# Time to Produce and Emerging Market Crises *

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**Abstract**

The opportunity cost of waiting for goods to be produced and sold increases with the cost of financing. This channel is evident in emerging market crises, when industries that use more inventories lose more of their output and lag behind in the recovery. An open economy model with lags in the production process ("time to produce") generates comparable cross-sectoral differences in response to a shock to the foreign interest rate and, in the year of the crisis, accounts for up to 25% of the deviation of output from its previous trend. In contrast, an equivalent model without time to produce generates a boom in the year of the crisis and cannot account for the cross-sectoral differences. Likewise, it is impossible to generate the cross-sectoral differences in response to a productivity shock.

JEL classification: E22, E23, F41

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# 1 Introduction

Firms have to wait between using an input and finishing the output and between finishing the output and selling the good. For the duration of the wait, firms incur the opportunity cost of investing in these inputs. The value of this investment is measured by total inventories (raw materials, work in process and finished goods) since, by definition, inventories are an accumulation of costs that a firm has incurred in the past but which do not correspond to a good that has been sold.

This paper investigates whether time lags in production and sales were relevant during emerging market crises. These crises were characterized by sharp drops in output shortly after an interruption in foreign financial flows. I show that sectors that hold more inventories relative to their production costs lose relatively more of their output after the crisis. Interestingly, the difference is most pronounced three to five years after the onset of the crisis, suggesting that it does not reflect the adjustment to a surprise change in desired inventory holdings, but a systematic response to a persistent change in the economic environment.

While the cross-sectoral results conform to a simple partial equilibrium intuition, in a more completely specified model there might be counteracting effects. This motivates the analysis of a multi-sector general equilibrium model with lags between the use of inputs and the availability of output. Delays in production and sales enter parsimoniously, in the manner of Kydland and Prescott's (1982) time to build. I refer to all of these delays as "time to produce", the assumption being that not only production but also sales take time because of technological constraints. The time lags in the model are straightforward to calibrate using the same inventories-to-cost ratios exploited for the data analysis. This is a simple setup that, while it does not fully account for inventory adjustment dynamics, focuses sharply on the mechanism at play.[1]

In the model, the shocks to international financial flows express themselves as an increase in the interest rate paid on foreign bonds. This captures the notion that the cost of foreign capital increases if there is an interruption to international financial flows. Importantly, the shock only affects the modeled economy, so that foreign demand for exports does not change. This assumption is consistent with an understanding of emerging market crises as interruptions in credit flows that, even when they occur during a worldwide credit contraction, are particularly concentrated among a small group of countries.[2] The model is otherwise completely frictionless.

I simulate the crisis as the response to a financial shock such that the model approximates the post-crisis paths of aggregate G.D.P. and the rate of investment.[3] For a wide range of parameter

[1]For papers that rely on more sophisticated models to match inventory adjustment facts see for example Kahn and Thomas (2007) and Alessandria et al. (2008).

[2]For example, Calvo et al. (2008b) shows that internal conditions such as prevalence of dollar denominated liabilities make countries more vulnerable to Sudden Stops. Also, see Mendoza (2010) for a model with this feature.

[3]I do not use bond prices. They may exaggerate the cost of capital, since they incorporate risk premia and may understate it since financial markets in emerging markets are highly segmented. I look instead at the choices of the agents and back out the prices that support these choices under the assumption that these prices are the same for all agents. See Blankenau et al. (2001) for a similar approach. Naturally, given market segmentation, the assumption that the price is the same for all is not entirely realistic.

values, the model is able to generate differences in sectoral responses in line with the estimates from the data. Furthermore, the calibration procedure requires a persistent increase in the interest rate in order to account for the persistent drop in investment ratio that typically occurs after a crisis. This allows the model to match the persistence in cross-sectoral differences observed in the data.

Simulations with alternative parameter values clarify the ranges for which the results are consistent with the data. The elasticity of foreign demand for exports should be high enough that export demand does not excessively limit the impact of what is essentially a cost shock. Also, the model performs better if there are high adjustment costs to capital: with higher adjustment costs, a larger interest rate shock is needed for the model to account for the same drop in the rate of investment.

With a general equilibrium model it is possible to assess the extent to which time to produce matters for the aggregate response to a shock to the foreign interest rate. The shock reduces wages and the price of non-tradables. As a consequence, without time to produce an interest rate shock may lead to a boom, as tradable production becomes cheaper and exports increase.[4] Allowing for time to produce ensures that output drops instead of booming in the year of the crisis. Depending on the choice of parameters, the model is able to account for 12 % to 25% of the drop in output in the year of the crisis.

Lastly, the model also has interesting implications for the response of the economy to a productivity shock. Productivity shocks have been advanced as an explanation for emerging market crises since they can generate contemporaneous drops in output, consumption, and investment, regardless of payment or other frictions.[5] However, simulations of a crisis as a pure reaction to an aggregate productivity shock show that such a shock cannot account for the cross-sectoral differences in the data. The bottom line is that reductions in productivity are likely to be an integral part of emerging market crises, but they cannot be the whole story.

The link between financing costs and production cost emerges often because of form of payment friction. In Christiano et al. (1992) firms need to hold cash in order to pay the wage bill, so that if financing costs goes up, these payments become more costly. In the context of emerging market economies, the cash in advance constraint proposed by Christiano et al. (1992) is problematic, since it implies that there should be large shifts in the volatility of output as these economies transitions in and out of hyper-inflationary periods.[6] For this reason, Neumeyer and Perri (2005) propose that in emerging markets, payments are made in real, non-interest rate bearing assets. This assumption allows them to match the observed negative correlation between de-trended output and the real interest rate on government bonds, while encompassing both periods with high and low inflation. Their success has prompted others to use a similar device in more elaborate models of emerging market business

[4]The mechanism is different from Chari et al. (2005). The boom does not come about because of a wealth effect on labor supply, but because of a cheapening of non-tradable goods combined with a flexible capacity utilization margin.

[5]See Aguiar and Gopinath (2007), Otsu (2007), Bergoeing et al. (2001), Kehoe and Ruhl (2008) among others.

[6]Nevertheless, cash-in-advance constraints in the payment of inputs do have a long tradition in the emerging market business cycle literature, as seen for example in Cavallo (1981). See Agenor and Montiel (2002), Chs. 6 and 7 for a discussion of this early literature.

cycles.[7] While the assumption is successful in terms of its aggregate implications, Chari et al. (2005) criticize it for the lack of a clear empirical counterpart in micro-data that it can be tested against. Allowing for time to produce resolves the issue. The mechanism follows the spirit of Neumeyer and Perri (2005) in emphasizing that the cost of variable inputs depends on the real interest rate, but grounds it on the production technology rather than in a payment friction, and generates implications which are testable at a disaggregate level.

Time to produce provides a channel through which the cost of capital affects output, but it leaves open the determination of this cost. Mendoza (2010) demonstrates how a business cycle model with an occasionally binding constraint on foreign debt is able to generate alternating periods of normal business cycle variations and sudden stops.[8] However Mendoza relies on a payment-in-advance constraint similar to Neumeyer and Perri (2005) to generate a stronger short run impact on output. On the empirical side, a similar comparison applies to studies by Kroszner et al. (2006) and Dell'Ariccia et al. (2007). They find that, in banking crises, industries that rely more on external financing to fund long term investment lose relatively more of their output. Their empirical results show that banking crises affect the cost of financing, but they leave open how this exposure translates into a drop in output.

The empirical findings in this paper are complementary to independent work by Tong and Wei (2009). Using data from emerging market firms, the authors show that a high inventories-to-sales ratio was associated with a relatively large drop in share prices in the aftermath of the latest global crisis. Their price evidence complements the quantity evidence presented here. Raddatz (2006) presents another set of related empirical findings. He finds that industries with a high inventories-to-sales ratio are relatively more volatile in countries with a low level of financial development. His findings emphasize the role of the financial system in providing liquidity insurance.[9] Finally, within the United States, Maccini et al. (2004) show that inventory holdings react to the interest rate as long as the shock is a large break with previous patterns, although Bivin (2010) finds that the relationship is not robust when it comes to work-in-process and raw materials in durable sectors. Jones and Tuzel (2010) find a robust relationship between inventory investment and risk premia.

The paper proceeds as follows: Section 2 lays out the accounting framework used to map inventories-to-cost data into production lags. Section 3 contains the data analysis. It documents the cross-industry correlation between the inventories-to-cost ratio and the change in value added during emerging market

[7]See for example Christiano et al. (2004), Mendoza (2010), Uribe and Yue (2006), Otsu (2007) and Calvo et al. (2008a) and Meza and Benjamin (2009). The literature on emerging market crises and emerging market business cycles frequently assumes that financial costs directly affect to the cost of variable inputs. An exception is Gertler et al. (2007), in that the interest rate shocks affect production quickly through the impact of changes in the real exchange rate on capacity utilization decisions. Also, Caballero and Krishnamurty (2001) and Cook and Devereux (2006) use timing assumptions similar to the one I use, but do not motivate or calibrate them using inventories data.

[8]As in this paper, the marginal cost of capital in Mendoza (2010) is the same for all firms. Implicitly, the balance sheet constraints in his model are the ones faced by a representative domestic financial intermediary as opposed to individual domestic productive units, as suggested by Krishnamurthy (2003).

[9]Markups vary less than inventories across firms, so that inventories-to-cost and inventories-to-sales ratios are normally closely linked.

crises, providing various robustness checks. Section 4 introduces the general equilibrium business cycle model, discusses its calibration, and reports the results of the different experiments. Section 5 concludes the paper.

# 2 Inventories-to-Cost as a Measure of Production Time

The inventories-to-cost ratio is a measure of time lags in production and sales. This is so because inventories accumulate production costs from the moment the cost is accrued until the corresponding good is sold:

$$\text{Inventories}_t = \text{Inventories}_{t-1} + \text{Current Costs}_t - \text{Cost of Goods Sold}_t$$

where "Current $\text{Costs}_t$" are the total costs incurred in period $t$ and "Cost of Goods $\text{Sold}_t$" denotes the costs associated with all the goods sold in time $t$. The equation implies that inventories, including finished goods inventories, are valued at replacement cost rather than at retail value.

If the firm is in steady state, both costs are the same and inventories are constant. Since inventories are an accumulation of costs, in steady state, the average time between the use of a dollar of input and the sales of the final good is given by

$$\text{Average Time} = \frac{\text{Inventories}}{\text{Cost of Goods Sold}}$$

Note that inventories are measured in dollars and the cost of goods sold is measured in dollars per unit of time. The ratio states how many months' worth of costs are held up in inventories.

A model helps to interpret these relationships. Consider, as an example, a production function that uses inputs (Z) to produce output. To simplify matters, let's abstract from finished goods inventories. Part of the inputs, $Z(0)$, is instantaneously transformed in output, but the other part, $Z(1)$, has to be used one period in advance. The production function is:

$$Y_t = Z_t\left(0\right)^{1-\omega} Z_{t-1}\left(1\right)^{\omega}$$

where $\omega$ is the share of "early" inputs in production.

The numbers in parentheses indicate the time lag between the use of the input and the final sales of the output. If the spot price of the input and of the final good is equal to 1, the cost of goods sold is

$$\text{Cost of Goods Sold}_t = Z_t(0) + RZ_{t-1}(1)$$

where $R$ is the one period interest rate. $Z_{t-1}(1)$ is multiplied by the opportunity cost of capital, which is part of its cost for the firm. The current costs are

$$\text{Current costs}_t = Z_t(0) + RZ_t(1)$$

That is, the current costs include the costs of all inputs accrued in a given period.

The change in inventories is the difference between the two:

$$\text{Inventories}_t - \text{Inventories}_{t-1} = RZ_t(1) - RZ_{t-1}(1)$$

Assuming that firms start off with zero inventories, steady state inventories are given by

$$\text{Inventories} = RZ(1)$$

Under perfect foresight, it is the case that, for a cost minimizing firm,

$$\frac{\text{Inventories}}{\text{Cost of Goods Sold}} = \frac{RZ(1)}{Z(0) + RZ(1)} = \omega$$

The model implies a direct mapping from inventories-to-cost data to lags in production, as captured by the share of "early" inputs. In the actual data, the relationships are not so exact. The reason is that the Cost of Goods Sold does not include all costs. The Cost of Goods Sold normally includes variable inputs, most prominently (a) raw materials, added to inventories as soon as they are acquired, and (b) direct labor, the cost of which is added to inventories as raw materials are transformed into work-in-process and finished goods.[10] The Cost of Goods Sold as accounted for in practice do not normally include the user cost of machines, equipment and buildings, do not include the opportunity cost of holding inventories and do not include indirect labor such as managerial and clerical work. This is a weakness of the measure. A strength of the measure is that the inventories-to-cost ratio is an "apples to apples" comparison by accounting definition. This implies that it should be a good proxy for production lags as long as the omitted costs are relatively less important or have a time distribution similar to the observed ones.

A last advantage of the measure is that, given this production function, it captures the sensitivity of costs to the interest rate. Consider the marginal impact of an interest rate increase on production costs one period ahead.[11] By Shephard's lemma:

$$\frac{\frac{\partial \text{Cost of Goods Sold}_{t+1}}{\partial R}}{\frac{\text{Cost of Goods Sold}_{t+1}}{\text{R}}} = \frac{RZ_t(1)}{Z_{t+1}(0) + RZ_t(1)} = \frac{\text{Inventories}_{t+1}}{\text{Cost of Goods Sold}_{t+1}}$$

so that the elasticity of costs to the interest rate is exactly equal to the inventories-to-cost ratio.

[10]The accounting discussed here is on accrual basis, so that costs refer to when the input was transferred to the firm or used by it, and not to when it was actually paid for.

[11]The result generalizes readily to a general class of concave functions if the interest rate shock is persistent.

# 3 Data Analysis

## 3.1 Events

The empirical analysis centers on events where capital inflows to an emerging market drop by an unusually large amount and there is a drop in G.D.P. either in the same year or in the following year.

The episodes satisfy the following criteria:

1) A large drop in capital inflows. Capital inflows are proxied on a monthly basis by the sum between the trade deficit and declines in international reserves, normalized by the linear trend of G.D.P..[12] The episodes of interest feature a pronounced change in capital flows over one year. A capital outflow event occurs when the difference between capital inflows over a 12 month period and the capital inflows in the previous 12 months is more than than two standard deviations below the mean change in capital flows, with both the mean and standard deviation calculated using all data from 1975 to the present but excluding the events themselves. [13] [14]

2) Two capital outflow events that either occur in consecutive years or are separated by a single year are part of a single event.

3) There is a drop in G.D.P. either in the year when the capital outflow event starts or in the subsequent year. Including drops that only take place in the following year accommodates episodes that occur late in the year.

I also exclude episodes that occur in countries with population below one million and during civil wars. To exclude civil wars, I use the same criteria as Cerra and Saxena (2008).

The criteria are similar to Calvo et al. (2006) and Calvo et al. (2008b), except that there is no attempt to identify exogenous or unpredictable events that may serve as natural experiments. Rather the methodological approach is to document regularities of interesting episodes and then compare them to a model. Because there is no attempt to claim exogeneity or unpredictability, there is no filter for international financial conditions. Also the episodes are compared with both post and pre crisis data as opposed to only pre crisis data as in their paper. The episodes are listed in table 1, and they include most episodes identified by Calvo et al. (2006).

## 3.2 Empirical Specification

I test whether time to produce is associated with lower performance at different horizons after the crisis. For horizons spanning from the year of the crisis to 8 years afterwards, I run the following regression:

[12] The proxy follows from the identity capital inflows + current account = change in reserves, together with the observation that changes in the current account are mostly due to changes in the trade balance. The methodology follows Calvo et al. (2008b).

[13] Pre 1975 data were excluded as capital flows were much less volatile before the end of the Bretton Woods regime.

[14] This requires an iterative procedure where events are first calculated given overall mean and standard deviations, then the moments are recalculated excluding the event data, generating possibly new events and repeating the process.

| Country | Year | Country | Year | Country | Year |
|---|---|---|---|---|---|
| Argentina | 1980 | Ghana | 1978 | Mexico | 1982 |
| Argentina | 1995 | Guatemala | 1986 | Mexico | 1988 |
| Argentina | 1999 | Haiti | 1992 | Mexico | 1994 |
| Bangladesh | 1977 | Honduras | 1979 | Nicaragua | 1977 |
| Bolivia | 1980 | Honduras | 1985 | Papua New Guinea | 1976 |
| Brazil | 1980 | Hong Kong | 1998 | Peru | 1976 |
| Brazil | 1999 | Indonesia | 1998 | Peru | 1999 |
| Chile | 1982 | Jamaica | 1977 | Phillipines | 1997 |
| Colombia | 1982 | Jamaica | 1984 | South Africa | 1977 |
| Colombia | 1998 | Jordania | 1984 | South Africa | 1983 |
| Costa Rica | 1981 | Kenya | 1976 | South Korea | 1998 |
| Costa Rica | 1999 | Kenya | 1981 | Sudan | 1977 |
| Cote d'Ivoire | 1980 | Kenya | 1992 | Thailand | 1997 |
| Cote d'Ivoire | 1984 | Kuwait | 1975 | Tunisia | 1981 |
| Croatia | 1999 | Kuwait | 1979 | Turkey | 1979 |
| Dominican Republic | 1977 | Kuwait | 1985 | Turkey | 1999 |
| Dominican Republic | 1981 | Malawi | 1979 | Uruguay | 1982 |
| Dominican Republic | 2002 | Malawi | 1985 | Uruguay | 2002 |
| Ecuador | 1981 | Malawi | 1998 | Venezuela | 1975 |
| Ecuador | 1988 | Malaysia | 1998 | Venezuela | 1979 |
| Ecuador | 1999 | Marocco | 1993 | Zambia | 1976 |
| Egypt | 1990 | Mauritius | 1979 | Zambia | 1991 |
| Ethiopia | 1997 | Mauritius | 1982 | | |

Table 1: Crises Episodes

The episodes start in years in which the capital account balance drops by an unusually large amount and G.D.P. drops either in the same year or in the following one.

$$y_{i,k,t^*+h} - y_{i,k,t^*-1} = \alpha_i + \beta\tau_k + \gamma X_{i,k,t^*} + \varepsilon_{ik}$$

where $y_{i,k,t^*+h}$ is log value added in industry $k$, episode $i$, $h$ years after the start of the event, $\tau_k$ is inventories-to-cost ratio for industry $k$ and $X_{i,k,t^*}$ is a vector of controls. I also allow for episode fixed effects $\alpha_i$. The hypothesis is that $\beta < 0$, so that firms with longer production time lose more of their output.

Value added data are available in INDSTAT3, a data set compiled by UNIDO. The data originate from official sources in UN member countries. The industries are classified according to three digit ISIC Rev. 2.[15]

Errors may be correlated both within episodes or within industries. To account for these correlations, the standard errors are robust to overlapping clusters at both the industry and episode level (Cameron et al. 2006).[16] For example, they allow the error term for Shoes in Thailand in 1997 to be correlated both with Electrical Machinery in Thailand in 1997 and shoes in Mexico in 1994. Because the standard error calculation allows for a widespread correlation between error terms, they are more conservative than usual "one way" clustering procedures.

## 3.3 Inventories-to-Cost Ratio

Reliable measures of inventories-to-cost ratios are not easily available for most countries in the sample. Instead, I use data from U.S. firms and, as a robustness check, from Korean firms. If the inventories-to-cost ratios in the U.S. reflect the underlying production technology, they should be a reasonable proxy for inventories-to-cost ratios in other countries. To the extent that the proxy is imperfect, the measurement error will tend to attenuate the results.

For American firms, I aggregate firm level data from COMPUSTAT into multiple sectors. COMPUSTAT includes decades' worth of financial reports from listed firms that operate in the U.S.. The long time series allows one to smooth business cycle fluctuations when calculating the inventories-to-cost ratios, obtaining something close to a steady state measure. Importantly, because COMPUSTAT is based on balance sheet data, the accounting identity between inventories and costs is exact.

When using COMPUSTAT data, the working assumption is that technological characteristics of listed U.S. firms are sufficiently informative about the technological characteristics of all firms in crisis countries. As a robustness check, I also use a measure of inventories-to-sales data from the Korean Financial Survey Analysis. This survey is representative of all Korean businesses and inventories-to-sales should be strongly correlated with inventories-to-cost as long as markups and the share of fixed

[15] I do not include non-crisis data in the regressions. The reason is that the data set includes a reasonable amount of methodological breaks in the time series that are not properly documented by UNIDO. This problem is especially severe among developing countries. By restricting the number of years of data used by each country to those around the crisis, I restrict the possibility of having these breaks contaminate the results. The use of the three digit level ISIC Rev. 2 classification allows me to have data for the early '80s.

[16] I implement these in STATA using the cgmreg.ado file produced by the authors.

inputs are not too variable across industries.[17]

There is a reasonable amount of correlation between the inventories-to-cost measures from COMPUSTAT and the inventories-to-sales data from the Korean Survey, a little above 0.6, (see table 3). This suggests that the inventories-to-cost ratios do reflect underlying technological characteristics. Table 2 has the descriptive statistics for the two variables. The average inventories-to-cost ratio is 2.5 months in the COMPUSTAT sample, ranging from less than a month worth of inventories held in Printing and Publishing to almost four months in manufacture of Electrical Machinery. The average inventories-to-sales ratio is slightly lower in the Korean data, which is to be expected, given that sales are larger than costs. Figure 1 shows the joint distribution between the two measures.

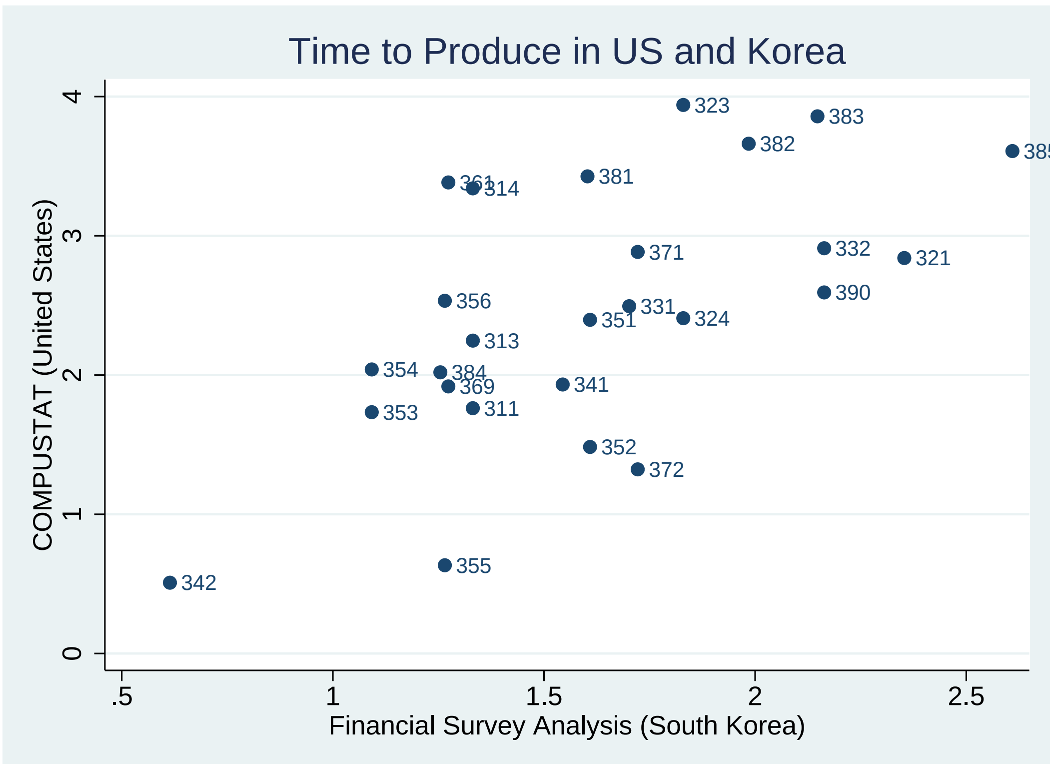


Figure 1: Inventory Turnover Measures
U.S. data are average of Inventories/Cost of Goods Sold across firms in industry, Korean data are average of Inventories/Sales across firms in industry. Industry classification is ISIC Rev. 2

### 3.4 Controls

Sectoral reallocation can occur because of a wide range of alternative forces. These are important to the extent that they are correlated both with the inventory turnover ratio and the change in value

[17]COMPUSTAT data suggest that inventories-to-cost and inventories-to-sales are very closely correlated. The calculations are available upon request.

added in the event period. This section describes the controls. Descriptive statistics are summarized in table 2 and correlations are shown in table 3.

| variable | mean | median | min | max | sd |
|---|---|---|---|---|---|
| Inventory/Cost (U.S. firms) | 2.457 | 2.451 | 0.509 | 3.940 | 0.908 |
| inventory/Sales (Korean firms) | 1.605 | 1.606 | 0.614 | 2.609 | 0.442 |
| Investment Share | 0.066 | 0.058 | 0.001 | 0.523 | 0.056 |
| Durable Consumption Share | 0.014 | 0.007 | 0.000 | 0.503 | 0.036 |
| Exported Share | 0.132 | 0.120 | 0.030 | 0.756 | 0.070 |
| Labor Share | 0.151 | 0.141 | 0.022 | 0.254 | 0.027 |
| Capital Share | 0.177 | 0.175 | 0.046 | 0.379 | 0.046 |
| Imported Inputs Share | 0.126 | 0.116 | 0.018 | 0.775 | 0.053 |
| External Dependence | 0.244 | 0.220 | -0.450 | 1.140 | 0.330 |
| Size | 1.365 | 1.438 | -2.057 | 2.144 | 0.371 |

Table 2: Descriptive Statistics

Inventory/Cost (U.S. firms) is the median ratio of inventories-to-cost across firms and years in the COMPUSTAT database using data since 1980. Inventory/Sales (Korean firms) is the average ratio of inventories-to-sales in the Financial Statement Analysis collected by the Korean government. Export, Investment and Durable Consumption represent the fraction of sectoral output that eventually finds its way to either of these final uses. Durable Consumption includes all consumption from industries whose ISIC numbers start with 33, 36 and 38 (Wood Products, Non-Metallic Minerals and Machinery and Equipment). External Dependence is the dependence on external financing as defined by Rajan and Zingales (1998). The numbers are taken from their paper. Size is the average over time of the ratio between employees and establishments for each country/industry observation calculated with data from the UNIDO database.

### 3.4.1 Demand Side

Demand for different goods react differently in a downturn. In particular, the more durable a good, the more pro-cyclical its demand. On the other hand, the more tradable a good, the less it should be affected by conditions that affect domestic demand.

A measure of the share of output that is ultimately destined to the production of exports, investment goods and durable consumer goods can be calculated from input-output matrices made available by OECD. The measure uses the Leontief inverse to allow for indirect effects through the supply chain. For example, this procedure clarifies that basic metals are sold largely as investment goods.

### 3.4.2 Cost

During a sudden stop, there are massive realignments in relative prices of inputs. The real foreign exchange rate depreciates, disproportionately affecting industries that use imported inputs heavily. Also the real wage rate declines, significantly affecting firms that use labor heavily. To capture these

| | Inventory/Cost, U.S. firms | Inventory/Sales, Korean firms |
|---|---|---|
| Inventory/Cost, U.S. firms | 1 | |
| Inventory/Sales, Korean firms | 0.6135 | 1 |
| Investment Share | 0.3584 | 0.2556 |
| Durable Consumption Share | 0.3977 | 0.4895 |
| Exported Share | 0.3839 | 0.5702 |
| Labor Share | 0.2817 | 0.3606 |
| Capital Share | -0.015 | -0.0612 |
| Imported Inputs Share | 0.0677 | 0.1912 |
| External Dependence | 0.1404 | 0.3606 |
| Size | -0.1071 | -0.3339 |

Table 3: Industry Level Correlations

Correlations only refer to cross industry variation. Variables that vary across countries are first averaged at the industry level. See notes in table 2 for details on how the variables are constructed.

effects I include the share of labor and imported inputs used in production as captured by the input-output matrices. For completeness, I also include a control for the share of fixed capital, defined as the difference between value added, the share of materials and the share of labor. Since the interest rate affects the user cost of fixed capital, firms that rely disproportionately on fixed capital are likely to be more heavily affected.

### 3.4.3 External Dependence

Rajan and Zingales (1998) define External Dependence as

$$\text{External Dependence} = \frac{\text{Capital Expenditure - Cash Flow}}{\text{Capital Expenditure}}$$

They calculate averages of this ratio for listed firms in the U.S.. Rajan and Zingales argue that the ratio captures technological aspects of production, in particular, the extent to which investment is front-loaded when compared to production. Everything else constant, if access to finance is more expensive, industries that require more up-front investment should reduce production by a greater amount. Dell'Ariccia et al. (2007) and Kroszner et al. (2006) have applied this insight to banking crises, and they find an important role for external dependence. For comparability, I use the same numbers for external dependence as Rajan and Zingales (1998).

### 3.4.4 Size

The empirical corporate finance literature has often focused on size as a determinant of differences in the supply of financing available to different firms.[18] Firm size can also matter because large firms are more likely to be exporters.[19] The UNIDO data include data on employment and number of establishments by industries. I calculate for each country/industry pair the average employment/establishment ratio.[20]

### 3.4.5 Previous Trend and Global Effects

Different industries may have different long run growth trends. To control for that, I calculate for each country/industry observation the average growth in the six years before the crisis as a control. This should pick up both inertia and mean reversal tendencies.

I also capture global effects. To this end, I include the average growth in the industry among non-crisis countries over the same period. These are countries that have not experienced a crisis over the previous 10 years. This average should capture how the growth of a certain industry depends on world conditions as well as also global trends.

### 3.4.6 Normally Expected Cyclical Behavior

One last control tries to account for the normally expected behavior of different industries given that aggregate output is depressed. This should help pick up whether the demand or costs of particular goods are more or less cyclical for reasons that are not well captured by the different controls.

I construct this control as follows: First, for each country/industry observation I run the following regression:

$$y_{i,k,t+h} - y_{i,k,t-1} = \lambda_{i,k,h} + \eta_{i,k,h}(gdp_{i,t+h} - gdp_{i,t}) + \epsilon$$

where again $y_{i,k,t}$ is log value added in industry $k$, country $i$, time $t$ and $gdp_{i,t}$ is log G.D.P. in country $i$ time $t$. If there is a crisis in the country, I include in the regression for all years prior to the crisis and all years over ten years after. For countries that do not face a crisis, I include all observations available. Since there is typically not a large number of observations for each industry, the estimates are quite noisy. I then calculate industry specific components:

[18] See Fazzari et al. (1988) for the seminal paper and Gertler and Gilchrist (1994) for an application specific to interest rate shocks. However, see also Kaplan and Zingales (1997) for a critique.

[19] See Melitz (2003).

[20] I also experiment with the employment/establishment ratio in the year before the crisis. The results are virtually identical.

$$\bar{\lambda}_{k,h} = \frac{\sum_i \lambda_{i,k,h}}{I}$$
$$\bar{\eta}_{k,h} = \frac{\sum_i \eta_{i,k,h}}{I}$$

Lastly, I calculate the expected industry behavior within a given window following the crisis given the drop in output:

$$\text{Normally expected cyclical behavior} = \bar{\lambda}_{i,h} + \bar{\eta}_{i,h}(gdp_{i,t^*+h} - gdp_{i,t^*-1})$$

This control is fairly stringent. It may be too stringent insofar as usual cyclical fluctuations are to some extent driven by the same factors that drive crises, but with smaller intensity. Furthermore, when comparing the empirical results to the model it will not matter whether the crisis is a special shock or just a more extreme version of usual business cycle fluctuation. For this reason, I omit this variable from the baseline regression results and only include it as a robustness check.

## 3.5 Results

Table 4 shows the benchmark regression results for different horizons using the COMPUSTAT data to calculate the inventories-to-cost ratios. The coefficient on the inventories-to-cost ratio is negative throughout, but is only significant at a 5% level three years after the onset of the crisis. It remains significant at that level five years afterwards and remains significant at a 10% level seven years after the crisis.

The only other controls that are significant at any level are the investment share in the year of the crisis, average firm size in multiple years and, at a high significance level throughout, the industry growth in non-crisis countries.

Figure 2 shows the estimated coefficient on inventories-to-cost using the COMPUSTAT data and the inventories-to-sales ratios from the Korean data for different horizons. The figures depict for each horizon the estimated coefficient of the drop in value added on the inventories-to-cost ratio together with 95% confidence intervals. Using inventories-to-sales data from Korean firms seems to make little difference for the qualitative results. The estimated coefficients are larger, consistent with inventories-to-sales ratios for Korean firms being smaller than the inventories-to-cost ratio for U.S. listed firms.[21]

The delayed and persistent effect is interesting because it indicates that the findings are most likely not associated with short-term inventory adjustment. Given a total inventory turnover ratio of less than three months, these dynamics should have been exhausted multiple years after the onset of the crisis.[22]

[21] This can at least in part be explained by the larger denominator in inventories-to-sales versus inventories-to-costs.

[22] In particular Alessandria et al. (2008) study the implications of inventory adjustment dynamics for the response of

| | 0 years | 1 year | 2 years | 3 years | 4 years | 5 years | 6 years | 7 years | 8 years |
|---|---|---|---|---|---|---|---|---|---|
| Inventory/Cost (U.S. firms) | -0.00849 | -0.0121 | -0.0256 | -0.0436** | -0.0435** | -0.0562** | -0.0474* | -0.0464* | -0.0427 |
| | (0.00755) | (0.0122) | (0.0160) | (0.0190) | (0.0174) | (0.0218) | (0.0243) | (0.0274) | (0.0264) |
| Investment Share | -0.417** | -0.224 | -0.126 | -0.0755 | -0.0464 | -0.0155 | -0.0889 | 0.0784 | 0.0302 |
| | (0.170) | (0.141) | (0.336) | (0.385) | (0.468) | (0.421) | (0.423) | (0.462) | (0.494) |
| Durable Consumption Share | 0.0988 | -0.244 | -0.403 | -0.469 | -0.152 | -0.0400 | 0.0882 | -0.786 | -0.721 |
| | (0.190) | (0.372) | (0.530) | (0.556) | (0.599) | (0.569) | (0.623) | (0.526) | (0.548) |
| Exported Share | 0.187 | 0.0991 | 0.186 | 0.286* | 0.156 | 0.0343 | 0.269 | 0.324 | 0.410 |
| | (0.129) | (0.121) | (0.138) | (0.172) | (0.250) | (0.332) | (0.224) | (0.253) | (0.259) |
| Labor Share | -0.175 | -0.193 | -0.290 | 0.0534 | 0.0460 | -0.0695 | -0.705 | -0.392 | -0.443 |
| | (0.237) | (0.359) | (0.379) | (0.467) | (0.455) | (0.473) | (0.663) | (0.443) | (0.452) |
| Capital Share | 0.119 | 0.0853 | 0.0200 | -0.0655 | -0.231 | -0.357 | -0.156 | -0.328 | -0.246 |
| | (0.199) | (0.204) | (0.252) | (0.355) | (0.398) | (0.396) | (0.384) | (0.557) | (0.514) |
| Imported Inputs Share | -0.221 | -0.164 | -0.194 | -0.180 | -0.141 | -0.0992 | -0.254 | -0.185 | -0.216 |
| | (0.150) | (0.149) | (0.165) | (0.149) | (0.225) | (0.295) | (0.189) | (0.218) | (0.247) |
| External Dependence | -0.0298 | -0.0293 | -0.0383 | -0.0521 | -0.0663 | -0.0359 | 0.00795 | -0.00950 | -0.00714 |
| | (0.0196) | (0.0350) | (0.0498) | (0.0676) | (0.0745) | (0.0768) | (0.0843) | (0.0800) | (0.0752) |
| Size | 0.0238 | 0.0808** | 0.0892** | 0.131** | 0.115* | 0.104 | 0.124 | 0.0837 | 0.0508 |
| | (0.0244) | (0.0357) | (0.0413) | (0.0544) | (0.0650) | (0.0745) | (0.0939) | (0.103) | (0.106) |
| Growth in Non-Crisis Countries | 0.870*** | 0.574** | 0.593** | 0.716** | 0.795*** | 0.556*** | 0.542* | 0.538** | 0.593*** |
| | (0.296) | (0.290) | (0.288) | (0.280) | (0.249) | (0.215) | (0.282) | (0.250) | (0.207) |
| Previous growth | -0.000180 | 0.0257 | 0.0438 | 0.0386 | 0.00620 | 0.00776 | 0.0154 | 0.0420 | 0.0593 |
| | (0.0446) | (0.0494) | (0.0567) | (0.0502) | (0.0544) | (0.0589) | (0.0711) | (0.0907) | (0.105) |
| Observations | 1,097 | 1,095 | 1,066 | 1,044 | 1,018 | 815 | 970 | 729 | 721 |
| R-squared | 0.323 | 0.343 | 0.306 | 0.375 | 0.437 | 0.486 | 0.511 | 0.473 | 0.459 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Regressions: Change in Value added from $t^* - 1$ to $t^* + h$

where $t^*$ is the starting year of a crisis event. The dependent variable is the log change in value added in the three years leading to the trough of G.D.P.. The columns refer to different horizons ($h$). Regressions include country fixed effects (omitted). Standard errors are robust to overlapping clusters on country and industry following (Cameron et al. 2006)

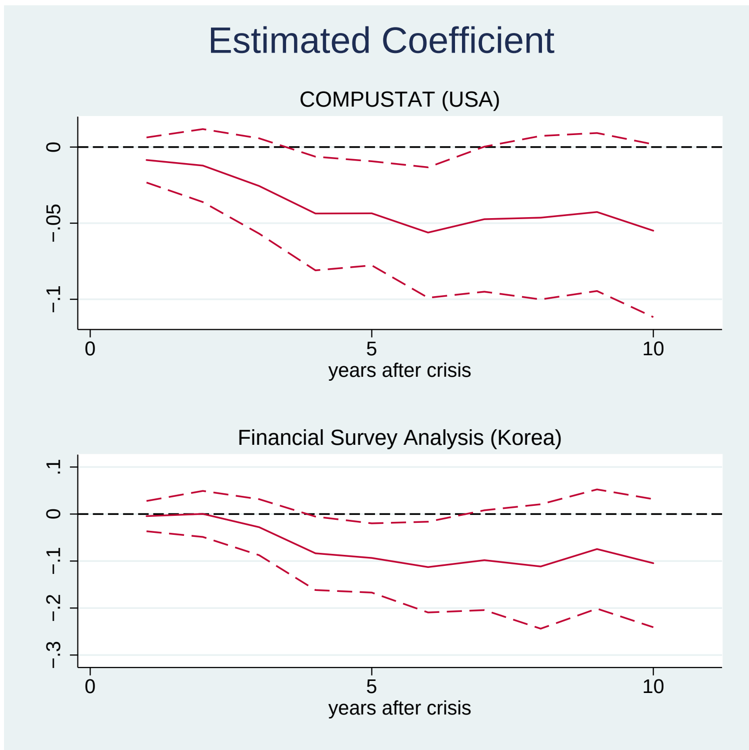


Figure 2: Estimated coefficient for different horizons.
The upper panel shows the coefficient on inventories-to-cost ratio showed in table 4, and the lower panel shows the coefficients on identical regressions using inventories-to-sales ratios from the Korean Financial Survey Analysis. The bands refer to the 95% confidence interval using two-way clustering technique following Cameron et al. (2006).

### 3.5.1 Sub-Samples

Crisis episodes were heavily concentrated in certain time periods and geographic regions. About half of the crises in the sample took place in the early eighties and the other half between the mid to late nineties. Geographically, about half of the crises were in Latin America and the rest distributed among all other continents. I assess whether the coefficient on the inventories-to-cost ratio is robust to splitting the sample in different ways.

The results are in figures 3 and 4. The point estimate of the coefficients is remarkably robust, as is the overall negative effect. Given that samples are half the size, it is not surprising that the statistical significance is reduced.

The robustness of the coefficients is especially interesting, since in the early eighties, the crises were followed by a much larger increase in inflation than in the nineties. This reinforces the conclusion that nominal factors played a small role in accounting for these differences.

### 3.5.2 Normally Expected Cyclical Behavior

The final set of regressions controls for the expected cyclical behavior outside of crises situations. The result is depicted in figure 5. Now the estimated coefficients are smaller in absolute value but still negative. Furthermore, they cease to be significant at a 95% level. However, this is a fairly stringent test. Among other things, it assumes that non-crisis business cycles are qualitatively different from crisis episodes in terms of the forces that generate them. What the results imply is that this is at best only partly true.

# 4 Quantitative Model

## 4.1 Model Setup

The model economy has multiple sectors. It has $N_T$ tradable sectors and $N_{NT}$ non-tradable sectors. The tradable sectors correspond to the manufacturing sectors in the data, and the non-tradable secotrs are included so as to fully account for all general equilibrium effects.

### 4.1.1 Household

Let $s^t$ denote the history of states of nature up to time $t$. There is a representative household who is able to borrow and lend abroad at risk-less bonds at an exogenous interest rate $e^{r(s^t)}$. The household supplies labor and consumes both durable and non-durable goods. The utility function of this household is time-separable with discount rate $\beta < 1$ and the period utility is

imports and import prices in the aftermath of devaluations. They find large effects which, however, exhaust themselves in less than a year.

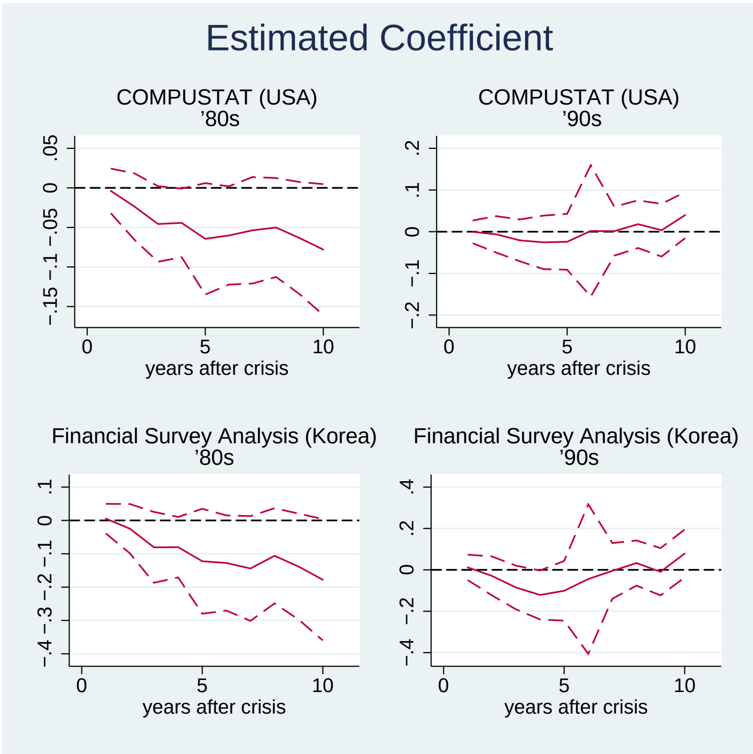


Figure 3: Estimated coefficient for different horizons and decades

The panels show the results for different decades. The upper panel shows the coefficient on inventories-to-cost ratios using COMPUSTAT data, and the lower panel shows the coefficients on identical regressions using inventories-to-sales ratios from the Korean Financial Survey Analysis. The left panels show the estimates using crises that started in the '80s and the right panels show the estimates from crises that started in the '90s. The bands refer to 95% confidence interval using two-way clustering technique following Cameron et al. (2006).

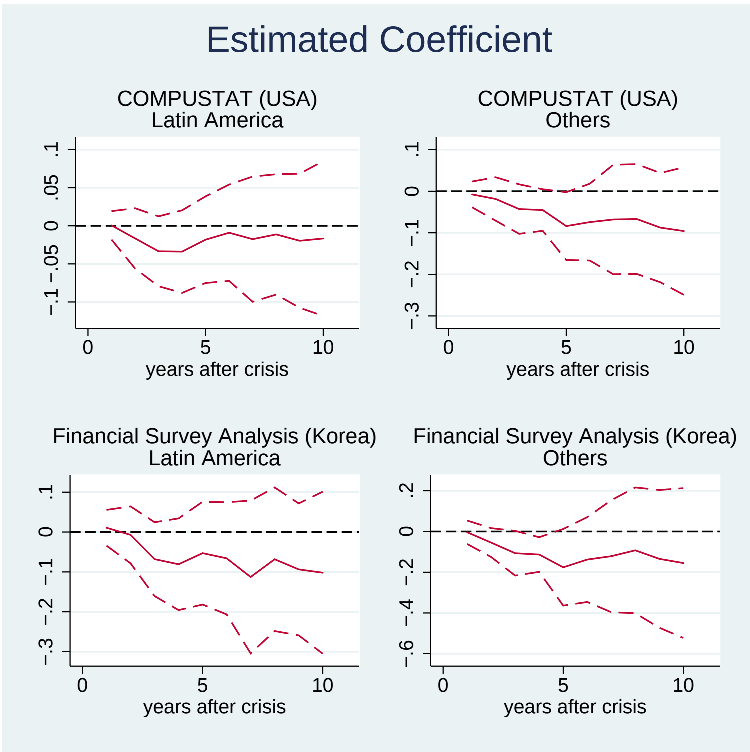


Figure 4: Estimated coefficient for different horizons and continents
The panels show the results for different continents. The upper panel shows the coefficient on inventories-to-cost ratios using COMPUSTAT data, and the lower panel shows the coefficients on identical regressions using inventories-to-sales ratios from the Korean Financial Survey Analysis. The left panels show the estimates using crises in Latin American countries and the right panels show the estimates from crises in other continents. The bands refer to a 95% confidence interval using two-way clustering technique following Cameron et al. (2006).

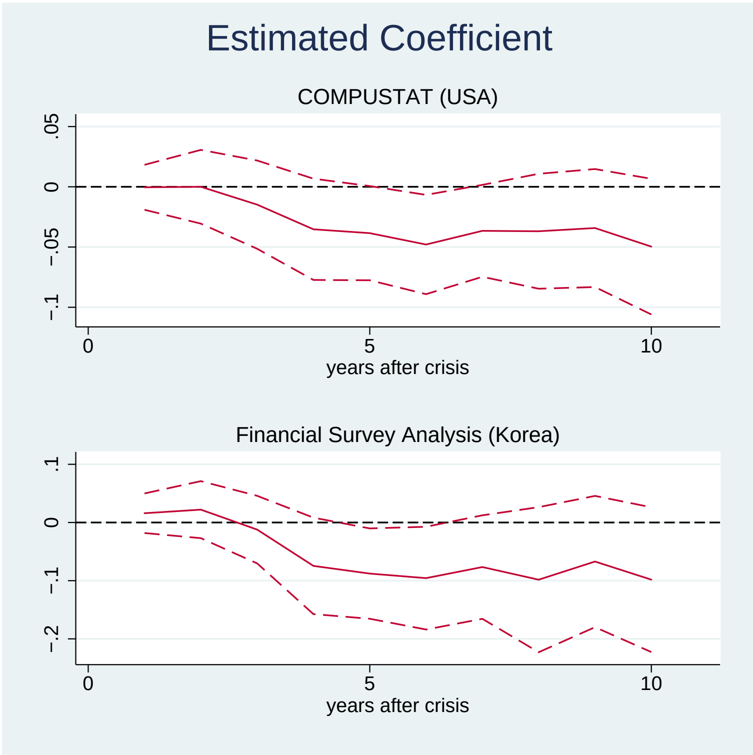


Figure 5: Estimated coefficient for different horizons, controlling for expected cyclical effect. The panels shows results controlling for the expected behavior of each industry in non-crisis periods. The upper panel shows the coefficient on the inventories-to-cost ratios using COMPUSTAT data, and the lower panel shows the coefficients on identical regressions using inventories-to-sales ratios from the Korean Financial Survey Analysis. The bands refer to a 95% confidence interval using two-way clustering technique following (Cameron et al. 2006)

$$u\left(C\left(s^{t}\right),K_{H}\left(s^{t}\right),L\left(s^{t}\right)\right)=\frac{1}{1-\sigma}\left(\left[\gamma^{d\frac{1}{\rho}}C\left(s^{t}\right)^{\frac{\rho-1}{\rho}}+\left(1-\gamma^{d}\right)^{\frac{1}{\rho}}K_{H}\left(s^{t}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}-\frac{L\left(s^{t}\right)^{1+\frac{1}{\psi}}}{1+\frac{1}{\psi}}\right)^{1-\sigma}$$

where $C\left(s^{t}\right)$ is non-durable consumption, $K\left(s^{t}\right)$ is the stock of durable goods held by the household and $L\left(s^{t}\right)$ is labor supply.

This utility function follows Greenwood et al. (1988). One motivation is that labor supply is costly because it implies a loss in output from home production or self employment. Such an interpretation is particularly suitable for developing countries, where a large fraction of the population is self-employed.[23] An important implication is that labor supply does not respond to the wealth of the household, only to wages. Finally, Small Open Economy business cycle models equipped with this utility function are more successful in generating realistic dynamics for the volatility of consumption and the cyclicality of the balance of trade (Correia et al. 1991).

### 4.1.2 Production Functions

The production function of each sector is

$$Y^{i}\left(s^{t}\right) \;=\; \prod_{v=0}^{\tau^{i}} Z_{i}\left(s^{t-v},v\right)^{\omega^{i}(v)},\ \sum\omega^{i}\left(v\right)=1$$

where $Y_i(s^t)$ is the production of the input $i$ in $t$. $Z_{i}\left(s^{t-v},v\right)$ denotes a composite of goods acquired in period $t-v$ to produce the finished good which is sold $v$ periods ahead. It is defined as:

$$Z_{i}\left(s^{t-v},v\right)=\gamma^{i}e^{a\left(s^{t-v}\right)}\left(u_{i}\left(s^{t-v},v\right)K_{i}\left(s^{t-v},v\right)\right)^{\alpha_{K}^{i}}\left(L_{i}\left(s^{t-v},v\right)\right)^{\alpha_{L}^{i}}\left(M_{i}\left(s^{t-v},v\right)\right)^{1-\alpha_{L}^{i}-\alpha_{K}^{i}}$$

where $u_{i}\left(s^{t-v},v\right)$ is the rate of utilization of fixed capital at $t$, $K_{i}\left(s^{t-v},v\right)$ is capital stock, $L_{i}\left(s^{t-v},v\right)$ is labor and $M_{i}\left(s^{t-v},v\right)$ is a composite of materials produced in the different sectors. The index $v$ implies that the input is meant for production of the output that will be available $v$ periods in the future.

Once inputs are combined into $Z_{i}\left(s^{t-v},v\right)$, they cannot be reassigned to a different sector or horizon. This will be important for the short run dynamics of the model, as it will be a source of inertia both in aggregate output and in cross-sectoral reallocation.

As an accounting matter, the composite $Z_{i}\left(s^{t-v},v\right)$ is part of inventories. In particular, in the beginning of each period, the inventories held by sector $i$ are the sum of all $Z_{i}\left(s^{t-v},v\right)$ with $v>0$,

[23] The motivation for strong wealth effects in labor supply relies to a large extent on the observation that there is not a clear long run trend in average hours worked (King et al. 1988). However, there a clear increase in labor force participation in emerging market economies. See, for example, Young (1995) for the Asian Tigers.

properly inflated by the accumulated interest rates over the period in question.

Lastly, as a national accounting matter, the production function in this section corresponds to total output, not to the value added by the sector. To get to value added, we need to subtract from output the cost of all materials used in production and the change in inventories (see appendix 5 for a detailed discussion and mathematical formulation).

### 4.1.3 Capital Accumulation, Utilization and Maintenance Costs

Capital is sector specific and is produced by combining old capital and investment goods as in Baxter and Crucini (1993):[24]

$$K_i\left(s^t\right)=\left(1-\delta_i-\frac{\delta_i}{\zeta-1}\right)K_i(s^{t-1})+\delta_i^{\frac{1}{\zeta}}\left(\frac{I_i(s^t)}{K^i(s^{t-1})}\right)^{\frac{\zeta-1}{\zeta}}K_i(s^{t-1})$$

Durable consumer goods are produced in a similar fashion:

$$K_H\left(s^t\right)=\left(1-\delta_H-\frac{\delta_H}{\zeta-1}\right)K_H(s^{t-1})+\delta_H^{\frac{1}{\zeta}}\left(\frac{I_i(s^t)}{K^H(s^{t-1})}\right)^{\frac{\zeta-1}{\zeta}}K_H(s^{t-1})$$

Whenever a firm uses capital, it has to use up spare parts in order to make up for wear and tear of the capital stock. This maintenance requirement is increasing in capacity utilization:[25]

$$\Omega_i\left(s^t\right)=\frac{\mu_i}{1+\xi}\left[u_i\left(s^t\right)^{1+\xi}-1\right]K_i\left(s^t\right)$$

### 4.1.4 Composite Goods

Non-durable consumption $C\left(s^t\right)$, fixed investment $I_i\left(s^t\right)$, investment in durable consumption goods $I_H\left(s^t\right)$, materials $M_i\left(s^t\right)$ and spare parts $\Omega_i\left(s^t\right)$ are composites of the goods produced in the $N_T+N_{NT}$ sectors and imported goods. These composites are represented by CES aggregates:

$$X\left(s^t\right)=\left[\begin{array}{c}\sum_{k\in\{1,\ldots,N_T+N_{NT}\}}\left(\gamma_X^k\right)^{\frac{1}{\rho}}\left(X^k\left(s^t\right)\right)^{\frac{\rho-1}{\rho}}\\+\left(1-\sum_{k\in\{1,\ldots,N_T+N_{NT}\}}\gamma_X^k\right)^{\frac{1}{\rho}}\left(X^*\left(s^t\right)\right)^{\frac{\rho-1}{\rho}}\end{array}\right]^{\frac{\rho}{\rho-1}}$$

where $X$ stands in for $C$, $I_i$, $\Omega_i$ or $M_{i,j}$. $X^*\left(s^t\right)$ is the amount of imported goods used for the production of $X$ and $\sum\gamma_X^i\leq 1$.

[24]This function has the property that, in steady state, capital increases one for one with investment and marginal $q$ is equal to 1.

[25]In the calibration, I choose units so that in steady state $u=1$ and the firm does not have any maintenance costs. This implies that spare parts needs can be negative if $u<1$. This assumption is made for tractability, but does not have any important consequences for the results.

### 4.1.5 Resource Constraints

While capital is sector specific, there is no limit in reshuffling it for the production at different horizons. This implies the following resource constraint for capital stock for sector $i$:[26]

$$\sum_{v} u_i\left(s^t, v\right) K_i\left(s^t, v\right) \leq u_i\left(s^t\right) K_i\left(s^t\right)$$

Raw materials respect an analogous resource constraint:

$$\sum_{v} M_i\left(s^t, v\right) \ \leq M_i\left(s^t\right)$$

In contrast, labor is perfectly mobile between sectors. This implies the following constraint:

$$\sum_{k\in\{1,\ldots,N_T+N_{NT}\}} \sum_{v}^{n} L_i\left(s^t, v\right) \leq L\left(s^t\right)$$

Finally, there is a resource constraint in the non-tradable sectors. This is:

$$C^i\left(s^t\right) + I_H^i\left(s^t\right) + G^i + \sum_{j\in\{1,\ldots,N_T+N_{NT}\}} \left(M_j^i\left(s^t\right) + I_j^i\left(s^t\right) + \Omega_j^i\left(s^t\right)\right) \leq Y^i\left(s^t\right)$$

where $G^i$ are government purchases, assumed to be constant over time.

### 4.1.6 Foreign Trade

While the economy is small with respect to capital markets, it can be large relative to product market. One motivation is that countries produce different varieties of goods that are not perfect substitutes.[27] This assumption implies tradable output may respond directly to shifts in domestic demand.

The tradable sectors face the following inverse demand function for exports:

$$p^i\left(s^t\right) = \chi^i\left[EXP^i\left(s^t\right)\right]^{-\frac{1}{\theta}}$$

where $p^i\left(s^t\right)$ is the price of good $i$ with respect to the foreign good and $EXP^i\left(s^t\right)$ are exports of sector $i$ good.

Exports are identical to the total output from sector $i$ minus the sum of the domestic demands for this good:

[26] The allocation procedure only determines $u_i\left(s^t, v\right) K_i\left(s^t, v\right)$ but not the individual components.

[27] It is a common assumption in the literature. See Gertler et al. (2007) and Kehoe and Ruhl (2008). Note that this does not imply monopolistic power if many producers in a country produce the same variety. All that is required is that the country be sufficiently big relative to the world demand for that variety.

$$EXP^i\left(s^t\right) = Y^i\left(s^t\right) - C^i\left(s^t\right) - I_H^i\left(s^t\right) - \sum_{j\in\{1,\dots,N_T+N_{NT}\}} \left(M_j^i\left(s^t\right) + I_j^i\left(s^t\right) + \Omega_j^i\left(s^t\right)\right)$$

For non-tradables, exports are equal to zero:

$$EXP^i\left(s^t\right) = 0 \text{ if } i \text{ is non-tradable}$$

Total imports are the sum of all foreign produced goods demanded for different uses:

$$IMP\left(s^t\right) = C^*\left(s^t\right) + I_H^*\left(s^t\right) + \sum_{j\in\{1,\dots,N_T+N_{NT}\}} \left(M_j^*\left(s^t\right) + I_j^*\left(s^t\right) + \Omega_j^*\left(s^t\right)\right)$$

The prices of the foreign goods are constant over time and are normalized to be equal to 1. The current account identity is

$$\begin{aligned} B\left(s^t\right) - R\left(s^{t-1}\right)B\left(s^{t-1}\right) &= IMP\left(s^t\right) \\ &\quad - \sum_{i\in\{1,\dots,N_T\}} p^i\left(s^t\right)EXP^i\left(s^t\right) \end{aligned}$$

where $B\left(s^t\right)$ is the amount of net foreign debt that domestic households hold.

### 4.1.7 Allocation

The economy has a representative household and insofar as domestic transactions are concerned, there are no frictions or missing markets. In a closed economy setup, this would imply that the equilibrium allocation is also the solution to a planner's problem. Such a solution method is also possible in this context if we modify it so that the planner does not internalize the impact of choices on $p^i\left(s^t\right)$.[28]

The equilibrium allocation is defined as follows: A social planner takes the functions $\left\{p^i\left(s^t\right)\right\}_{k\in\{1,\dots,N_T\}}$ as given and chooses all remaining functions of $s^t$ to maximize household welfare subject to technological and resource constraints described above. The equilibrium is the solution to the planner's problem and $\left\{p^i\left(s^t\right)\right\}_{k\in\{1,\dots,N_T\}}$ so that for all $s^t$, $\left\{p^i\left(s^t\right)\right\}_{k\in\{1,\dots,N_T\}} = \left\{\chi^i\left[EXP^i\left(s^t\right)\right]^{-\frac{1}{\theta}}\right\}_{k\in\{1,\dots,N_T\}}$.

## 4.2 Calibration

### 4.2.1 Sectors and Shares

The model has 15 tradable sectors and three non-tradable sectors. The tradable sectors seek to match the manufacturing sectors in the empirical sector (see appendix 5 for details). The three non-tradable sectors allow for differentiation between 1) construction, which has a long time to produce, and 2)

[28] This is analogous to an industry equilibrium in Stokey et al. (1989).

services and retail, which have a short time to produce. The third non-tradable sector is residential services. Its function is to absorb the residential capital built in the construction sector, thus allowing for a realistic calibration of the share of construction in manufacturing investment.[29]

To calibrate the model, I use an average of the input-output tables in the data analysis section 3. The resulting input-output table has 46 sectors which I then aggregate into 18. In order to find the shares, I need to take into account that non-tradable sectors do in fact trade and that the model features balanced trade. Appendix 5 discusses the assumptions and re-balancing procedures needed to accommodate them.

### 4.2.2 Time to Produce

I calibrate the production process in each sector as follows. First, for the manufacturing sectors, I set

$$Y^i\left(s^t\right) = Z_i\left(s^t, 0\right)^{1-\omega^i} Z_i\left(s^{t-1}, 1\right)^{\omega^i}$$

I choose $\omega^i$ for each sector so that the inventories-to-cost ratio matches the numbers constructed from COMPUSTAT.[30] This is straightforward, sufficing to set $\omega_i$ to the inventories-to-cost ratio (see section 2 for details).

The production function for services and residential services sectors is

$$Y^i\left(s^t\right) = Z_i\left(s^t, 0\right)$$

Finally, the construction sector requires inputs to be accumulated over four quarters, just as in Kydland and Prescott (1982)

$$Y^{\text{Const.}}\left(s^t\right) = Z_{\text{Const.}}\left(s^t, 0\right)^{\frac{1}{4}} Z_{\text{Const.}}\left(s^{t-1}, 1\right)^{\frac{1}{4}} Z_{\text{Const.}}\left(s^{t-2}, 2\right)^{\frac{1}{4}} Z_{\text{Const.}}\left(s^{t-3}, 3\right)^{\frac{1}{4}}$$

**Counter-Factual Calibration:** For the sake of comparison, I also include some counter-factual calibrations. I assume that all manufacturing sectors produce instantaneously, so that

$$Y^i\left(s^t\right) = Z_i\left(s^t, 0\right) \;\; \forall i \text{ tradable}$$

I keep time to build in construction since this is a more standard assumption.

[29]The service sector is really a residual sector that includes services, retail, utilities, public administration and agriculture. I treat mining as a foreign sector since it is highly tradable and employs relatively few. I also experimented with treating agriculture the same way as mining. The results are not sensitive to this assumption.

[30]For sectors which encompass more than one sector in my data, I pick the number corresponding to the one with relatively larger value added.

### 4.2.3 Export demand, Capital accumulation and Maintenance cost

One crucial parameter in the calibration is the price elasticity of demand for net exports, $\theta$. In fact, the literature on emerging market business cycles has diverged dramatically on the appropriate value for this parameter, with some papers setting it as low as 1 or 2 and many other papers assuming that the economy is small in the goods markets, so that, effectively, $\theta \to \infty$. Econometric estimates diverge, with Mendoza (1994) finding that there is no Granger causation running from exports to terms of trade, and Senhadji and Montenegro (1998) estimating price elasticities of export demand as low as 1.5. More relevant to the present work, Burstein et al. (2005) show that, over some important cases of large exchange rate depreciations the price of traded goods at the dock dropped very little in foreign currency terms, which suggests a high elasticity of demand for exports. I present results for $\theta = \infty$ (the small open economy case), $\theta = 40$ and $\theta = 2$. I use $\theta = 40$ as the benchmark.

Another parameter that is important for the results of the model is the curvature of the capital accumulation equation $\zeta$. This is the elasticity of investment to marginal 'q' (the ratio of the marginal value of capital relative to the marginal cost of investment). Most recent micro-data estimates of this parameter put it at very high levels (Cooper and Haltiwanger 2006), making it virtually irrelevant for aggregate behavior of the economy. However, calibration of macroeconomic models often use much lower values, sometimes as small as 1 (King and Watson 1996). I will use $\zeta = 3$ as a benchmark, but I will show results with $\zeta = 1.001$ and $\zeta = 15$.

For the capital accumulation equations, I set the depreciation of fixed capital $\delta_i$ equal to 10% annually for all sectors except residential services. The depreciation rate for the capital of the residential services sector I set at 2.3% annually. Finally, I set the depreciation of durable consumer goods $\delta_H$ to 17%. These values approximate the rate used by the Bureau of Economic Analysis to depreciate stocks of physical assets in the U.S. economy.

To calibrate the sensitivity of maintenance costs to capacity utilization, I set $\xi = 0.5$ and set $\mu_i$ such that $u^i\left(s^t\right) = 1$ in steady state. The calibrated value for $\xi$ is close to the estimate by Burnside and Eichenbaum (1996). As a robustness check, I also report results with $\xi = 1$, which is closer to the estimate by Basu and Kimball (1997). As far as the share parameters are concerned, I assume that they are identical to the investment good, except that I exclude output from the construction sector.

### 4.2.4 Household Preferences and Substitutability between Inputs

For the household preferences, there are three parameters to be calibrated, $\psi$, $\sigma$ and $\rho$. I follow Mendoza (1991) and Uribe and Yue (2006) and take $\psi = 2.28$ and $\sigma = 2$. The household discounts the future at a rate $\beta$. The steady state interest rate $\bar{R}$ is equal to $\beta^{-1}$, and I set both quantities to match the steady state investment rate recovered from an average of the input-output tables used to calibrate the share parameters. I also assume that $\rho = 2$, so that the output of different sectors are substitutes.

| | Parameter | Value |
|---|---|---|
| $\theta$ | Elasticity of demand for exports | 40 |
| $\rho$ | Elasticity of substitution between home sectors | 2 |
| $\sigma$ | Relative risk aversion | 2 |
| $\psi$ | Elasticity of labor supply | 2.8 |
| $\beta$ | Discount rate | 0.97% (per year) |
| $\zeta$ | Elasticity of investment to marginal $q$ | 3 |
| $\delta_i$ | Depreciation of fixed capital | 10% (per year) |
| $\delta_{\text{real estate}}$ | Depreciation of capital in residential services Sector | 2.3% (per year) |
| $\delta_H$ | Depreciation of durables | 17% (per year) |
| $\xi$ | Elasticity of maintenance cost to utilization | 0.5 |
| $\bar{r}$ | Steady state interest rate | 7.59% (per year) |

Table 5: Benchmark Calibration

### 4.2.5 Exogenous Processes

The exogenous state determines the path of the interest rate and of productivity. The productivity shock is standard in business cycle models. The interest rate shock, while standard in small open economy business cycle models, deserves more motivation. The interest rate shock as modeled here has two important characteristics: It is not insurable and it is not correlated with any change in the level or composition of foreign demand for domestic output. These two assumptions are consistent with a model similar to Mendoza (2010), Chari et al. (2005) and Kehoe and Ruhl (2008), where there is a sudden quantitative limit on the net amount of resources that can be transferred from abroad. Per definition, this limit cannot be insured against, and, in a decentralized setup, the imposition of this limit induces a wedge between the interest rate faced by domestic agents and that faced by foreigners. Allowing for an interest rate shock instead of a quantitative limit also accommodates models where the quantitative limit is not rigid, but the interest rate is increasing in the amount of capital inflows. Of course, a flexible enough interest rate shock could replicate the wedge induced by any such model.

The shocks follow the following autoregressive processes:

$$
\begin{aligned}
r\left(s^t\right) &= \left(1-\eta_r\right)\bar{r} + \eta_r r\left(s^{t-1}\right) + \varepsilon^r\left(s_t\right) \\
a\left(s^t\right) &= \eta_a a\left(s^{t-1}\right) + \varepsilon^a\left(s_t\right)
\end{aligned}
$$

The steady state interest rate $\bar{r}$ is equal to 7.59% per year. Given this interest rate, the steady state ratio of investment to output in the model matches the ratio obtained from the input output matrices. The interest rate is high but is consistent with the high interest rates and low investment rates often observed in emerging markets.

To solve the model, I log-linearize the model equations around the non-stochastic steady state and then solve for the rational expectations equilibrium. This approximation is necessary because of the large number of state variables.[31]

## 4.3 Model Dynamics

It is interesting to study the model dynamics in response to different type of shocks in order to build intuition before comparing it with the data.

I consider shocks to total factor productivity (T.F.P. shock) and the interest rate on foreign bonds (R shock). In order to build the intuition, I show the extreme cases in which the shocks are almost perfectly persistent (i.e., $\eta_a = \eta_r = 0.9999$), and in which they only last for a single period ($\eta_a = \eta_r = 0$). The parameters correspond to the benchmark calibration summarized in table 5.

In the experiments with a productivity shock, T.F.P. drops by 1% and in the experiments with the interest rate shock, the annual interest rate increases 4.98%. The size of the interest rate shock is chosen to ensure that the two shocks generate the same average drop in G.D.P. over the first three years. This facilitates comparison of the relative effect of the shocks in series other than G.D.P..

In the benchmark experiments, I will consider what happens when the price elasticity of exports $\theta = 40$. This is very close to a pure small open economy case ($\theta \to \infty$), but imposes enough curvature in the demand function to avoid oscillatory dynamics, making the results easier to visualize. In the end of this subsection, I discuss what changes with $\theta \to \infty$ or $\theta = 2$.

### 4.3.1 Aggregate Dynamics

Figure 6 shows, for models with and without time to produce in manufacturing, the response of aggregate G.D.P. to both permanent (first row) and temporary (second row) shocks to the interest rate (R shock, first column) and total factor productivity (T.F.P. shock, second column). Figure 7 shows the response of aggregate investment to these same shocks.

Let's start with the temporary shocks. When the economy is hit by a temporary R shock, G.D.P. responds if there is time to produce, but only in the second period. Without time to produce in manufacturing there is barely any response to the shock. In contrast, the T.F.P. shock generates a response in both models, but the model with time to produce responds in a delayed fashion, distributing the impact on output over the first two quarters.

The delayed response of G.D.P. to temporary shocks in the model with time to produce deserves elaboration. In the first period, there are sunk costs in the production of current output. This keeps production from reacting immediately. However, there is also increased use of inputs for production in the following period. This affects production one period ahead. After a couple of periods, the impact of a temporary shock largely disappears.

Neither of the temporary shocks has much of an impact on investment. This is natural given that the shocks are very short lived and that investment decisions look far into the future.

[31] I solve the model using Dynare.

In response to a persistent R shock and absent time to produce in manufacturing, G.D.P. first rises and then slowly declines as time passes. The boom occurs because the manufacturing industry takes advantage of lower wages and lower input prices to increase capacity utilization and production. In contrast, G.D.P. drops if there is time to produce in manufacturing. G.D.P. drops steeply immediately after the shock and recovers somewhat in the second period. As will become clearer in , the non-monotonic pattern reflects the inertia that time to produce induces in manufacturing production.

Aggregate investment drops substantially in response to persistent shocks to T.F.P. and to the interest rate, slowly at first as construction projects that were started previously are finished, and faster afterwards. The response of investment to the interest rate shock is much larger than to the productivity shock, even though the shocks are chosen so that G.D.P. drops by a similar amount in both cases. The reason is that the interest rate shock increases the rate at which future capital flows are discounted, thus reducing the value of capital over and above what is implied by the reduction in expected revenues.

### 4.3.2 Manufacturing Dynamics

The first row of figure 8 shows the response of manufacturing sectors to persistent interest rate and T.F.P. shocks. What is depicted is a simple (non-weighted) average of the different sectors. While manufacturing production drops in response to a persistent T.F.P. shock, it actually booms in response to the interest rate shock. Introduction of time to produce has two implications for the reaction of manufacturing to the interest rate shock: It delays the boom in manufacturing by one period and dampens the boom by a small amount. In contrast, time to produce does not change the effect of the T.F.P. shock on manufacturing after the first period.

That manufacturing, and hence tradable production,, does better than the overall economy is a desirable feature of the model as it conforms to the qualitative findings by Tornell and Westermann (2002). However, the model goes too far in this dimension, generating a boom in manufacturing production. The same problem was identified by Kehoe and Ruhl (2008), who study the reallocation from non-tradables to tradables in a general equilibrium model of the Mexican economy, and conclude that a productivity shock is needed to ensure that all sectors drop during the crisis. Time to produce helps mitigate the boom in manufacturing bringing the model more in line with the data, but it is not enough to keep the boom in manufacturing from taking place.

The bottom panels show the response of Paper and Printing (inventories-to-cost ratio equal to 0.3 quarters in the calibration) and Electrical Machinery (inventories-to-cost ratio equal to 1 quarter in the calibration) to both types of shock, with and without time to produce. Allowing for time to produce increases the difference in the response of the two sectors to a persistent interest rate shock, with Electrical Machinery producing less and paper and printing producing more. As for the response to the T.F.P. shock, it is very similar in the models with and without time to produce in manufacturing, with the exception of the first period when time to produce keeps output from reacting.

The cross-sectoral results highlight an important difference between a downturn generated solely

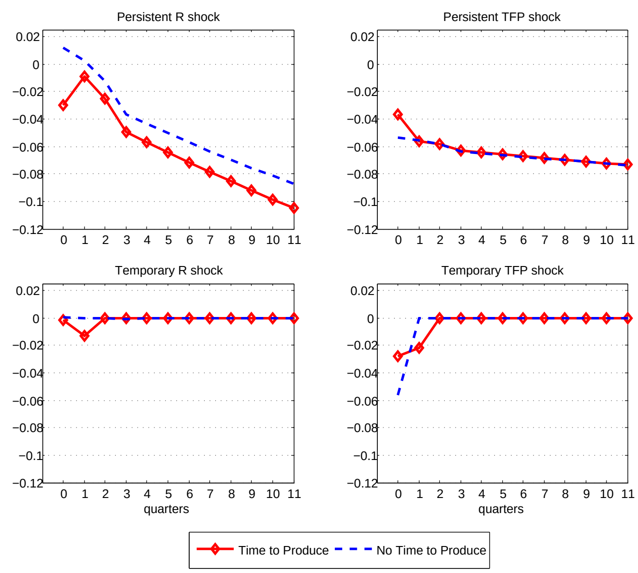


Figure 6: Effect of shocks to the interest rate and T.F.P. on G.D.P..
Time path of variables quarter by quarter. The shocks to T.F.P. and the interest rate are equal to -1% and 4.98% (annually), respectively. Calibration is the benchmark, given in table 5.

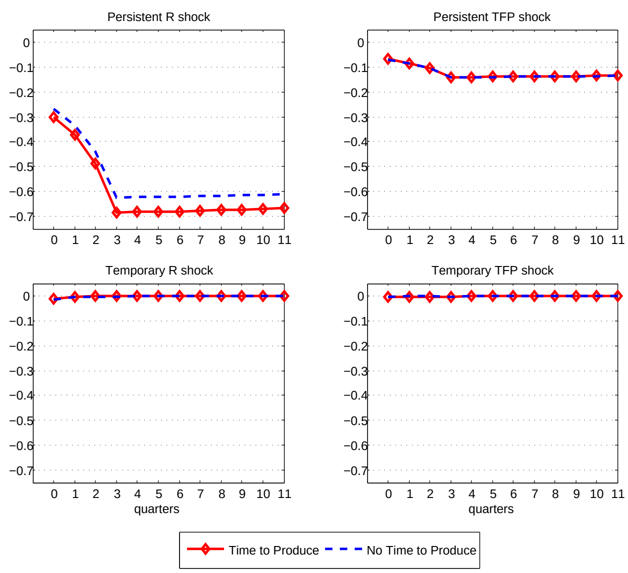


Figure 7: Effect of shocks to the interest rate and T.F.P. on Investment.
Time path of variables quarter by quarter. The shocks to T.F.P. and the interest rate are equal to -.1% and 4.98% (annually), respectively. Calibration is the benchmark, given in table 5.

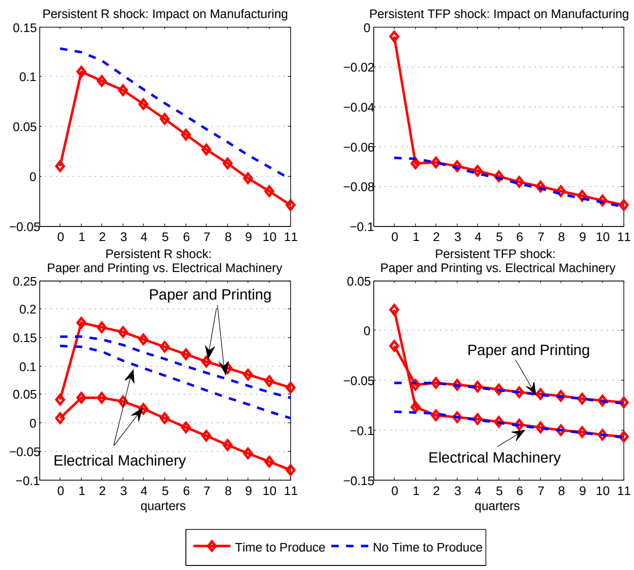


Figure 8: Effect of shocks to the interest rate and T.F.P. on Manufacturing production. Time path of variables quarter by quarter. The shocks to the T.F.P. and the interest rate are equal to -.1% and 4.98% (annually), respectively. Calibration is the benchmark, given in table 5. The upper panel is an arithmetic average of the log-deviation from steady state among manufacturing sectors.

by a productivity shock from one generated at least in part by an interest rate shock. A downturn generated by an interest rate shock will feature differences in sectoral outcomes that are associated with their time to produce, but the same is not true for downturns generated solely by productivity shocks.

### 4.3.3 Model Dynamics and the Price Elasticity of Exports

To finalize the discussion of the model dynamics, consider how the model changes its response to the interest rate and productivity shocks for different levels of the price elasticity of exports ($\theta$). Reducing $\theta$ makes the economy more closed, since fluctuations in the trade-balance are checked by changes in the terms of trade.

The first result is that for $\theta \to \infty$ the model exhibits a two period oscillation. When the productivity shock hits, the economy is endowed with inventories from early inputs. The optimal course of action is to take advantage of these inventories to complete current production at the expense of the formation of new inventories. In the second period the situation has reversed itself, with a small amount of inventories pushing resources toward starting new lines rather than completing the old ones. The response to the interest rate shock also exhibits oscillatory dynamics, except that the first cycle is upwards, as manufacturing firms take advantage of reduced wages to increase their output in the second period. Once a little curvature is allowed in the foreign demand for exports, the oscillating path for output ceases to be an equilibrium.

It is also interesting to look at what changes with $\theta = 2$. The interest rate shock has a larger impact on output, as manufacturing sectors find that their attempt to increase exports is met by lower sales prices. In contrast, the impact of the T.F.P. shock on output is mitigated in a more closed economy where there are fewer opportunities for inter-temporal substitution.

## 4.4 Simulating Emerging Market Crises

### 4.4.1 Calibration of Shocks

I simulate the crisis as the response to three types of shocks: An interest rate shock only, a productivity shock only and a simultaneous combination between an interest rate shock and a productivity shock. For the case with an interest rate shock only I also look at how changes in parameters affect the results.

The calibration of the shocks relies only on aggregate data, leaving the cross section to be determined by the endogenous dynamics of the model.[32] To calibrate the shocks, I choose their magnitude and persistence to minimize the mean square distance between the log of G.D.P. and of the Investment-to-G.D.P. series generated by the model and their counterparts in the data. The data counterparts of the aggregate variables are the deviations from the trend estimated using the 10 years before the crisis. I avoid using information from after the crisis for detrending since this would tend to understate the persistent losses in output and investment experienced by the affected economies.[33]

I favor matching aggregate series over using direct data on interest rates or total factor productivity because the aggregate series are less prone to measurement error. In particular, market interest rates may overstate the risk adjusted cost of financing because they incorporate risk premia, or they may understate it if market segmentation or financial repression means that we only see the interest rates paid by a fortunate few. Likewise, good total factor productivity is difficult to construct for many of the countries in the sample, as it relies on good labor supply data, including hours worked.

The target series are depicted in figure 10 together with simulations from the benchmark model

[32]In order to match the model with the data, I need to convert the quarterly model generated data to yearly. See appendix 5 for a detailed discussion of the time aggregation procedure.

[33]These persistent losses have been widely documented elsewhere. See for example Cerra and Saxena (2008) and Reinhart and Rogoff (2009).

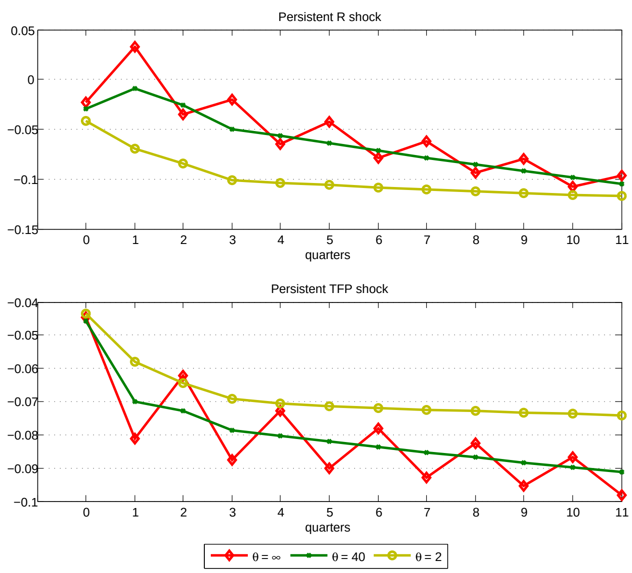


Figure 9: Effect of shocks to the interest rate and T.F.P. on G.D.P..
Time path of variables quarter by quarter. The shocks to T.F.P. and the interest rate are equal to -.1% and 4.98% (annually), respectively. Calibration is the benchmark, given in table 5.

| | | $\eta_r$ | $\eta_a$ | R(0) | a(0) | MSE |
|---|---|---|---|---|---|---|
| Benchmark | $\omega_i \geq 0$ | 1.00 | - | 1.9% | - | 0.07% |
| | $\omega_i = 0$ | 1.00 | - | 2.0% | - | 0.09% |
| $\theta = \infty$ | $\omega_i \geq 0$ | 1.00 | - | 1.9% | - | 0.08% |
| | $\omega_i = 0$ | 0.99 | - | 2.0% | - | 0.10% |
| $\theta = 2$ | $\omega_i \geq 0$ | 1.00 | - | 2.8% | - | 0.04% |
| | $\omega_i = 0$ | 1.00 | - | 3.0% | - | 0.05% |
| $\zeta = 1.001$ | $\omega_i \geq 0$ | 0.99 | - | 4.4% | - | 0.07% |
| | $\omega_i = 0$ | 0.99 | - | 4.5% | - | 0.10% |
| $\zeta = 15$ | $\omega_i \geq 0$ | 1.00 | - | 1.2% | - | 0.15% |
| | $\omega_i = 0$ | 1.00 | - | 1.3% | - | 0.15% |
| $\xi = 1$ | $\omega_i \geq 0$ | 1.00 | - | 1.8% | - | 0.07% |
| | $\omega_i = 0$ | 1.00 | - | 1.9% | - | 0.07% |
| $\xi = \infty$ | $\omega_i \geq 0$ | 1.00 | - | 1.8% | - | 0.07% |
| | $\omega_i = 0$ | 1.00 | - | 1.9% | - | 0.07% |
| T.F.P. Shock | $\omega_i \geq 0$ | - | 1.00 | - | -1.66% | 0.59% |
| | $\omega_i = 0$ | - | 1.00 | - | -1.66% | 0.59% |
| Both shocks | $\omega_i \geq 0$ | 1.00 | 0.95 | 1.55% | -1.10% | 0.03% |
| | $\omega_i = 0$ | 1.00 | 0.96 | 1.53% | -1.13% | 0.03% |

Table 6: Alternative calibrations

Alternative calibrations with the parameters of the shock process that minimize the distance to the path of output and investment/output ratios. $\theta$ is the price elasticity of export demand, $\zeta$ is the short run 'q' elasticity of investment, $\xi$ is the elasticity of maintenance costs to capital utilization and $\eta_r$ and $\eta_a$ are the persistence of the itnerest rate and the productivity shock.

with the interest rate shock only. The model does a good job in matching the investment/output ratio, but it understates the drop in output in the first years. This is a general difficulty in frictionless models of financial crises (Otsu 2007). In section 4.4.3, I discuss the extent to which allowing for time to produce helps along that dimension.

Table 6 shows the size and persistence of the shocks for different parameter constellations and the mean squared distance between the model and the target. For all parameter constellations, the calibrated shock to the interest rate is extremely persistent. This is needed to account for the extremely persistent drop in investment to output ratio depicted in figure 10. Insofar as the magnitude of the shock is concerned, the interest rate shock is largest if $\zeta$ (the q-elasticity of investment) is low. The reason is if investment is less sensitive to q, it takes a larger shock to achieve a same change in investment to output ratio.

The last column in the table shows the mean square distance between the simulated path for output and investment/output ratio and the data average. It is overall very small, on the order of 0.07%, but becomes twice as large with $\zeta = 15$. In other words, in spite of the micro evidence pointing to large $\zeta$'s, the model does a much better job in matching the macro facts with $\zeta = 3$.

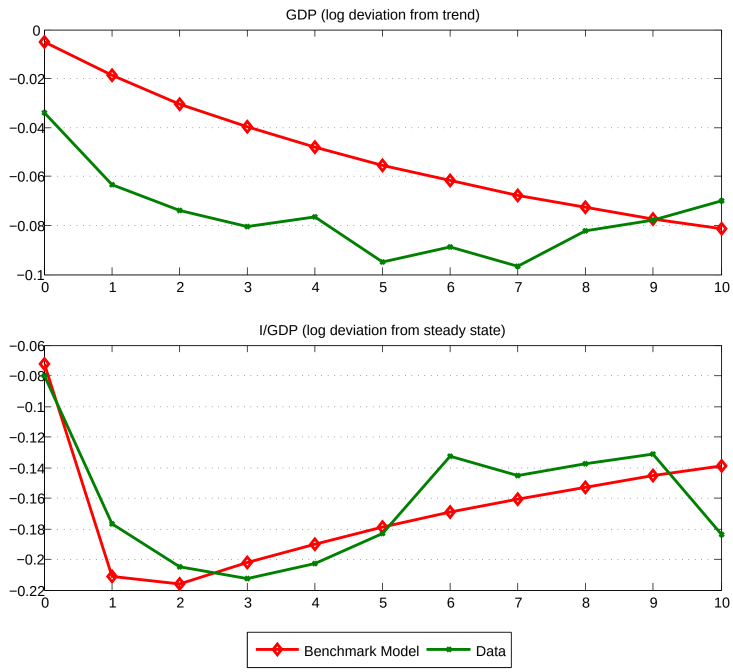


Figure 10: Aggregate Investment and G.D.P.

Time path of variables year by year. The G.D.P. is the average across crises of the log deviation from trend of G.D.P. with the trend being based on a linear estimate using data from 10 years before the onset of the crisis of G.D.P.. The Investment-to-G.D.P. data are the average of the log deviation between Investment-to-G.D.P. and the long run average estimated using data from 10 years before the onset of the crisis.

### 4.4.2 Cross Section: The Coefficient on Inventories-to-Cost Ratio

To compare the model to the data, I repeat the regressions in section 3 using the series generated by the model and including in the right hand side all the sources of cross-sectoral heterogeneity incorporated in the model. This includes all the demand and cost shares as well as the steady state inventories-to-cost ratios. It excludes average firm size, external dependence, world trend and previous trend, none of which have a clear counterpart in the model.

Figure 11 shows the coefficients on inventories-to-cost estimated from the model for different time horizons together with the confidence intervals for the corresponding coefficients in the data. The model with time to produce does a generally better job in keeping the coefficients within the 95% interval. In fact, the coefficients that emerge from models with no time to produce fall mostly outside the 95% confidence interval except when the interval includes 0. With time to produce, the coefficient on inventories-to-cost is increasing in the price elasticity of exports $\theta$. While $\theta \to \infty$ overshoots the confidence interval, with $\theta = 2$ it undershoots the interval. At $\theta = 40$ the simulations fall within the interval.

The bottom right panel shows that the coefficient increases with the adjustment costs to capital increase. This is because the low $\zeta$ model requires a larger shock in the foreign interest rate.

Table 7 shows the results for the parameterizations in figure 11 and other alternatives for the years in which the estimated coefficient on time to produce is significantly different from zero (three, four and five years after the crisis). Apart from repeating the information in the graph, the table shows that the coefficient decreases in $\xi$, the elasticity of maintenance costs to capacity utilization, but the decrease is relatively small, even when the capacity utilization margin is shut down ($\xi = \infty$).

The last couple of rows of table 7 show what changes once a T.F.P. shock is allowed for. The benchmark model with T.F.P. does not generate any cross-sectoral differences worthy of notice and the model with both shocks generates differences which are very close to benchmark. These two results hold consistently for all the parameterizations, but I omit them for the sake of conciseness.

### 4.4.3 How Much Does Time to Produce Amplify Initial Impact of the R shock?

Even if the interest rate shock accounts for large cross-sectional differences, it does not follow that it explains an overall drop in G.D.P.. In fact when the economy is hit by an interest rate shock, lower wages or input prices can push manufacturing production up, leading to a boom. Table 8 shows how much of the deviation of output from trend the calibrated interest rate shock can account for. Over the years, the interest rate shock becomes increasingly important as the capital stock depreciates. As would be expected, this medium term result does not depend on whether or not the model features $\omega_i$'s greater than zero.

In the year of the crisis, the interest rate shock is most successful in the model with low elasticity of export demand ($\theta = 2$). This is true irrespective of whether there is time to produce or not. In this case the transmission from the financial shock to output takes place from the demand side. This channel is not operative in prototypical small open economy models such as Mendoza (1991) or

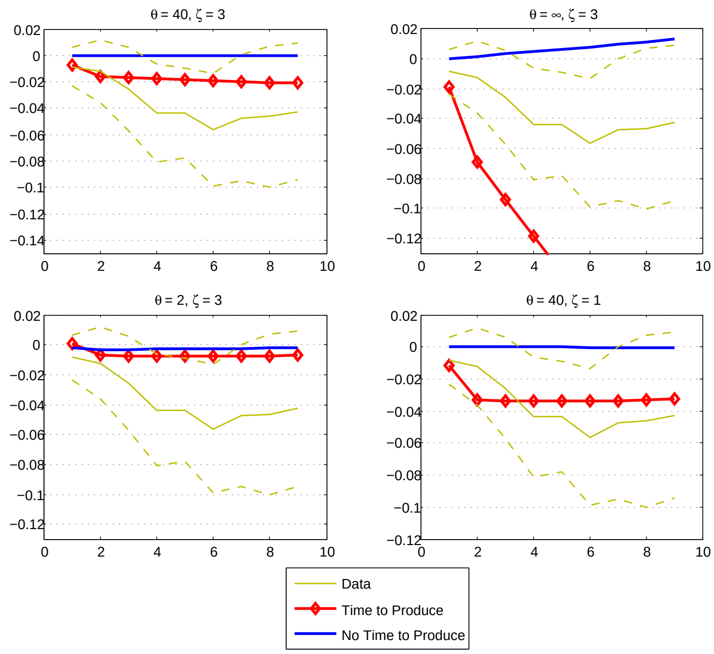


Figure 11: Projection coefficient of industry output on inventories-to-cost ratio
Time path of variables year by year. See text for details about construction. Dashed lines correspond to 95% confidence intervals around the point estimates.

| | | 3 years | 4 years | 5 years |
|---|---|---|---|---|
| Benchmark | $\omega_i \geq 0$ | **-0.018** | **-0.019** | **-0.019** |
| | $\omega_i = 0$ | 0.000 | 0.000 | 0.000 |
| $\theta = \infty$ | $\omega_i \geq 0$ | -0.118 | -0.142 | -0.165 |
| | $\omega_i = 0$ | 0.005 | 0.007 | 0.008 |
| $\theta = 2$ | $\omega_i \geq 0$ | **-0.007** | -0.007 | -0.007 |
| | $\omega_i = 0$ | -0.003 | -0.003 | -0.003 |
| $\zeta = 1.001$ | $\omega_i \geq 0$ | **-0.034** | **-0.034** | **-0.034** |
| | $\omega_i = 0$ | 0.000 | 0.000 | 0.000 |
| $\zeta = 15$ | $\omega_i \geq 0$ | **-0.013** | **-0.014** | **-0.014** |
| | $\omega_i = 0$ | 0.000 | 0.001 | 0.001 |
| $\xi = 1$ | $\omega_i \geq 0$ | **-0.015** | **-0.016** | **-0.017** |
| | $\omega_i = 0$ | 0.000 | 0.000 | 0.000 |
| $\xi = \infty$ | $\omega_i \geq 0$ | **-0.009** | **-0.011** | **-0.012** |
| | $\omega_i = 0$ | 0.000 | 0.000 | 0.000 |
| T.F.P. shock | $\omega_i \geq 0$ | 0.000 | 0.000 | 0.000 |
| | $\omega_i = 0$ | -0.001 | -0.001 | -0.001 |
| Both shocks | $\omega_i \geq 0$ | **-0.016** | **-0.017** | **-0.0171** |
| | $\omega_i = 0$ | 0.002 | 0.002 | 0.0025 |

Table 7: Projection coefficient of industry output on inventories-to-cost ratio
Numbers in bold are inside the 95% confidence interval estimated for each horizon in section 3. Coefficients come from the projection of the deviation of output from trend in each of the manufacturing industries in the model on the corresponding inventories-to-cost ratio after controlling for the share of output, which is destined to investment, exports or durable consumption as well as the share of capital, labor and imported inputs in production.

| | | 0 years | 4 years | 8 years |
|---|---|---|---|---|
| Benchmark | $\omega_i \geq 0$ | 14.4% | 62.7% | 88.6% |
| | $\omega_i = 0$ | -0.8% | 56.9% | 82.6% |
| $\theta = \infty$ | $\omega_i \geq 0$ | 4.8% | 58.8% | 85.1% |
| | $\omega_i = 0$ | -7.6% | 51.8% | 77.6% |
| $\theta = 2$ | $\omega_i \geq 0$ | 54.9% | 87.7% | 88.5% |
| | $\omega_i = 0$ | 63.4% | 83.4% | 82.8% |
| $\zeta = 1.001$ | $\omega_i \geq 0$ | 24.0% | 68.0% | 89.8% |
| | $\omega_i = 0$ | -1.7% | 53.3% | 77.2% |
| $\zeta = 15$ | $\omega_i \geq 0$ | 9.8% | 70.4% | 91.8% |
| | $\omega_i = 0$ | -2.7% | 68.0% | 88.9% |
| $\xi = 1$ | $\omega_i \geq 0$ | 12.4% | 67.4% | 98.1% |
| | $\omega_i = 0$ | 0.7% | 63.7% | 94.1% |
| $\xi = \infty$ | $\omega_i \geq 0$ | 7.4% | 75.0% | 115.9% |
| | $\omega_i = 0$ | 1.5% | 74.7% | 115.2% |

Table 8: Fraction of drop in output explained by the R shock

The fraction is calculated as the ratio of the log deviation from the steady state of G.D.P. (annually aggregated) to G.D.P. when there is only the R shock and the log deviation with both the R and the T.F.P. shocks.

Correia et al. (1991), since in these cases foreign demand for domestic production is completely elastic, corresponding to the $\theta \to \infty$.

The interesting differences between the models with and without time to produce show up when $\theta$ is large enough that domestic demand does not represent a substantial constraint on aggregate output. In these cases, the model without time to produce assigns at best 1.3% of the drop in output to the interest rate shock when there is no capacity utilization margin ($\xi \to \infty$) and in all other cases the share turns negative, meaning that the model implies a boom in the year of the crisis. Allowing for time to produce eliminates the negative sign in all cases.

The interest rate shock is particularly important if we are willing to accept a low elasticity of investment to the marginal value of capital ($\zeta = 1$). In this case, the interest rate shock explains 25% of the drop in output in the year of the crisis. This follows simply because the model requires a high interest rate shock to generate the same drop in investment.

Finally, allowing for a capacity utilization margin is important for the interest rate shock to have a sizeable impact on output. When the elasticity of maintenance costs to utilization $\xi$ is taken to infinity the interest rate shock is able to explain only 7% of the drop in output, whereas it explains three times as much if it is set to its benchmark level, $\xi = 0.5$. This follows because output is more responsive to cost shocks if there is a capacity utilization margin. The flip side of this greater flexibility is that allowing for a capacity utilization margin implies a larger boom in response to the interest rate shock.

To summarize, it is in environments where output is responsive to shocks either because of flexible capacity utilization margin or of elastic demand that time to produce plays the most important role in generating recessions in response to interest rate shocks. This is not surprising, as time to produce is essentially a channel through which interest rates affect the marginal cost of production.

# 5 Conclusion

Financial shocks can have a short run impact on output because of their effect on production costs. This helps explain how interruptions in capital inflows to a given economy can generate a drop in output even if openness to foreign trade means that production in this economy is not constrained by domestic demand.

The aggregate impact will be more important if the model features "high substitution" in the sense emphasized by King and Rebelo (1999). These are environments where prices do not react strongly to shocks, so that small cost shocks can have a large impact on quantities.

The demand that the model be able to account for the cross-sectional facts all but rules out the possibility that the crisis is caused by a pure productivity shock. More generally, the paper illustrates how cross-sectional data can be used to discipline macroeconomic models: if different sectors react differently to a macroeconomic event, the differences ought to provide useful information about the type of shock that is affecting the economy and the mechanism through which that shock affects the economy.

Conversely, the paper also highlights the peril of relying on cross-sectional evidence without recourse to a general equilibrium model. In this particular example, while the cross-sectional evidence points to a large role for an interest rate shock, the aggregate model requires particular parametric assumptions for the shock to have a large aggregate impact.

The insight that changes in the cost of capital can have a quick and sizeable impact on output is more general and applies to other setups. For example the insight might be important for the quantitative predictions of models with financial frictions. Kocherlakota (2000) argues that, since capital is a small share of output and depreciates slowly, financial frictions may not be quantitatively important. Cordoba and Ripoll (2004) verify that this is indeed the case in a calibrated business cycle model where capital depreciates slowly. Allowing for time to produce increases the capital share and reduces average capital depreciation. It would be interesting to see how allowing for time to produce would change the results of this kind of model.

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# Appendix A: Value Added Accounting with Time to Produce

Suppose the production function is

$$\begin{aligned} Y_t &= \left( [Z_t(0)]^{1-\omega} [Z_{t-1}(1)]^{\omega} \right) \\ Z_t(v) &= (M_t(v))^{1-\alpha_L} (L_t(v))^{\alpha_L} \end{aligned}$$

The numbers in parentheses denote the distance in time between the acquisition of the input and the sale of the output. $Z_t(v)$ is a composite of materials, $M_t(v)$ and labor $L_t(v)$.

Let $q_t$ be the price of raw materials and $w_t$ the wage rate. Then

$$VA_t = Y_t - q_t (M_t(0) + M_t(1)) + Z_t(1) - Z_{t-1}(1)$$

# Appendix B: Details of data construction

## Inventories-to-Cost ratios in COMPUSTAT

In the benchmark regressions, the inventories-to-cost ratio is calculated using firm level balance sheet data from COMPUSTAT. The numerator is total inventories and the denominator is the cost of goods sold. An accounting identity ensures that the two encompass exactly the same goods, making it a precise measure. To calculate the inventories-to-cost ratio for a given industry, I take the median of the ratio across firms and years. Because COMPUSTAT includes observations spanning over twenty years of data, business cycle fluctuations are smoothed out. I also correct for seasonality. By far most of the observations are from statements in December, so that such a correction is helpful. To deal with seasonality, I first take medians over data disclosed in December and June separately. The final number is an arithmetic average of the two.

## Controls for demand

To measure the demand for durable consumer goods consumption, I assume that all the consumption from certain sectors is durable.[34]

I allow for indirect demand effects through the supply chain. As a consequence, the control variable takes into account that the demand for basic metals is heavily affected by the demand for investment goods. Let $a_i^j$ be the $i, j^{th}$ entry in the matrix of technical coefficients $A$. If sector $j$ produces $Y^j$ then it uses $Y_i^j = a_i^j Y^j$ inputs from sector $i$. Let $V_i$ denote the demand for final use of the products of sector $i$. Then it must be the case that

[34]I define as durable consumption all the consumption of Wood Products, Furniture, Non-Metallic Mineral, Machinery and Equipment and half of Manufacturing n.e.c. I likewise use the Leontief inverse to account for indirect effects.

$$Y^i = \sum_j a_i^j Y^j + V_i$$

In terms of percentage changes,

$$\frac{dY^i}{Y_i} = \sum_j a_i^j \frac{Y_j}{Y_i} d\frac{Y^j}{Y^j} + \frac{V_i}{Y^i}\frac{dV_i}{V_i}$$

Let $B$ be a matrix with entries $b_j^i = a_i^j Y_j / Y_i$, $D$ a vector with entries $Z_i/Y^i$. Also (with abuse of notation), let $dY/Y$ be a vector with entries $dY^i/Y_i$. Likewise, let $dV_i/V_i = dV/V$. Then

$$\frac{dY}{Y} = B\frac{dY}{Y} + \frac{dV}{V}$$

so that,

$$\frac{dY}{Y} = (I - B)^{-1} D \frac{dV}{V}$$

where I is a conformable identity matrix and (I-B) is invertible.

Thus, the elasticity of output in each sector to a given change in final demand is given by the corresponding entry in the $(I - B)^{-1}D$ vector.

It is natural to extend the framework to look at the effect of changes in different components of demand. All that is needed is to substitute $D$ for a matrix with entries $I_i^H/Y^i$, $I_i/Y^i$ and $EXP_i/Y^i$.

In the calibration, I use country specific input-output matrices whenever possible; otherwise I use an average for the region.[35]

[35] Thus, for example, the input-output structure for Malaysia is the average between South Korea and Indonesia.

# Appendix C: Details of calibration

To calibrate the shares I use information from the same input-output matrices used to construct indicators of the demand shares. I assign to each of the manufacturing sectors in the input-output table an ISIC Rev. 2 code in order to match the data in the empirical section. The correspondence is not perfect. Some sectors that are differentiated in the empirical section, such as textiles and apparel, only appear as a single sector in the input-output matrix. On the other hand, the input-output matrix includes more machinery producing sectors than in the UNIDO data set. In this latter case, I consolidate the sectors in order to build equivalents to the ones in section 3.

The sectors that I treat as non-tradable do, in fact, trade. I treat all their sales abroad as domestic sales and all the purchases from their counterpart abroad as domestic purchases. I am still left with a (small) imbalance. Also, at the aggregate level there is a trade imbalance that does not come up in the steady state of the model. I remove these imbalances by re-scaling the size of the non-tradable sector and of domestic absorption.

I re-scale the labor shares up by a factor of 2, conforming to the findings in Young (1995) and Gollin (2002) that labor shares in developing countries are frequently underestimated because of the large number of self-employed workers. This brings the aggregate labor share close to 0.6, which is the norm for developed countries. Also, I do not allow explicitly for indirect taxes in the model, so that I split them between labor and capital income.[36] Given the input-output table, it is straightforward matter to calculate the factor shares for the different sectors as well as the weight of each sector in each of the different composite goods. The only extra care needed is to take into account that the values in the input-output matrices do not account for the opportunity cost of capital.[37]

In order to calibrate the shocks I use yearly data on output and investment for the episodes in my sample. First, for each G.D.P. series I estimate a linear trend using 10 years before the crisis and collect the deviation from this trend in the years after the crisis (I use log values for G.D.P. and gross fixed capital formation). I then average across all the episodes. I perform a similar exercise with the Investment-to-G.D.P. ratio, however, taking the average ratio in the 10 years before the crisis instead of its trend as the benchmark. The implicit assumption is that in steady state the investment-to-G.D.P. ratio should be constant.

In order to perform the comparison to the calibrated data, I have to time aggregate it. I also have to take into account that there are different possible quarters in which the crisis may have started. Thus, the model counterpart of output in year $t^*$ is an average across crises whose starting dates correspond to these different cases. The average is weighted by the frequency of crises starting in different quarters.

Let $\widehat{GDP}_t$ and $\widehat{I/GDP}_t$ correspond, respectively, to the average log deviations from trend of G.D.P.

[36] For an interesting account of how heterogeneity in indirect taxes provides a foundation for fluctuations in T.F.P., see Benjamin and Meza (2009).

[37] Hence, for a manufacturing sector $i$, $\alpha_M^i = \frac{M_i}{Y_i} \times \left(\frac{\omega_i}{R} + 1 - \omega\right)^{-1}$. An analogous calculation applies to labor share and to the construction sector.

and investment-to-G.D.P. $t$ years after the crisis and $GDP_t$ and $I/GDP_t$ the model equivalents. The persistence and magnitude of the shocks solve:

$$\min_{\eta_a,\eta_r,\varepsilon^a(s^0)\varepsilon^r(s^0)} \sum_{t=0}^{10} \left(\widehat{GDP}_t - GDP_t\right)^2 + \left(\widehat{I/GDP}_t - I/GDP_t\right)^2$$