Basu, Fernald, and Kimball (2004), and Francis and Ramey (2005) argue that hours decrease on impact in response to technology shocks. This result is at odds with the standard RBC model, which implies an increase in hours worked in response to a positive technology shock. The conclusion drawn is that the RBC model should be amended by including nominal rigidities, habit formation in consumption and investment adjustment costs, a short-run fixed proportion technology, or different shocks.[14] Our results on the importance of demand shocks in driving labor-market variables and on atypical responses of these variables to supply shocks can be interpreted as an extension of the "negative hours response" findings, though in a milder form.

Table 3.16 shows the variance contributions of the shocks at business cycle frequencies. The contribution of shock i to the total variance is computed as follows:

- we simulate data with only shock i, say Z_t^i;
- we band-pass filter Z_t^i and Z_t to obtain their business cycle components, $(Z_t^i)^{BC}$ and $(Z_t)^{BC}$, respectively;
- the contribution of shock i is computed by dividing the variance of $(Z_t^i)^{BC}$ by the variance of $(Z_t)^{BC}$.

[14]Christiano, Eichenbaum, and Vigfusson (2004), on the other hand, argue that the negative impact response of hours to technology shocks is an artifact of over-differencing hours in VARs.

The left panel of table 3.16 shows the variance contribution with the price-output restriction. The non-monetary demand shock is the most important shock. The monetary and supply shock contribute about equally to the business cycle variation of labor and non-labor market variables.

3.4.1. Matching Function Estimates

We can further analyze the possibly differential response of the labor market to shocks by estimating a shock-specific matching function. In the Mortensen-Pissarides model, the number of hires is related to the size of the unemployment pool and the number of vacancies via a matching function $M(U,V)$.[15] Assuming a Cobb-Douglass functional form, the matching function is given by

$$M(U,V) = AU^{\alpha_u}V^{\alpha_v},$$

where α_v is the elasticity of the number of matches with respect to vacancies and measures the positive externality caused by firms on searching workers; α_u is the elasticity with respect to unemployment and measures the positive externality from workers to firms; and A captures the overall efficiency of the matching process.

Under the assumption of constant returns to scale (CRS), i.e., $\alpha_u + \alpha_v = 1$, the job-finding rate can then be expressed as

$$\ln f_t = \ln A + \alpha(\ln v_t - \ln u_t). \tag{3.7}$$

If we do not impose CRS, we get

[15] Petrongolo and Pissarides (2001) survey the matching function literature.

$$\ln f_t = \ln A + \alpha_v \ln v_t - (1 - \alpha_u) \ln u_t.$$

To consider the effect of the shocks we identified on the matching process, we consider a sample of 1,000 draws from the posterior distributions of A and the elasticity parameters estimated from artificial data.

Each draw involves the following steps:

(1) consider a vector of accepted residuals constructed as if the shock(s) of interest were the only structural shock(s);

(2) use this vector of accepted residuals and the VAR parameters to generate artificial data $\tilde{Z}_t$;

(3) construct unemployment using the steady-state approximation $\tilde{u}_{t+1} = \tilde{s}_t / \left(\tilde{s}_t + \tilde{f}_t\right)$ from the artificial data;

(4) regress $\ln \tilde{f}_t$ on either $\ln \tilde{v}_t$ and $\ln \tilde{u}_t$ (not assuming CRS) or $\ln (\tilde{v}_t / \tilde{u}_t)$ (under the CRS assumption).

The artificial data constructed using only monetary shocks, for example, induce a posterior distribution for α and A for a hypothetical economy in which monetary shocks are the only source of fluctuations.

Table 3.17 reports the median, 16th, and 84th percentiles of 1,000 draws from the posterior distributions for the output and price identification scheme. The first two columns show the estimates for α_v and A when we impose CRS. The CRS estimates suggest that aggregate shocks do not entail a differential effect on the matching process. The estimated efficiency parameters A are somewhat lower for monetary and demand shocks than for the supply shock, but the median estimates differ by less than 5%. The last three columns of Table 3.17 show the unrestricted estimates for α_v, α_u, and A. Estimates of α_v and α_u across shocks are close and the sum of the coefficients is around 0.70, corresponding to decreasing returns to scale. There are no significant differences in the median estimates of the efficiency parameter A.

3.5. Robustness

We analyze the robustness of our results by considering medium-run and long-run restrictions on productivity to identify technology shocks. We also consider subsample stability and a minimal VAR specification to identify the shocks of interest.

3.5.1. Restricting the Medium-Run Response of Labor Productivity

We push further the technological interpretation of supply shocks by identifying them as ones that increase labor productivity in the medium run. We leave unrestricted the short-run responses of output and the price level. This allows us to capture, as supply shocks, "news effects" on future technological improvements (see Beaudry and Portier, 2003) and is akin to the long-run restrictions used in the literature. We will analyze the latter in the next subsection. The advantage of this medium-run restriction is that it allows us to identify the other shocks within the same framework as above.

In particular, we require that a technology shock raise labor productivity throughout quarters 33 to 80 following the shock. The demand-side shocks, on the other hand, are restricted to have no positive medium-run impact on labor productivity, while affecting output, the price level, and the interest rate as above. The identifying restrictions are summarized in Table 3.14. This restriction is similar, in spirit, to the long-run restriction on productivity adopted by Galì (1999). Uhlig (2004) and Francis, Owyang, and Roush (2006) identify technology shocks in ways similar to ours. According to Uhlig (2004), a technology shock is the only determinant of the k-periods-ahead forecast error variance. Francis, Owyang, and Roush (2006) identification is data-driven and attributes to technology shocks the largest share of the k-periods-ahead forecast error variance.

Figures 3.10 and 3.11 report the median, 16^{th}, and 84^{th} percentiles of 1,000 draws from the posterior distribution of acceptable IRFs to the structural shocks. By construction, the demand-side shocks identified satisfy the restrictions in the previous section as well. The responses of all variables to demand-side shocks and of output and inflation to supply shocks are almost identical to the ones above. A sizable fraction (49.3 percent) of the supply shocks identified by restricting productivity in the medium run generate short-run responses of output and prices of opposite sign. Note that the responses of the labor market variables to the supply shocks are smaller in absolute value than under the previous identification scheme. Furthermore, a sizeable fraction of the responses of labor market variables points to a reduction in employment and hours and an increase in unemployment.

For the variance decomposition displayed in Table 3.6, we again find that the two demand shocks are more important than supply shocks in driving fluctuations in labor market variables. This is also true for the variance contributions at business cycle frequencies, displayed in Table 3.16.

Table 3.18 shows the matching function estimates under the labor productivity identification scheme. The estimates are very similar. Now, only the efficiency of the matching process in response to non-monetary demand shocks is lower than the corresponding estimate for the supply shock under constant returns to scale.

3.5.2. Restricting Labor Productivity using a Long-Run Restriction

Following Galì (1999), we now identify technology shocks using long-run restrictions. Technology shocks are the only shocks to affect average labor productivity in the long run. The long-run effects of the structural shocks are given by

$$Z_{\infty} = \Theta \epsilon_t,$$

$$\Theta \equiv \left[I - A\left(1\right)\right]^{-1} A_0^{-1}.$$

The identifying assumption boils down to assuming that the first row of matrix Θ has the following structure:

$$\Theta\left(1, :\right) = \left[\Theta\left(1, 1\right), 0_{1\times 9}\right].$$

We additionally identify monetary policy shocks via a recursiveness assumption as in Christiano, Eichenbaum, and Evans (1999) by assuming that the 9^{th} column of A_0 has the following structure[16]:

$$A_0\left(:, 9\right) = \left[0_{1\times 9}, A_0\left(9, 9\right)\right]'.$$

This identification assumption can be interpreted as signifying that the monetary authority follows a Taylor-rule-like policy, which responds to all the variables ordered before the interest rate in the VAR.

[16]Notice that there is one overidentifying restriction. The first element of ϵ_t would be just identified by imposing the long-run restriction. The identification of monetary policy shocks imposes one additional zero restriction.

Figure 3.12 shows the impulse responses to a technology shock. Note that none of the response of the labor market variables are significantly different from zero.

Figure 3.13 shows the response to a monetary policy shock. The responses are consistent with the ones identified above.

Table 3.6 displays the variance decompositions and variance contributions at business cycle frequencies. Note that although monetary policy shocks contribute much less to variance of output and productivity than the technology shocks, fluctuations in the labor market variables are to a much larger extent driven by the monetary shock.

3.5.3. Subsample Stability[17]

Several papers[18] documented a drop in the volatility of output, inflation, interest rates, and other macroeconomic variables since the early- or mid-1980s. Motivated by these findings, we estimate our SVAR with pre-1984 and post-1984 subsamples. The post-1984 responses have similar shapes, but are smaller than the pre-1984 and the whole sample responses for all the shocks. This is consistent with a reduction in the volatility of the structural shocks. However, supply shocks have more persistent effects in the post-1984 subsample for both identification schemes. The responses of labor market variables to supply shocks identified by restricting productivity are insignificantly different from zero for both subsamples.

In terms of forecast error decomposition, supply shocks are the most important for output in the post-1984 subsamples; for hours, monetary shocks are the most important in

[17]The full set of IRFs and variance decompositions for the two subsamples is available upon request from the corresponding author.

[18]See Kim and Nelson (1999), McConnell and Perez-Quiros (2000), and Stock and Watson (2003).

the pre-1984 subsample, while in the post-1984 subsamples the three shocks we identify are equally important.[19] For worker and job flows, each demand shock is at least as important as the supply shock, across subsamples and identification schemes.

3.5.4. Small VAR

To further check the robustness of our results, we used a lower-dimensional VAR containing labor productivity, inflation, the nominal interest rate, and hours to identify the shocks using the same sign restrictions as above. For a draw that satisfies the identifying restrictions we then regressed

$$z_t = a + \sum_{j=0}^{T} \beta_j^M \widehat{\varepsilon}_{t-j}^M + \sum_{j=0}^{T} \beta_j^D \widehat{\varepsilon}_{t-j}^D + \sum_{j=0}^{T} \beta_j^S \widehat{\varepsilon}_{t-j}^S + \nu_{z,t},$$

where $\left(\varepsilon^M, \varepsilon^D, \varepsilon^S\right)$ denote the three shocks identified in the minimal VAR, z_t is one of the variables not contained in the VAR, i.e. either vacancies, the job-finding rate, the separation rate, the job-creation rate, or the job-destruction rate. Also, a and $\nu_{z,t}$ denote a constant and an i.i.d. error term, respectively. The length of the moving average terms was set to thirty, i.e., $T = 30$. The impulse responses for the labor market variables are given by the respective β_j.

For both identification schemes, the qualitative conclusions are similar to above. The responses of the job-finding rate and vacancies to a non-monetary demand shock are, however, less persistent then above. Furthermore, the responses to supply shocks are even less pronounced then for the VAR specification discussed in Section 3.3 above.[20]

[19] Our results on the increased importance in the later subsampes of supply shocks in accounting for the forecast error of output are consistent with Fisher (2006). On the other hand, for hours, Fisher (2006) argues that the importance of technology shocks decreased post-1982.

[20] The figures are available upon request.

Again, demand shocks are as important as supply shocks in driving fluctuations of the labor market variables.

3.6. Conclusion

This chapter considers alternative short-run, medium-run, and long-run restrictions to identify structural shocks in order to analyze their impact on worker flows, job flows, vacancies, and hours. We find that demand shocks are more important than supply shocks (technology shocks more specifically) in driving labor market fluctuations. When identified via short-run price and output restrictions, supply shocks have qualitatively similar effects to demand shocks. They raise employment, vacancies, the job-creation rate, and the job-finding rate while lowering unemployment, separations and job destruction. These effects are more persistent for supply shocks. When identified via medium-run or long-run restrictions on labor productivity, however, supply shocks do not have a clear cut effect on the labor market variables.

Table 3.1. Data sources

Country	Code	Source NA	Trade Data	Interest Rate
Emerging				
Argentina	arg	IFS	UN-NBER	Neumeyer and Perri (2005): 1983-1994
				EMBI: 1994-2000
Brazil	br	IFS	UN-NBER	EMBI: 1994
Chile	chl	IFS	UN-NBER	
Colombia	col	IFS	UN-NBER	
Greece	gr	IFS	UN-NBER	
Indonesia	ind	IFS	UN-NBER	
Israel	is	IFS	UN-NBER	
Korea Rep	ko	IFS	UN-NBER	EMBI: 1994
Malaysia	mal	IFS	UN-NBER	
Mexico	mex	IFS	UN-NBER	EMBI: 1995
Peru	per	IFS	UN-NBER	
Philippines	ph	IFS	UN-NBER	EMBI: 1994
Portugal	port	IFS	UN-NBER	
South Africa	sa	IFS	UN-NBER	EMBI:1995
Thailand	th	IFS	UN-NBER	
Turkey	tk	IFS:1987	UN-NBER	
Venezuela	ven	IFS	UN-NBER	
Developed				
Australia	aus	IFS	UN-NBER	OECD Corporate CP: 1968
Austria	austr	IFS	UN-NBER	
Belgium	bel	IFS	UN-NBER	IFS: 1981
Canada	can	IFS	UN-NBER	OECD Corporate CP: 1970
Denmark	den	IFS	UN-NBER	IFS:1980
Netherlands	nl	IFS	UN-NBER	BoN, Call Money: 84-85, AIBOR: 86-00
Spain	spa	IFS	UN-NBER	IFS:1980
Sweden	swe	IFS	UN-NBER	OECD Treasury Rate: 1982
G-7				
Italy	it	IFS	UN-NBER	IFS: 1980
Japan	jp	IFS	UN-NBER	IFS: 1980
USA	us	IFS	UN-NBER	IFS: 1980

Note: The definition of an emerging market follows the classification of the International Finance Corporation. IFS: International Financial Statistics. EMBI: Emerging Markets Bond Index. UN-NBER is data from Feenstra, Lipsey, Deng, Ma, and Mo (2005).

Table 3.2. Capital goods import and export shares

Country	$X^{K,\$}/X^{\$}$	$M^{K,\$}/M^{\$}$	$X^{K,\$}S/Y$	$M^{K,\$}S/Y$
Emerging				
Argentina	5.99	40.66	0.52	2.21
Brazil	17.28	30.74	1.53	1.75
Chile	0.97	42.13	0.25	7.62
Colombia	2.02	37.24	0.24	4.27
Greece	6.02	30.33	0.66	6.61
Indonesia	1.52	37.50	0.43	6.61
Israel	23.49	31.25	4.93	8.92
KoreaRep	36.13	34.28	9.37	9.42
Malaysia	33.54	50.40	25.75	33.20
Mexico	39.16	46.36	6.17	5.17
Peru	0.90	36.21	0.10	4.25
Philippines	25.65	29.37	5.64	8.28
Portugal	19.23	35.81	4.18	10.93
South Africa	2.32	42.90	0.62	7.34
Thailand	20.87	40.08	5.80	15.26
Turkey	8.77	34.68	1.02	6.00
Venezuela	1.06	43.76	0.31	5.57
Group Median	8.77 [5.99,25.65]	37.24 [36.21,40.08]	1.02 [0.52,5.64]	6.61 [5.57,8.28]
Developed				
Australia	6.39	44.23	0.59	3.51
Austria	35.92	37.12	8.23	10.21
Belgium	27.40	25.55	15.78	15.29
Canada	36.31	51.90	8.81	11.79
Denmark	23.08	30.90	3.76	4.49
Netherlands	22.25	30.97	10.48	12.06
Sweden	42.78	38.14	11.33	8.93
Group Median	31.66 [25.24,36.30]	36.59 [30.94,37.63]	8.52 [6.16,9.65]	9.57 [7.66,11.79]
G-7				
Italy	35.68	28.62	5.59	4.76
Japan	69.69	15.31	7.12	0.94
USA	45.94	43.31	3.20	3.84

Note: To calculate the GDP share of imports and exports in national currencies, the dollar value of traded capital goods was multiplied by the average exchange rate in a given year. Block-bootstrapped 95% confidence intervals in brackets.

Table 3.3. Cyclicality of national accounts variables

Country	Correlations with output Y			
	TB/Y	TB^G/Y	C	I
Emerging				
Argentina	-0.87	-0.86	0.74	0.93
Brazil	-0.37	-0.47	0.05	0.51
Chile	-0.71	-0.72	0.85	0.87
Colombia	-0.31	-0.22	0.43	0.72
Greece	-0.22	-0.27	-0.04	0.65
Indonesia	-0.39		0.76	0.86
Israel	-0.51	-0.49	0.58	0.58
Korea Rep	-0.72	-0.74	0.89	0.84
Malaysia	-0.71	-0.68	0.81	0.89
Mexico	-0.68	-0.68	0.69	0.80
Peru	-0.58	-0.61	0.77	0.80
Philippines	-0.68	-0.57	0.74	0.91
Portugal	-0.41	-0.31	-0.05	0.64
South Africa	-0.65	-0.69	0.77	0.78
Thailand	-0.88	-0.89	0.89	0.97
Turkey	-0.61	-0.63	0.73	0.87
Venezuela	-0.77	-0.75	0.60	0.84
Group Median	-0.66 [-0.71,-0.51]	-0.65 [-0.70,-0.49]	0.73	0.80
Developed				
Australia	-0.52	-0.51	0.27	0.90
Austria	-0.15	-0.07	0.69	0.64
Belgium	-0.21	-0.09	0.36	0.89
Canada	-0.16	-0.18	0.62	0.75
Denmark	-0.12	-0.08	-0.05	0.89
Netherlands	-0.35	-0.35	0.77	0.80
Sweden	-0.12	-0.08	-0.05	0.89
Group Median	-0.16 [-0.35,-0.12]	-0.09 [-0.35,-0.07]	0.39	0.89
G-7				
Italy	-0.21	-0.22	0.91	0.90
Japan	-0.57	-0.53	0.63	0.95
USA	-0.47	-0.40	0.71	0.94

Note: Trade Balance (TB) is exports of goods and services (EXP) minus imports of goods and services (M) over GDP (Y). The Goods Trade Balance (GTB) is goods exports minus goods imports over GDP. Consumption (C) is private consumption. Investment (I) is gross fixed capital formation. All series except the trade balances are in logs.Block-bootstrapped 95% confidence intervals in brackets.

Table 3.4. Cyclicality of trade variables

Country	Correlations with output Y					
	X	X^K	X^K/X	M	M^K	M^K/M
Emerging						
Argentina	-0.60	-0.24	0.38	0.65	0.62	0.61
Brazil	-0.34	-0.11	0.24	-0.08	0.59	-0.23
Chile	-0.06	0.32	0.32	0.86	0.78	0.53
Colombia	0.10	0.25	0.17	0.66	0.24	0.41
Greece	0.21	0.41	0.35	0.60	0.43	0.31
Indonesia	0.18	-0.02	0.02	0.39	0.46	0.51
Israel	0.01	-0.11	-0.04	0.44	0.50	0.34
Korea Rep	-0.24	0.02	0.52	0.78	0.47	0.27
Malaysia	0.23	0.26	0.25	0.65	0.57	0.09
Mexico	-0.70	-0.89	-0.38	-0.09	0.08	0.11
Peru	-0.40	-0.14	0.04	0.54	0.34	-0.01
Philippines	0.42	0.16	0.26	0.84	0.78	0.65
Portugal	-0.03	0.01	0.22	0.34	0.67	0.52
South Africa	0.16	0.24	-0.27	0.83	0.79	-0.22
Thailand	0.11	0.06	0.06	0.80	0.71	0.37
Turkey	-0.13	-0.35	0.29	0.71	0.90	0.72
Venezuela	-0.48	-0.14	0.06	0.81	0.72	0.51
Group Median	-0.03	0.01	0.22	0.65	0.59	0.37
	[-0.24,0.10]	[-0.11,0.06]	[0.04,0.29]	[0.54,0.80]	[0.47,0.72]	[0.11,0.51]
Developed						
Australia	0.29	0.40	-0.54	0.71	0.62	-0.07
Austria	0.58	0.44	-0.07	0.63	0.69	0.29
Belgium	0.44	0.43	0.00	0.44	0.16	-0.20
Canada	0.73	0.55	-0.17	0.77	0.73	0.14
Denmark	0.38	0.24	0.39	0.48	0.16	0.29
Netherlands	0.36	0.55	0.17	0.51	0.77	0.32
Sweden	0.38	0.29	0.04	0.48	0.56	0.62
Group Median	0.38	0.43	0.00	0.51	0.62	0.29
	[0.36,0.58]	[0.29,0.55]	[-0.07,0.17]	[0.48,0.63]	[0.16,0.73]	[-0.07,0.32]
G-7						
Italy	0.65	0.72	0.25	0.66	0.77	0.33
Japan	0.65	0.58	-0.33	0.76	0.74	0.08
USA	0.43	0.54	0.17	0.83	0.76	0.08

Note: TB/Y is exports of goods and services (EXP) minus imports of good and services (IMP) over GDP. Consumption (C) is private consumption. Investment (I) is gross fixed capital formation. All series except the trade balance are in logs. Block-bootstrapped 95% confidence intervals in brackets.

Table 3.5. Business cycle volatility of national accounts and trade variables

Country	% Standard deviation		% Standard deviation of Variable / % Standard deviation of Y					
	Y	TB/Y	C	I	X	M	X^K	M^K
Emerging								
Argentina	3.49	1.54	1.40	2.72	3.31	3.80	5.58	6.39
Brazil	2.15	1.15	2.68	4.70	5.40	3.19	4.58	6.25
Chile	2.84	2.15	1.20	3.82	2.27	2.72	11.73	6.31
Colombia	1.24	1.79	3.04	8.93	6.89	4.59	14.84	11.17
Greece	0.95	1.01	1.16	7.57	4.87	3.10	20.73	10.73
Indonesia	6.07	1.88	0.68	1.47	1.74	1.65	5.22	2.85
Israel	1.13	1.71	2.52	5.11	4.46	4.10	7.60	8.13
Jordan	2.28	2.72	1.55	2.58	2.62	2.13	4.96	6.40
Korea Rep	2.67	4.11	1.53	4.46	1.23	2.36	2.90	3.95
Malaysia	2.21	1.93	1.58	3.32	4.61	3.20	2.20	7.52
Mexico	4.68	2.25	0.99	2.13	2.10	1.66	6.79	5.02
Philippines	2.91	1.88	0.52	3.91	1.56	2.76	2.88	7.35
Portugal	1.34	1.87	2.67	6.10	5.02	4.85	7.38	10.78
South Africa	1.54	2.00	1.48	3.92	3.75	4.72	22.60	7.16
Thailand	2.73	3.10	1.04	3.64	1.59	3.08	3.22	5.71
Turkey	2.84	1.92	1.11	2.36	3.04	2.49	2.46	5.23
Venezuela	2.96	5.91	1.84	5.28	4.14	4.97	7.02	8.20
Group Median	2.67	1.92	1.48	3.91 [3.32,4.70]	3.31	3.10	5.58 [4.58,7.60]	6.40 [6.31,7.35]
Developed								
Australia	1.27	0.75	0.58	3.76	3.09	3.60	7.76	6.43
Austria	1.10	0.44	1.17	1.88	3.33	3.42	5.83	7.48
Belgium	0.95	0.39	0.75	3.97	3.85	4.20	8.95	9.93
Canada	1.49	0.76	0.85	3.04	2.75	3.30	3.08	3.94
Denmark	1.17	0.68	0.89	4.38	3.75	3.81	6.09	7.32
Netherlands	1.01	0.69	1.09	2.60	4.09	3.92	7.20	8.12
Sweden	1.17	0.68	0.89	4.38	3.75	3.81	5.93	8.25
Group Median	1.17	0.68	0.89	3.76 [3.04,3.97]	3.75	3.81	6.09 [5.93,7.20]	7.48 [7.32,8.12]
G-7								
Italy	3.29	0.64	1.00	1.33	1.63	1.88	2.07	3.06
Japan	1.07	0.46	0.70	2.69	5.34	9.08	4.68	8.77
USA	1.17	0.33	0.82	2.40	2.99	3.22	3.15	4.48

Note: Trade Balance (TB) is exports of goods and services (E) minus imports of good and services (M) over GDP. Consumption (C) is private consumption. Investment (I) is gross fixed capital formation. All series except the trade balance are in logs. Block-bootstrapped 95% confidence intervals in brackets.

Table 3.6. Business-cycle properties of output and interest rates

Country	% Standard deviation		Correlation
	Y	R	(Y,R)
Emerging			
Argentina	3.59	2.96	-0.71
Brazil	0.99	2.16	-0.88
KoreaRep	3.79	1.28	-0.81
Mexico	1.36	2.66	-0.67
Philippines	2.76	0.98	-0.85
South Africa	0.92	0.35	-0.94
Group Median	2.06	1.72	-0.83
Developed			
Australia	1.27	1.70	0.47
Belgium	0.98	0.87	0.24
Canada	1.25	1.33	0.29
Denmark	1.14	1.69	-0.18
Netherlands	0.87	1.02	0.48
Spain	1.02	1.62	0.23
Sweden	1.14	1.91	-0.06
Group Median	1.14	1.62	0.24
G-7			
Italy	3.29	7.01	0.60
Japan	1.07	0.60	0.02
USA	1.17	0.82	0.15

Note: See table 1 for data sources and available time span of the different interest rate series.

Table 3.7. Parameter values used in calibration

Parameter	Value	Source
σ	2	Curvature utility function
β	0.96	Discount rate $1/(1+R^*)$
δ	0.02	Set to match average investment to GDP ratio of 20 percent (Argentina: 1980-2000)
α	0.40	Capital Share
θ	0.60	Labor curvature
ω		30 percent of overall time spent working
ω_H	0.50	Share of home goods in investment
tb/y	0.01	Average trade-balance to output (Argentina: 1980-2000)

Table 3.8. Cyclicality of actual and simulated business cycle moments

$Corr(y,\cdot)$	tb/y	i^F	c	i
Data	-0.65 [-0.70,-0.49]	0.59 [0.47,0.72]	0.73	0.80
Two-Sector Model	-0.47	0.87	1	0.87
One-Sector Model				
Cobb-Douglas Preferences	0.58		0.96	0.80
GHH Preferences	0.01		0.98	0.81

Note: Model statistics are averages over 100 simulations of 200 periods. Series are detrended with the Hodrick-Prescott filter.

Table 3.9. Volatility of actual and simulated business cycle moments

Reported as %	σ_y	$\frac{\sigma_c}{\sigma_y}$	$\frac{\sigma_i}{\sigma_y}$	$\frac{\sigma_{i^F}}{\sigma_y}$	σ_n	$\sigma_{tb/y}$
Data	2.67	1.92	3.91	6.40	2.99	1.92
Two-Sector Model	2.70	0.71	3.52	3.50	2.94	1.23
One-Sector Model						
Cobb-Douglas Preferences	2.50	0.20	2.90		1.26	1.20
GHH Preferences	2.65	0.73	2.6		2.23	0.35

Note: Model statistics are averages over 100 simulations of 200 periods. Series are detrended with the Hodrick-Prescott filter.

Table 3.10. Cross-correlation of output and interest rates

$\text{corr}(y_t, R_{t+k})$	-2	-1	0	-1	-2
Data	-0.40	-0.51	-0.52	-0.28	-0.14
	[0.45,−0.01]	[−0.64,−0.17]	[−0.69,−0.22]	[−0.38,0.03]	[−0.27,−0.18]
Two-sector Model IAC BAC	-0.28	-0.37	-0.49	-0.25	0.38
Two-sector Model	0.12	0.25	0.39	0.57	0.72
One-Sector Model					
Cobb-Douglas Preferences	0.56	0.76	0.98	0.69	0.43
GHH Preferences	0.50	0.71	0.80	0.60	0.40

Note: Block-bootstrapped ninety-five percent confidence intervals in brackets. Model statistics are averages over 100 simulations of 200 periods. Series are detrended with the Hodrick-Prescott filter.

Table 3.11. Correlation matrix of business-cycle components.

	f	s	JC	JD	u	v	h	APL	y
f	6.27 [5.54,6.99]	−0.48 [−0.63,−0.29]	−0.04 [−0.24,0.15]	−0.53 [−0.66,−0.39]	−0.98 [−0.99,−0.96]	0.95 [0.93,0.97]	0.96 [0.93,0.98]	0.20 [−0.03,0.4]	0.88 [0.81,0.92]
s		2.55 [2.21,2.99]	−0.55 [−0.68,−0.37]	0.86 [0.78,0.91]	0.54 [0.39,0.66]	−0.62 [−0.73,−0.49]	−0.48 [−0.61,−0.33]	−0.63 [−0.77,−0.44]	−0.67 [−0.78,−0.53]
JC			4.26 [3.61,4.97]	−0.58 [−0.7,−0.41]	0.08 [−0.10,0.26]	0.04 [−0.17,0.24]	−0.11 [−0.3,0.09]	0.53 [0.33,0.68]	0.14 [−0.11,0.36]
JD				6.73 [5.89,7.59]	0.53 [0.40,0.63]	−0.65 [−0.76,−0.53]	−0.53 [−0.66,−0.39]	−0.70 [−0.82,−0.54]	−0.72 [−0.84,−0.58]
u					7.27 [6.39,8.24]	−0.95 [−0.96,−0.93]	−0.95 [−0.97,−0.92]	−0.18 [−0.38,0.01]	−0.86 [−0.90,−0.81]
v						8.84 [8.13,9.78]	0.95 [0.94,0.97]	0.34 [0.14,0.53]	0.94 [0.9,0.96]
h							1.10 [1.01,1.19]	0.17 [−0.06,0.38]	0.89 [0.84,0.93]
APL								0.65 [0.56,0.77]	0.58 [0.43,0.7]
y									1 [NA]

Note: Standard deviations (relative to output) are shown on the diagonal. All series were logged and detrended using a BP(8,32) filter. Block-bootstrapped confidence intervals in brackets.

Table 3.12. Contribution of the job finding and separation rates to unemployment: levels and business-cycle components.

	Levels			BC component		
	$\frac{s_t}{s_t+f_t}$	$\frac{\bar{s}}{\bar{s}+f_t}$	$\frac{s_t}{s_t+\bar{f}}$	$\frac{s_t}{s_t+f_t}$	$\frac{\bar{s}}{\bar{s}+f_t}$	$\frac{s_t}{s_t+\bar{f}}$
$\text{Corr}(x, u_{t+1})$	0.99 [0.99,1]	0.85 [0.76,0.92]	0.79 [0.64,0.87]	0.99 [0.99,1]	0.93 [0.90,0.95]	0.74 [0.62,0.82]
$\text{Std}(x)\,/\text{Std}(u_{t+1})$	1.01 [1,1.03]	0.69 [0.6,0.82]	0.49 [0.42,0.58]	1.03 [1.01,1.05]	0.79 [0.73,0.86]	0.31 [0.28,0.36]

Note: The business cycle component is extracted with a BP(8,32) filter. Block-bootstrapped confidence intervals in brackets.

Table 3.13. Sign restrictions: demand and supply shocks

	Demand shocks		Supply shocks
Variable	Monetary	Other	
Output	$\uparrow 1-4$	$\uparrow 1-4$	$\uparrow 1-4$
Price level	$\uparrow 1-4$	$\uparrow 1-4$	$\downarrow 1-4$
Interest rate	$\downarrow 1$	$\uparrow 1$	$-$

Table 3.14. Sign restrictions: demand and supply shocks

	Demand shocks		Supply shocks
Variable	Monetary	Other	
Productivity	not $\uparrow 33-80$	not $\uparrow 33-80$	$\uparrow 33-80$
Output	$\uparrow 1-4$	$\uparrow 1-4$	$-$
Price level	$\uparrow 1-4$	$\uparrow 1-4$	$-$
Interest rate	$\downarrow 1$	$\uparrow 1$	$-$

Table 3.15. Variance decompositions for output and price restrictions

	4			8			20			32		
	M	D	S	M	D	S	M	D	S	M	D	S
Output	9.5	6.4	13.4	8.1	5.8	14.4	7.1	7.0	12.3	6.7	6.9	11.5
	[2.7,23.8]	[1.6,19.9]	[3.8,30.9]	[2.5,21.3]	[2.4,13.4]	[4.4,32.5]	[2.8,15.5]	[2.5,16.7]	[3.9,28.2]	[2.8,15.1]	[2.7,6.9]	[3.7,26.3]
Inflation	6.8	8.6	9.5	8.4	9.6	8.5	8.7	9.6	9.0	9.1	10.2	9.3
	[2.1,18.6]	[2.4,24.8]	[2.3,27.8]	[2.5,21.3]	[2.8,26.4]	[2.4,23.7]	[2.9,21.5]	[3.7,23.4]	[3.3,21.3]	[3.4,19.7]	[4.2,10.2]	[3.7,20.9]
Int. rate	4.8	19.6	5.2	6.9	20.0	5.4	7.7	17.7	7.0	8.0	16.3	8.0
	[1.6,11.7]	[5.4,29.6]	[1.3,18.3]	[2.4,14.8]	[6.4,38.4]	[1.6,14.9]	[3.0,17.1]	[6.9,32.3]	[2.5,15.0]	[3.3,16.4]	[6.9,16.3]	[3.3,15.7]
Hours	8.4	7.8	8.5	8.9	6.0	10.9	8.6	9.0	10.8	9.1	9.2	10.4
	[1.2,26.6]	[1.4,26.5]	[1.4,27.4]	[1.8,25.5]	[1.9,17.1]	[2.2,29.8]	[2.8,19.2]	[3.0,19.2]	[3.2,25.1]	[3.1,18.9]	[3.5,9.2]	[3.8,22.8]
Job Finding	9.3	6.8	8.2	9.4	6.1	10.4	8.5	10.7	10.0	8.6	11.2	10.1
	[2.0,27.8]	[1.7,22.8]	[2.2,25.7]	[1.9,26.3]	[2.2,16.0]	[2.5,28.7]	[2.7,18.7]	[4.1,21.6]	[3.2,25.4]	[3.1,18.6]	[4.4,11.2]	[3.5,23.8]
Separation	8.7	6.3	8.8	8.5	8.5	10.0	8.8	10.0	10.8	8.6	9.5	11.0
	[2.7,22.5]	[1.7,18.0]	[2.4,22.3]	[3.2,19.8]	[3.3,17.7]	[3.3,21.9]	[3.8,16.7]	[4.2,18.5]	[4.0,21.1]	[3.8,15.3]	[4.3,9.5]	[4.4,20.7]
JC	7.2	9.7	7.2	8.6	12.6	7.8	9.6	12.5	8.4	9.6	12.5	8.4
	[2.1,20.9]	[3.5,21.7]	[2.5,19.0]	[3.4,18.7]	[5.4,22.8]	[3.1,18.0]	[4.3,20.0]	[5.7,22.1]	[3.6,17.4]	[4.4,19.5]	[5.7,12.5]	[3.7,17.3]
JD	11.5	10.3	6.6	11.4	11.9	7.5	11.3	12.7	7.5	11.2	12.8	7.7
	[3.8,27.8]	[2.7,26.1]	[2.2,17.9]	[4.1,24.9]	[4.1,24.8]	[3.0,,17.5]	[4.4,25.3]	[4.9,25.3]	[3.1,16.5]	[4.4,24.9]	[5.1,12.8]	[3.2,16.1]
Vacancies	9.0	5.5	7.9	8.5	6.3	9.3	9.0	11.5	8.6	9.3	11.4	8.8
	[1.0,27.0]	[1.1,19.4]	[1.1,25.9]	[1.4,25.5]	[2.5,14.6]	[1.6,27.8]	[3.0,18.3]	[4.3,24.3]	[2.5,22.0]	[3.3,18.7]	[4.7,11.4]	[3.3,20.8]
APL	4.4	4.8	7.7	4.6	5.7	7.4	4.5	5.4	6.6	4.5	5.5	7.4
	[1.0,16.5]	[1.4,15.7]	[1.4,27.9]	[1.4,14.9]	[1.6,16.6]	[1.6,24.7]	[1.3,14.3]	[1.5,17.0]	[1.6,22.7]	[1.3,14.5]	[1.5,5.5]	[1.7,24.2]

Note: :percentage of the j-periods ahead forecast error explained by monetary (M), other demand (D), and supply shocks (S).
Numbers in brackets are 16th and 84th percentiles from 1.000 draws.

Table 3.16. Variance contributions at the business cycle frequency (in percent)

	Price-Output Restriction			Labor Productivity Restriction		
	Monetary	Demand	Supply	Monetary	Demand	Supply
Output	9.3 [3.4,20.6]	12.5 [4.3,25.9]	9.8 [2.9,23.5]	8.8 [3.4,19.6]	12.3 [4.7,25.1]	7.5 [2.0,19.4]
Inflation	6.1 [1.7,16.1]	12.4 [4.3,29.5]	10.3 [3.4,25.2]	6.6 [2.0,15.0]	13.9 [4.7,28.8]	8.8 [2.4,22.4]
Int. rate	6.5 [2.3,14.3]	15.5 [4.7,33.6]	5.8 [1.6,14.4]	6.4 [2.4,13.7]	16.0 [6.0,33.9]	6.2 [1.8,16.8]
Hours	9.3 [2.6,24.1]	13.8 [4.0,31.6]	9.1 [2.6,23.1]	8.8 [2.5,22.2]	14.8 [4.8,32.2]	7.8 [2.1,20.5]
Job Finding	9.5 [2.6,24.3]	12.8 [3.5,31.1]	9.2 [2.8,22.5]	9.5 [3.3,22.8]	13.8 [4.2,30.6]	8.0 [2.1,20.5]
Separation	9.3 [3.6,22.0]	10.9 [3.4,27.6]	8.7 [2.7,29.8]	9.9 [3.7,20.8]	11.2 [3.7,27.3]	8.1 [2.6,19.4]
JC	7.3 [2.3,18.7]	11.4 [4.4,24.1]	6.2 [1.8,15.7]	7.1 [2.4,19.2]	11.6 [4.6,23.5]	6.6 [2.1,16.6]
JD	9.5 [2.9,22.8]	13.3 [3.6,28.7]	6.3 [1.8,16.3]	9.3 [3.4,20.8]	13.7 [4.1,29.7]	7.1 [1.8,16.6]
Vacancies	9.7 [2.3,23.0]	12.5 [3.9,27.4]	8.6 [2.3,22.0]	9.1 [2.7,22.7]	13.0 [4.6,28.3]	8.0 [2.0,19.7]
APL	7.5 [2.817.0]	10.5 [3.6,20.8]	8.8 [2.6,21.1]	7.4 [2.7,16.4]	9.9 [4.0,20.8]	8.5 [2.7,20.9]

Note: Numbers in brackets are 16th and 84th percentiles obtained from 1.000 draws.

Table 3.17. Matching function estimates for output and price restrictions: elasticities and matching efficiency

	CRS		no CRS		
	α_v	A	α_v	α_u	A
Monetary	0.39 [0.38,0.40]	3.35 [3.30,3.58]	0.27 [0.24,0.30]	0.44 [0.42,0.47]	0.81 [0.65,1.14]
Other Demand	0.39 [0.38,0.40]	3.33 [3.24,3.52]	0.27 [0.25,0.31]	0.46 [0.44,0.48]	0.92 [0.77,1.29]
Supply	0.41 [0.41,0.42]	3.69 [3.61,3.86]	0.27 [0.25,0.31]	0.43 [0.43,0.44]	0.85 [0.72,1.14]
All	0.40 [0.40,0.41]	3.54 [3.49,3.69]	0.25 [0.25,0.29]	0.43 [0.43,0.44]	0.75 [0.69,1.01]
Data	0.40 [0.40,0.41]	3.55 [3.44,3.66]	0.25 [0.25,0.29]	0.43 [0.43,0.43]	0.74 [0.70,1.02]

Note: Median of the posterior distribution; 16^{th} and 84^{th} percentiles in parentheses.

Table 3.18. Matching function estimates for productivity restrictions: elasticities and matching efficiency.

	CRS		no CRS		
	α_v	A	α_v	α_u	A
Monetary	0.39 [0.39,0.4]	3.46 [3.29,3.53]	0.26 [0.24,0.32]	0.44 [0.42,0.46]	0.83 [0.64,1.29]
Other Demand	0.38 [0.37,0.39]	3.18 [3.14,3.37]	0.26 [0.23,0.31]	0.43 [0.42,0.47]	0.80 [0.59,1.33]
Supply	0.39 [0.38,0.40]	3.42 [3.30,3.57]	0.26 [0.23,0.32]	0.45 [0.42,0.47]	0.79 [0.66,1.30]
All	0.39 [0.39,0.39]	3.40 [3.26,3.50]	0.25 [0.23,0.31]	0.43 [0.42,0.46]	0.73 [0.61,1.17]
Data	0.40 [0.40,0.41]	3.50 [3.44,3.65]	0.25 [0.24,0.29]	0.42 [0.42,0.44]	0.70 [0.65,1.01]

Table 3.19. Variance decompositions for productivity restriction

	4			8			20			32		
	M	D	S	M	D	S	M	D	S	M	D	S
Output	8.0 [2.2,21.5]	5.4 [1.3,16.0]	7.6 [1.4,24.3]	7.2 [2.0,18.5]	5.3 [2.3,10.8]	8.3 [2.0,26.4]	5.8 [2.2,13.0]	6.5 [2.614.5,]	10.4 [3.1,26.0]	5.1 [2.0,11.5]	5.7 [2.3,12.9]	10.9 [3.8,26.2]
Inflation	7.0 [2.4,19.0]	8.7 [2.7,23.7]	6.9 [1.8,22.3]	9.1 [2.9,20.8]	10.6 [3.4,24.7]	7.6 [2.2,20.6]	10.2 [3.8,21.8]	10.7 [4.1,22.6]	8.3 [2.8,28.9]	10.7 [4.5,20.3]	11.5 [5.0,21.8]	8.2 [3.0,18.2]
Int. rate	4.5 [1.8,10.4]	19.5 [6.5,41.4]	5.6 [1.3,18.3]	6.5 [2.4,13.8]	20.5 [7.4,29.7]	6.4 [1.7,16.7]	7.3 [3.0,16.8]	20.5 [7.4,32.7]	8.0 [2.6,16.8]	7.9 [3.3,15.9]	16.8 [7.7,28.5]	8.3 [3.1,17.3]
Hours	7.1 [0.9,24.5]	8.0 [1.4,25.8]	6.4 [1.1,21.4]	7.3 [1.2,25.4]	6.1 [2.0,16.9]	6.8 [1.5,20.8]	9.0 [3.4,18.8]	6.1 [4.0,20.1]	7.3 [2.2,18.6]	10.4 [3.8,20.1]	11.2 [4.9,20.9]	7.3 [2.5,17.3]
Job Finding	9.5 [2.9,27.0]	7.3 [1.9,20.9]	6.1 [1.4,19.6]	9.8 [2.6,25.0]	6.4 [2.5,14.7]	6.6 [1.7,19.9]	8.5 [3.2,18.7]	6.4 [4.7,21.5]	7.8 [2.4,19.4]	9.1 [3.5,19.5]	11.8 [5.1,21.7]	7.9 [2.7,19.1]
Separation	8.9 [2.7,21.8]	6.2 [1.9,19.4]	7.4 [2.1,20.5]	8.5 [3.2,18.7]	8.7 [3.6,18.3]	8.4 [2.9,19.9]	8.8 [4.2,16.0]	8.8 [4.7,18.7]	9.3 [3.8,19.0]	8.9 [4.8,15.4]	10.1 [5.0,17.2]	9.3 [3.9,19.2]
JC	7.4 [2.2,23.2]	9.3 [3.4,21.1]	7.4 [2.8,19.5]	8.8 [3.6,20.1]	12.4 [5.7,21.9]	8.2 [3.3,18.7]	9.8 [4.3,20.4]	12.4 [6.3,21.6]	8.4 [3.6,17.8]	9.9 [4.4,20.1]	12.5 [6.5,21.4]	8.5 [3.8,17.6]
JD	11.2 [4.2,26.1]	10.5 [2.9,26.1]	6.9 [2.2,18.6]	10.9 [4.4,23.4]	11.9 [4.5,24.6]	7.7 [2.9,17.6]	11.1 [4.8,23.1]	11.9 [5.5,25.3]	7.8 [3.0,16.8]	11.1 [5.0,23.0]	13.2 [5.7,25.4]	7.9 [3.2,16.7]
Vacancies	8.8 [1.2,26.8]	5.2 [1.1,19.8]	6.5 [0.8,21.4]	7.6 [1.6,24.5]	6.5 [2.5,14.7]	7.0 [1.4,21.2]	8.6 [3.0,18.5]	6.5 [4.9,23.5]	7.8 [2.5,18.6]	9.0 [3.4,19.5]	12.3 [5.3,23.3]	8.4 [3.1,17.8]
APL	4.9 [0.9,17.8]	4.5 [1.4,12.8]	7.6 [1.5,26.0]	5.2 [1.4,15.1]	5.7 [1.7,15.4]	8.0 [1.7,25.4]	5.5 [1.4,15.5]	5.7 [1.7,16.2]	7.7 [1.5,25.4]	5.0 [1.4,14.0]	5.7 [1.5,15.4]	8.1 [1.7,26.0]

Note: percentage of the j-periods ahead forecast error explained by monetary (M), other demand (D), and supply shocks (S).
Numbers in brackets are 16th and 84th percentiles obtained from 1.000 draws.

Table 3.20. Variance decompositions for recursiveness and long-run restrictions

	4		8		20		32		Business Cycle	
	M	Tech	M	Tech	M	Tech	M	Tech	M	Tech
Output	5.9 [3.3,9.6]	21.4 [10.9,41.5]	14.2 [8.1,19.7]	35.1 [22.0,51.7]	10.4 [5.4,14.3,]	56.1 [39.4,66.9]	12.1 [4.1,11.6]	64.0 [47.4,73.8]	12.1 [7.7,23.6]	15.1 [6.0,25.2]
Inflation	1.2 [0.3,2.9]	25.7 [4.33,32.6]	0.9 [0.7,3.3]	26.4 [5.0,32.7]	1.4 [1.4,6.2]	25.8 [6.0,30.8]	3.3 [1.5,6.3]	24.9 [6.7,30.7]	3.3 [1.8,8.9]	30.3 [4.0,31.2]
Int. rate	50.5 [38.4,54.0]	5.7 [0.7,10.8]	32.9 [23.9,38.9]	6.1 [1.0,12.5]	26.3 [19.2,32.3]	5.4 [1.6,12.3]	32.3 [16.6,28.3]	6.6 [2.8,14.6]	32.3 [26.6,51.6]	6.1 [1.2,12.0]
Hours	4.4 [2.4,7.9]	1.3 [0.8,10.7]	17.1 [10.0,24.4]	6.9 [2.1,16.2]	18.4 [9.7,23.6]	21.4 [4.5,26.6]	14.6 [8.8,22.0]	22.3 [4.8,27.4]	14.6 [8.1,25.5]	7.9 [2.1,13.1]
Job finding	5.2 [2.9,9.1]	2.,2 [1.1,9.7]	18.6 [11.4,27.0]	2.7 [1.9,11.1]	22.7 [12.7,28.5]	9.2 [3.0,17.9]	14.6 [12.1,27.3]	9.3 [3.3,18.4]	14.6 [8.1,26.1]	9.1 [2.1,13.6]
Separation	9.4 [5.6,13.9]	1.8 [1.2,7.5]	16.7 [9.7,21.4]	4.3 [2.4,9.9]	12.8 [7.5,17.2]	9.9 [3.5,15.5]	16.5 [6.1,14.6]	13.6 [4.3,20.3]	16.5 [9.7,24.8]	7.4 [2.0,12.1]
JC	4.9 [2.5,8.1]	3.3 [2.1,9.2]	4.9 [2.8,8.2]	5.5 [2.5,11.3]	5.4 [4.0,10.1]	5.5 [2.8,11.4]	6.6 [4.0,10.1]	5.5 [3.0,11.5]	6.6 [4.9,14.7]	4.1 [1.5,10.4]
JD	9.9 [6.1,14.9]	3.4 [1.3,9.1]	17.6 [10.8,22.4]	4.2 [1.8,9.7]	16.2 [10.27,21.4]	4.4 [2.0,10.2]	13.3 [10.3,21.4]	4.7 [2.1,10.4]	13.4 [9.0,23.5]	5.3 [1.4,11.6]
Vacancies	10.6 [6.5,15.5]	0.5 [0.2,7.4]	25.0 [15.6,31.7]	3.0 [1.4,10.4]	21.7 [12.5,26.6]	6.3 [2.3,15.1]	17.3 [10.9,24.0]	6.2 [3.5,15.9]	17.3 [10.1,29.6]	7.5 [2.0,12.8]
APL	2.1 [0.8,4.3]	37.1 [22.3,69.3]	1.6 [0.7,3.7]	41.2 [26.1,74.8]	0.8 [0.7,3.5]	42.4 [29.0,80.6]	6.2 [0.6,7.1]	47.0 [36.2,84.8]	6.2 [3.6,12.5]	25.7 [14.3,50.5]

Note: percentage of the j-periods ahead forecast error explained by monetary (M) and technology shocks (Tech). The last column presents the variance contributions at the business cycle frequency (see text). Numbers in brackets are 16th and 84th percentiles obtained from 10.000 draws.

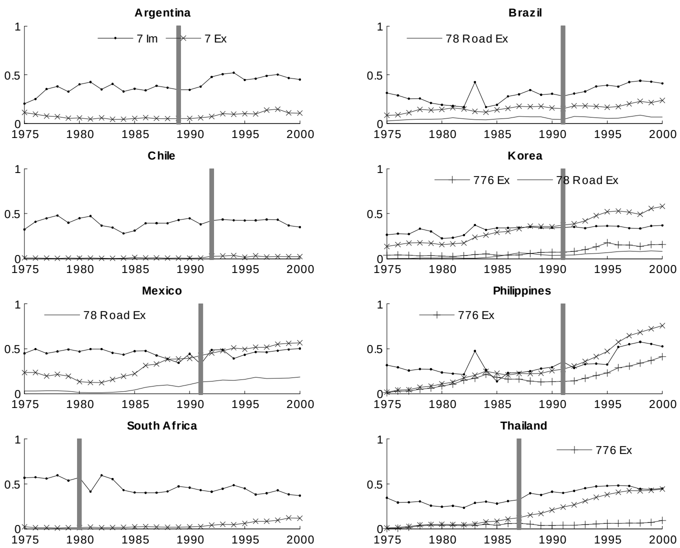

Figure 3.1. Capital good import and export shares for emerging economies.

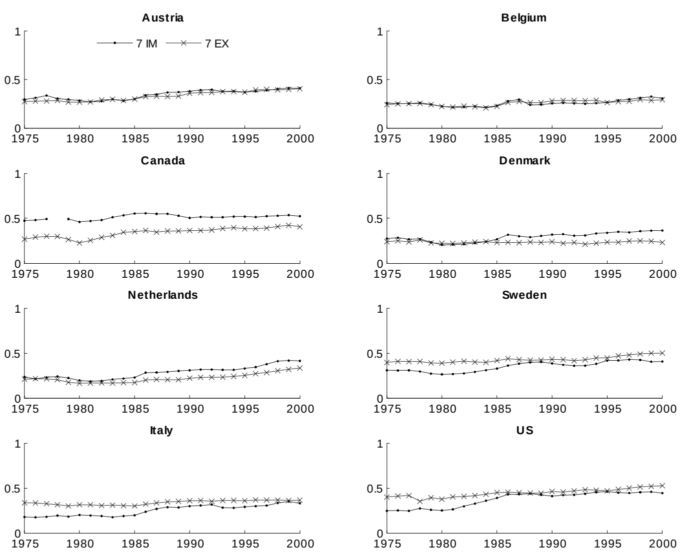

Figure 3.2. Capital good import and export shares for developed economies.

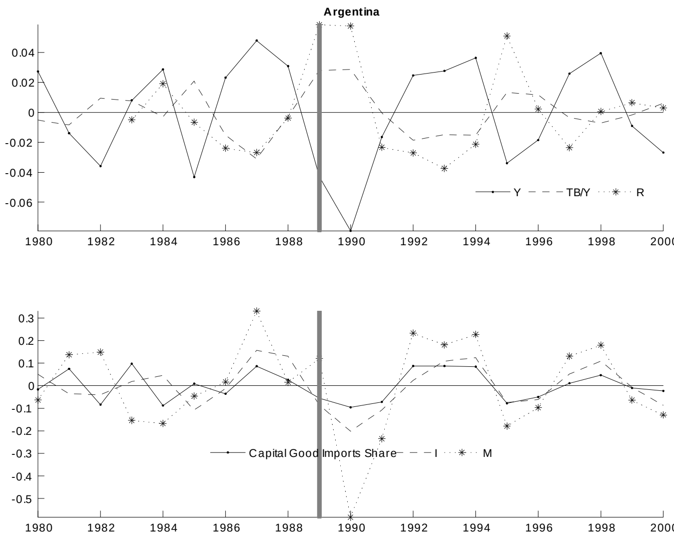

Figure 3.3. Business cycles in Argentina, 1980-2000.

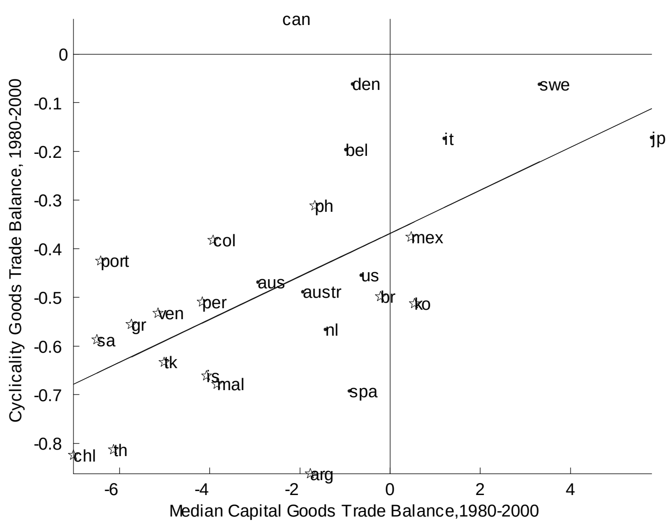

Figure 3.4. Median capital goods trade balance and cyclicality of the trade balance, 1980-2000

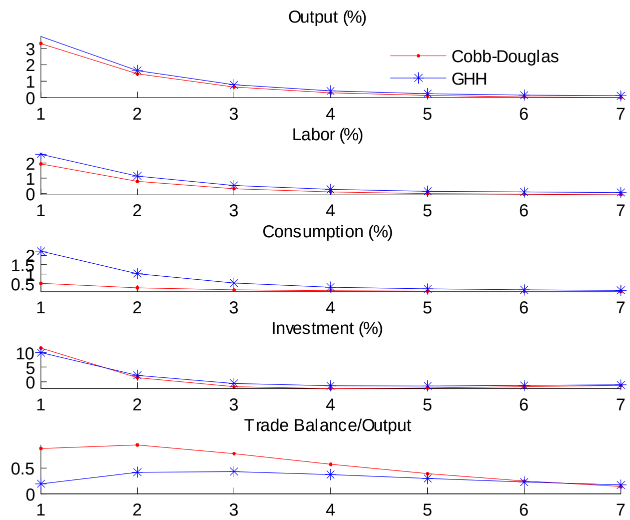

Figure 3.5. Impulse response function to a productivity shock with Cobb-Douglas and Greenwood-Hercowitz-Huffman preferences

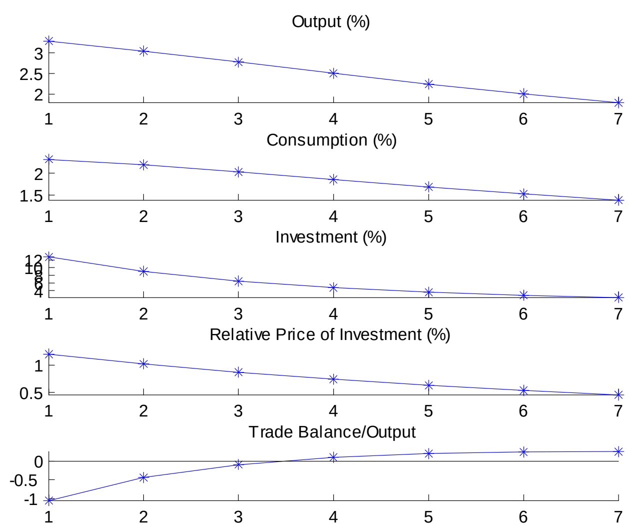

Figure 3.6. Impulse response function to a productivity shock in the two-sector model

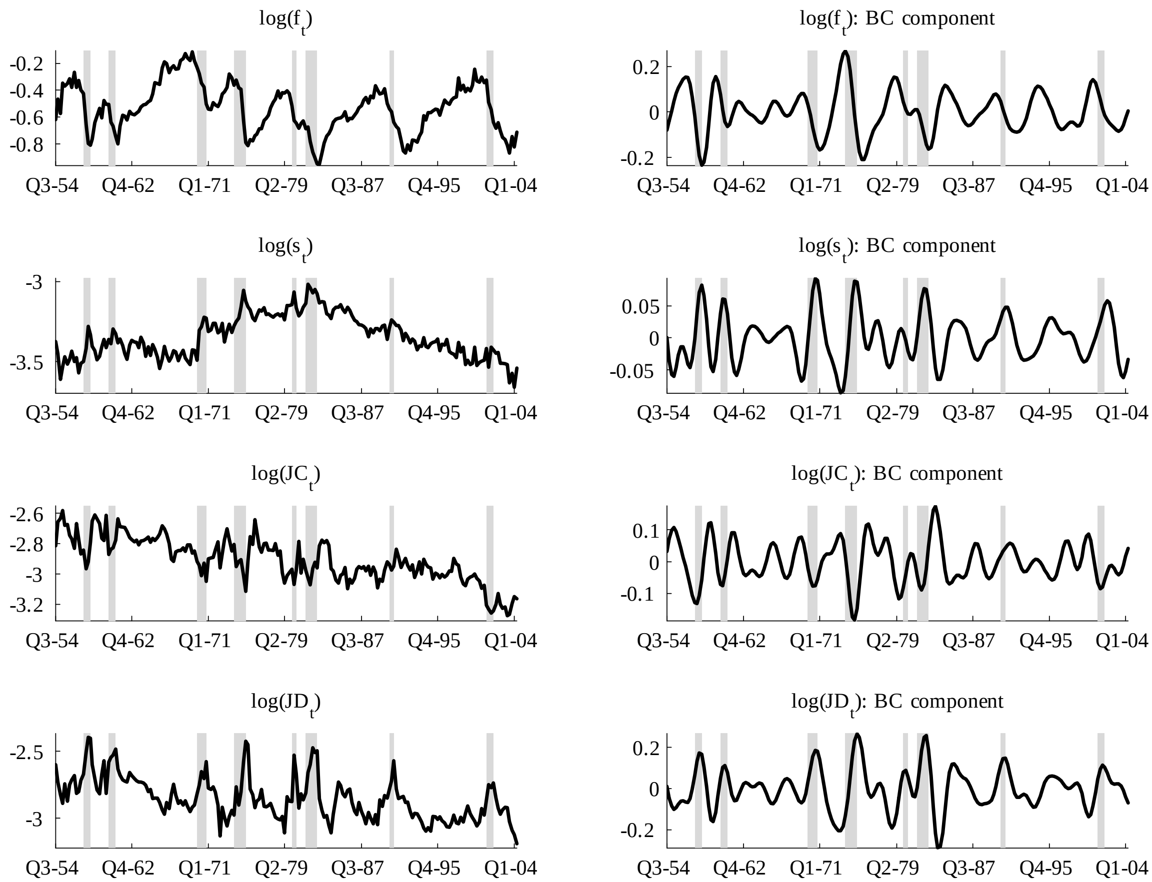

Figure 3.7. Worker and job flows: levels and business-cycle components

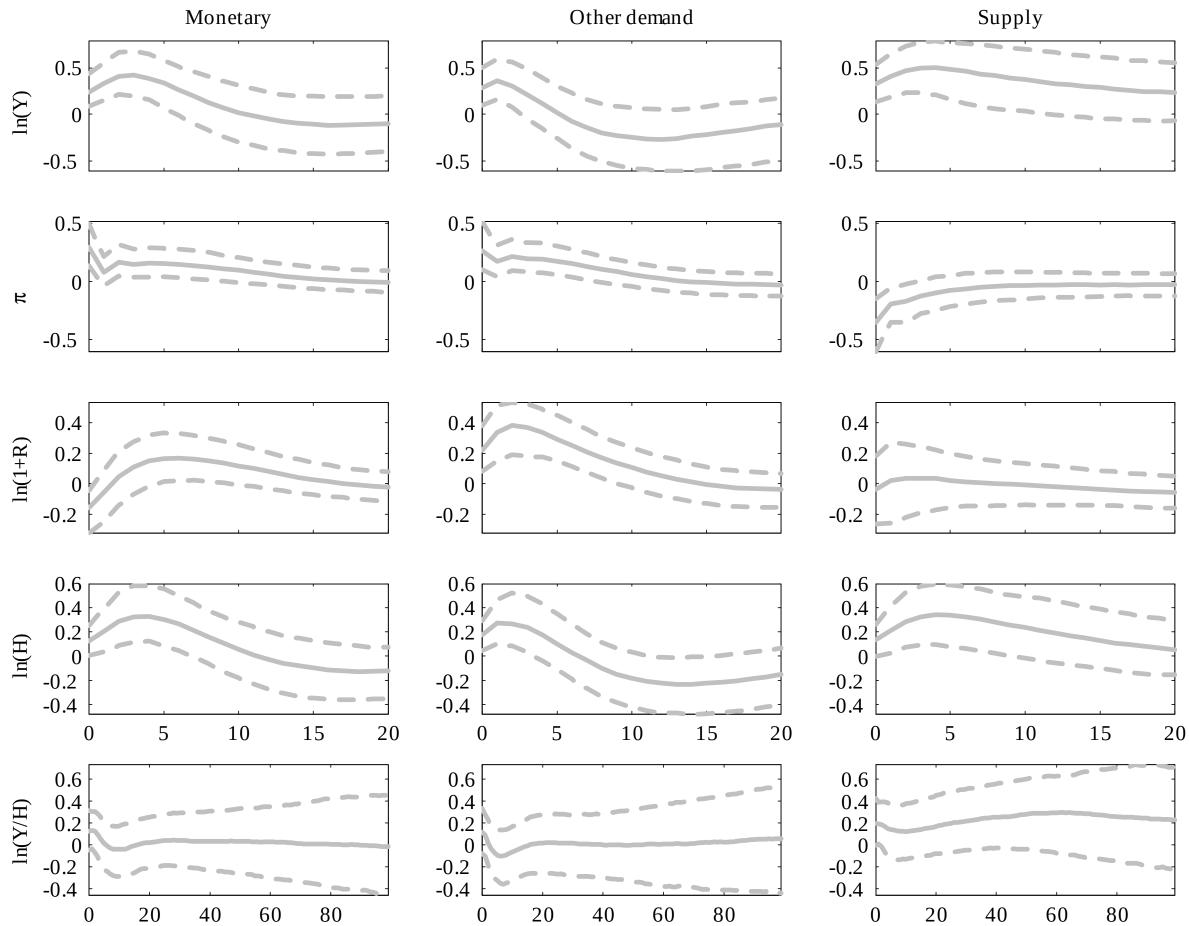

Figure 3.8. Price Restriction: IRFs for non-labor market variables and hours (%): demand and supply shocks

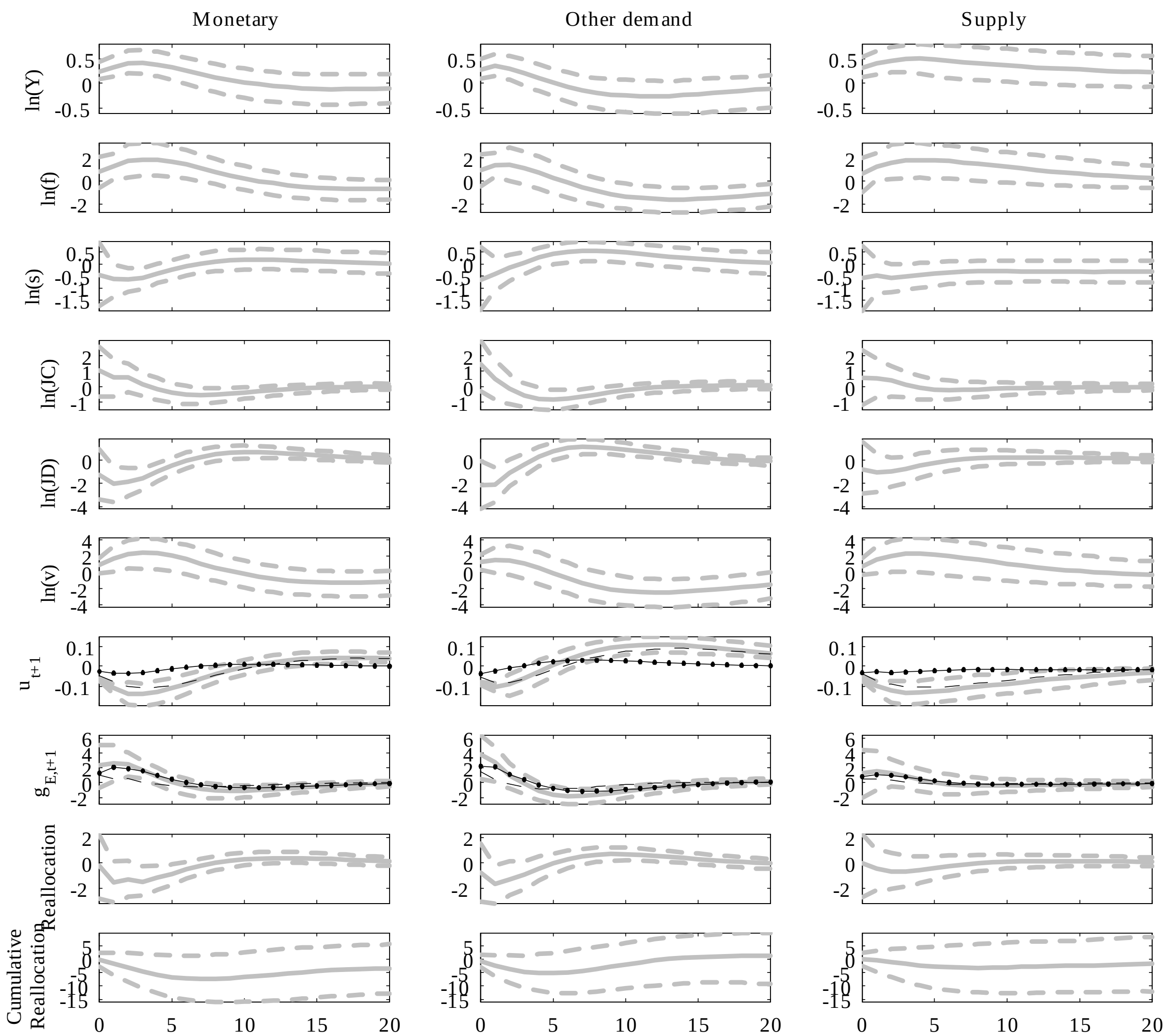

Figure 3.9. Price Restriction: IRFs for labor market variables (%): demand and supply shocks.

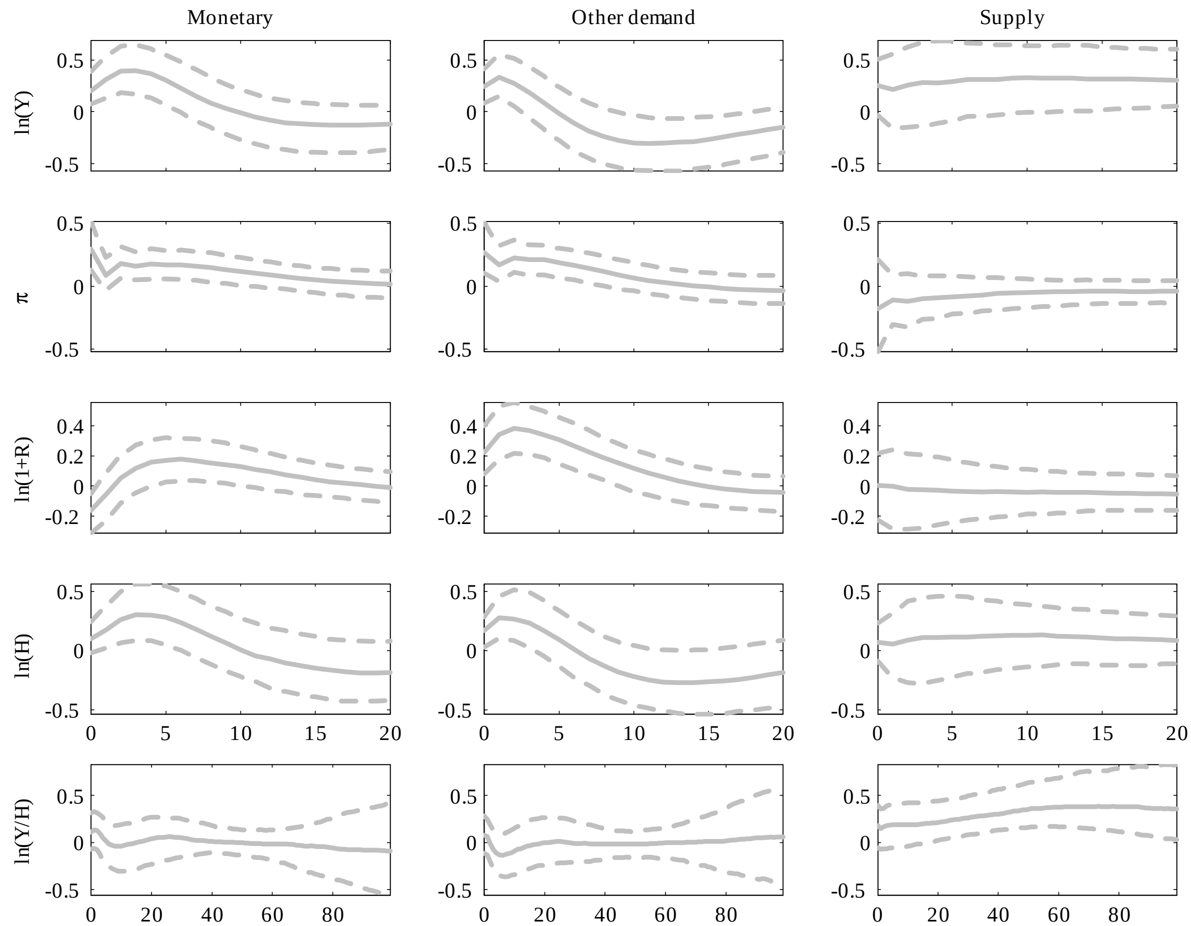

Figure 3.10. Labor Productivity Restriction: IRFs for non-labor market variables and hours (%): demand and supply shocks.

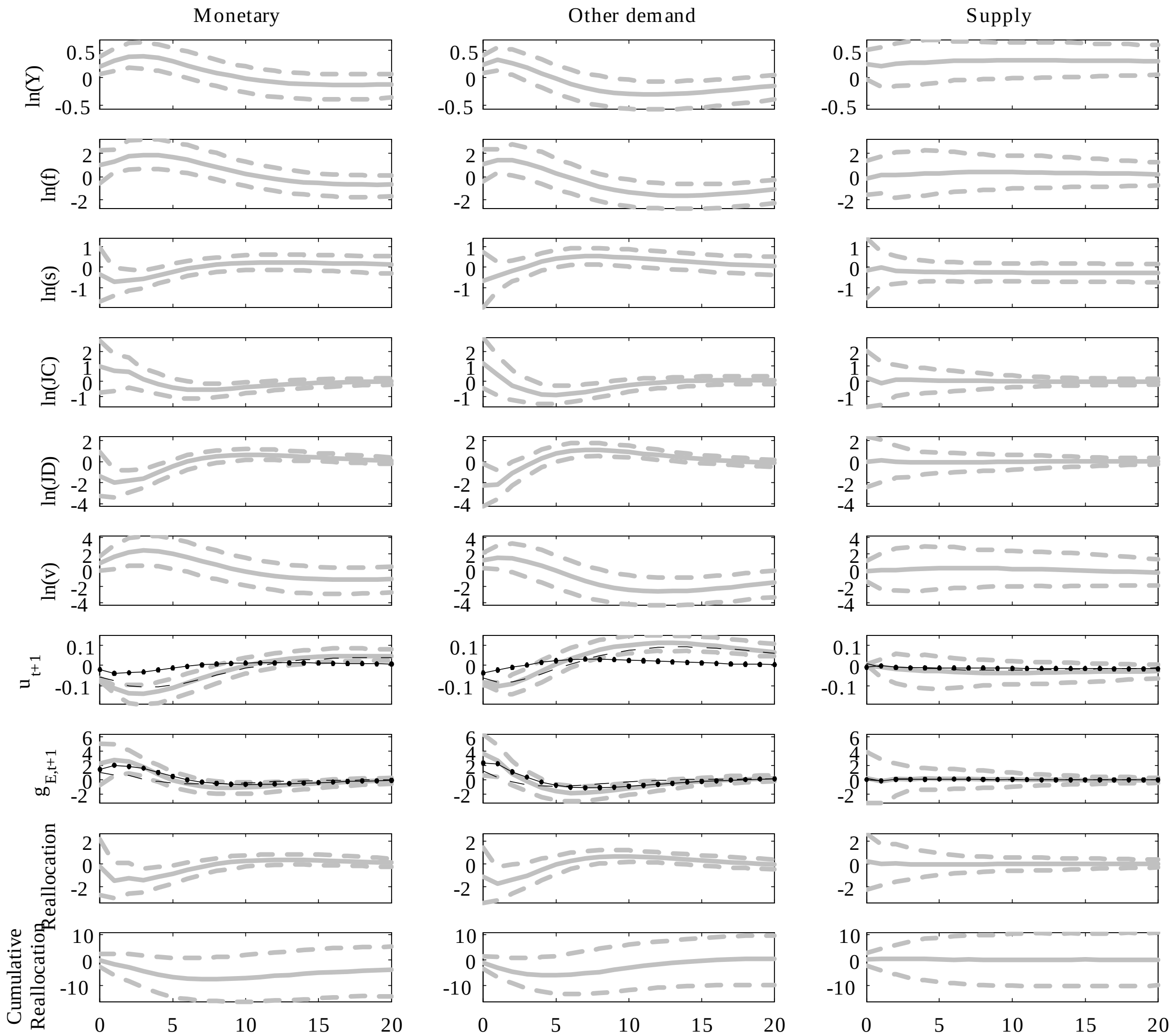

Figure 3.11. Labor Productivity Restriction: IRFs for labor market variables (%): demand and supply shocks.

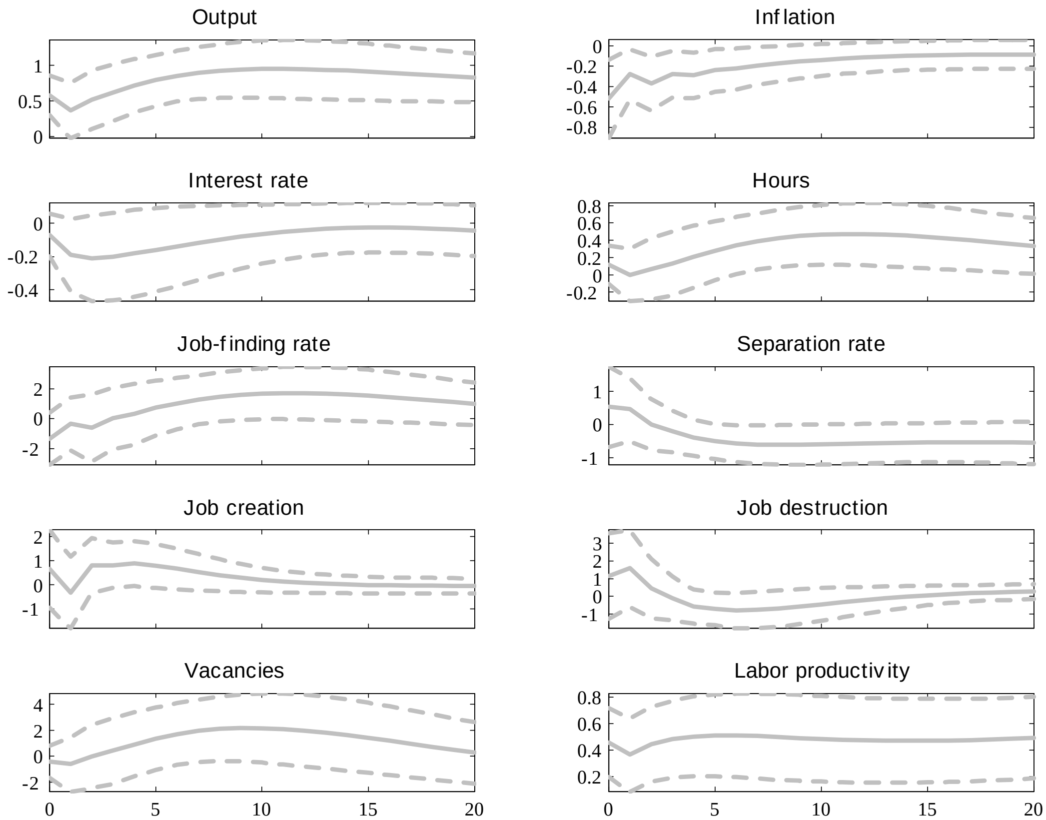

Figure 3.12. IRF's to a technology shock identified with a long-run restriction on productivity.

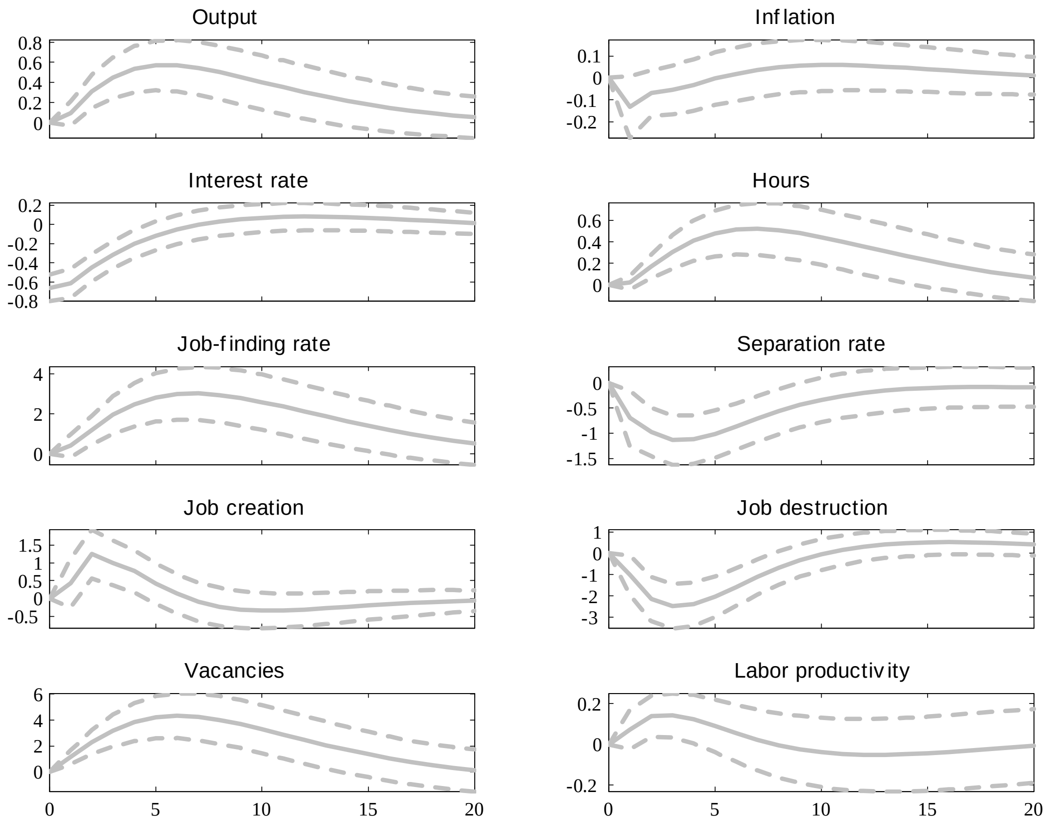

Figure 3.13. IRF's to a monetary shock identified with a contemporaneous restriction.

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Appendix

1. Description Baseline Small-Open Economy Model

This appendix briefly describes the baseline small-open economy model referred to in the text. Close variants of this model can be found in Mendoza (1991) and Schmitt-Grohe and Uribe (2003).

1.1. Baseline model

The utility function is time-separable:

$$E_0 \sum \beta^{t-1} U(C_t, L_t),$$

and L_t is leisure and employment $N_t = 1 - L_t$. Popular specifications for the utility function $U(\cdot)$ used in the literature are either Cobb-Douglas or Greenwood-Hercowitz-Huffman discussed in section 2.4. The budget constraint is:

$$C_t + I_t + \left[(1 + R^*_{t-1})D_{t-1} + \Psi(D_t)\right] + \Phi(K_{t+1} - K_t) \leq Y_t + D_t, \tag{.8}$$

R^*_{t-1} denotes the world interest rate at which the small open economy borrows internationally and I_t is expressed in terms of consumption units. D_t is the foreign (dollar denominated) non-indexed bond (net foreign asset position). The timing for the bond in the budget constraint specification is similar to Schmitt-Grohe and Uribe (2003). The functional form for $\Psi(\cdot)$ is:

$$\Psi(D_t) = \frac{\psi}{2}(D_t - \bar{d})^2.$$

The first order condition for bond holdings is then:

$$\begin{aligned} \underbrace{\lambda_t \left[1 - \psi(D_t - \bar{d})\right]} &= \beta E_t \left[\lambda_{t+1}(1 + R^*_{t+1})\right] \\ \text{Marginal Benefit} &= \text{Marginal Cost of Unit Debt Increase} \\ \hat{\lambda}_t - \psi D \hat{d}_t &= \hat{\lambda}_{t+1} + \frac{R}{1+R}\hat{R}^*_{t+1} \end{aligned}$$

Schmitt-Grohe and Uribe (2003) interpret this condition as follows; if the household chooses to borrow an additional unit, then current consumption increases by one unit minus the marginal portfolio adjustment cost $\psi(D_t - \bar{d})$. The value of this increase in consumption in terms of utility is given by the left-hand side. Next, the household must repay the additional unit of debt plus interest.

Following Mendoza (1991), Schmitt-Grohe and Uribe (2003), Neumeyer and Perri (2005) or Aguiar and Gopinath (2007), the functional form for the capital adjustment function $\Phi(\cdot)$ is quadratic:

$$\Phi(K_{t+1} - K_t) = \frac{\phi}{2}(K_{t+1} - K_t)^2.$$

1.2. Equilibrium

A equilibrium is a set of allocations and prices such that given exogenously determined prices :

- the households maximize utility subject to the budget constraint and the capital accumulation technology.
- Factor markets clear. Given the import price of capital and the demand for exports firms choose to maximize the profit functions.
- Markets clear.

2. Other Variables Used in VAR Analysis

Table A.21 describes the data (other than the job flows and worker flows data) used in the paper and provides the corresponding Haver mnemonics. The data are readily available from other commercial and non-commercial databases, as well as from the original sources (Bureau of Economic Analysis, Bureau of Labor Statistics, Board of Governors of the Federal Reserve System).

The remaining variables used in the VAR analysis are constructed from the raw data as follows:

$$\Delta \ln p = 4\Delta \log\left(\mathrm{JGDP}\right), \ H = \frac{\mathrm{LXNFH}}{\mathrm{LN16N}}, \ v = \frac{\mathrm{LHELP}}{\mathrm{LF}}.$$

Variable	Units	Haver (USECON)
Civilian Noninstitutional Population	Thousands, NSA	LN16N
Output per hour all persons (Nonfarm Business Sector)	Index, 1992=100, SA	LXNFA
Output (Nonfarm Business Sector)	Index, 1992=100, SA	LXNFO
GDP: Chain Price Index	Index, 2000=100, SA	JGDP
Real GDP	Bil. Chn. 2000 $, SAAR	GDPH
Federal Funds (effective) Rate	% p.a.	FFED
Hours of all persons (Nonfarm Bus. Sector)	Index, 1992=100, SA	LXNFH
Index of Help-Wanted Advertising in Newspapers	Index, 1987=100, SA	LHELP
Civilian Labor Force (16yrs +)	Thousands, SA	LF
Civilian Unemployment Rate (16yrs +)	%, SA	LR

Table A.21. Source other time series data