Time to Produce and Emerging Market Crises *

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Abstract

This paper argues that interest rates affect output through their impact on the cost of variable inputs such as materials and labor. This effect occurs because of time lags in the production process. To test the theory, I exploit the following cross-sectional implication: industries that usually hold more inventories relative to their variable costs should react more strongly to changes in the cost of capital. The empirical analysis relies on information from emerging market crises. I find that in the course of these episodes there is a large and robust reallocation towards sectors with low inventory-to-cost ratios. I set up a multi-sector general equilibrium model with production lags which match the inventory-to-cost ratios in the data. Exogenous shocks calibrated to reproduce movements in aggregate variables during the crises generate a sectoral reallocation compatible with the empirical predictions. Furthermore, the model generates a sizeable and quick reaction of aggregate output in reaction to an isolated interest rate shock, which is consistent with findings in the previous literature. All these results rely only on the assumption about the production technology, without any reference to financial or payment frictions.

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1 Introduction

This paper argues that interest rates affect output through their impact on the cost of variable inputs such as materials and labor. The cost of variable inputs increases in the interest rate because of time lags in the production process. When a firm sets out to produce a good, it first has to purchase raw materials and allocate workers, and only after a period of time it is able to sell the finished good. In the interim, the firm foregoes interest income or incurs interest costs. If the interest rate goes up, the production process becomes more costly so that the firm optimally chooses to reduce its sales.

To test the theory, I exploit the following cross-sectional implication: industries that usually hold more inventories of all stages of processing relative to their variable costs should react more strongly to changes in the cost of capital. The reason is that inventories account for the value of all variable inputs accumulated between the time of their acquisition and the sale of the corresponding output. As a consequence, the ratio between total inventories and variable costs captures the importance of the foregone interest rate income associated with the purchase of variable inputs.

The paper focuses on the experience of emerging market economies. In these countries, movements in interest rates and capital flows are frequent, large and closely followed by changes in aggregate output. This relationship is visible in raw correlations, in the aftermath of crisis events, and in at least one VAR study of emerging market economies. As a consequence, mechanisms that link interest rate changes to output are likely to be particularly relevant.

The empirical analysis relies on information from sudden stop episodes identified by Calvo et al. (2006). I find that in the course of these episodes there is a large and robust reallocation towards sectors with low inventory-to-cost ratios. Figure shows the reallocation pattern in the data. Each point refers to a manufacturing industry. The vertical axis depicts the loss in value added in the three years leading to the lowest point in GDP, averaged over 21 sudden stop episodes. The horizontal axis represents a proxy for the inventory-to-cost ratio calculated for each industry. The addition of controls reduces the slope of the regression coefficient, but the correlation is remarkably robust.

The reduced form estimates establish that the reallocation goes in the direction predicted by the theory. To assess whether time lags in production can plausibly account for the magnitude of the effects, I set up a multi-sector general equilibrium model with production lags. I calibrate the

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1 The bulk of inventories are raw materials and work-in-process, the value of which are naturally tied to production plans. Also, finished goods inventories have been found to follow sales quite closely at yearly frequencies, so that it is adequate to interpret these as factors of production (Ramey 1989).

2 As opposed to inventory to sale ratio, since sales also include markups and income of fixed factors which have little role in the short term decisions.


4 I use data from manufacturing industries in the US, following the tradition initiated by Rajan and Zingales (1998). Total inventories are the sum of the stocks of raw materials, work in process and finished good inventories, and the variable costs include materials and direct labor costs. Inventories are measured in dollars and costs are measured in dollars per month. Hence the ratio is measured in months. A ratio of 2 implies that firms hold an amount of inventories equivalent to two months worth of costs.
production lags so that they are compatible with the inventory-to-cost ratios in the data. I then simulate a crisis in the model as a combination of shocks to the interest rate, productivity and export demand, chosen to match the behavior of aggregate variables. The model is able to generate a sectoral reallocation in response to a crisis-like event very much in line with the estimates from the data.

Lastly, I can also use the model to assess the importance of the production time channel for the impact of interest rate shocks on aggregate output. The model generates an effect compatible with previous estimates in the literature: In the benchmark calibration, a 10% increase in the annual interest rate implies an immediate drop in output of close to 2%, which is compatible with previous estimates by Uribe and Yue (2006).

This large effect may come across as puzzling given the short lags in the production process. Two features of the model account for this result. The first is a relatively high level of “substitution”, in the sense emphasized by King and Rebelo (1999). I allow firms to choose capacity utilization and, following the practice in the Small Open Economy RBC literature, do not allow for wealth effects in labor supply. These assumptions imply that the supply capital and labor do act as a constraint on the effect of the shocks.

The second reason for the large effect is the existence of cross-sectoral linkages in the purchase of materials. The time lags in the production process imply a structure similar to Long and Plosser (1982): If a given sector reduces production, this implies a lower availability of raw materials in later periods, thus propagating the effect across all the sectors. Conversely, a planned reduction in the production of a sector with long production time implies a reduced demand for the output of the other sectors, which will optimally choose to reduce their output. Intuitively, production time adds up across sectors once the production chain is taken into account.

The notion that interest rates affects the cost of variable inputs is hardly new. However, the usual mechanisms rely on some form or another of payment frictions. For example, Christiano et al. (1992) propose that firms need to hold cash in order to pay for their workers, so that if the interest rate goes up, these payments become more costly. This assumption is problematic when it comes to emerging market economies that underwent periods of very large inflation. The reason is that, with a cash-in-advance constraint, the financial cost is increasing not in the real, but in the nominal interest rates. During inflationary times the variability in inflation, and hence in the nominal interest rate, was larger by an order of magnitude when compared with the post-stabilization period. Given a cash-in-advance constraint, this would imply a commensurate difference in the volatility of production costs and of output.

Neumeyer and Perri (2005) propose that in emerging markets payments are made in real, non-interest rate bearing assets instead of cash. This assumption allows them to match the negative correlation between detrended output and the real interest rate on government bonds observed in

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5 These are the drop in GDP, exports and investment, averaged over the crises episodes under analysis.

6 Nevertheless, cash-in-advance constraints in the payment of inputs has a long tradition in the emerging market business cycle literature, for example Cavallo (1981). See Agenor and Montiel (2002), Ch. 6 and 7 for a discussion of this early literature.
Argentina, while encompassing both periods with high and low inflation. Their success has prompted many authors to use a similar device in more elaborate models of emerging market business cycles. While the assumption is successful in terms of its aggregate implications, Chari et al. (2005) criticize the assumption because it does not have a clear empirical counterpart. This paper resolves the issue by proposing that the purchase of variable inputs is itself a real, short-term investment, so that no recourse to payment frictions is needed.

This paper discusses how a change in the cost of capital affects output, but it leaves open the determination of this cost. This task is undertaken, for example, by Mendoza (2006). The author demonstrates how a business cycle model with occasionally binding credit constraint at the level of the economy is able to generate alternating periods of normal business cycle variations and sudden stops. In itself, however, these frictions do not imply a drop in output, and Mendoza recurs to a payment-in-advance constraint to get this effect. On the empirical side, a similar point can be made about the studies by Kroszner et al. (2006) and Dell’Ariccia et al. (2007). They find that, in banking crises, industries that rely more on external finance to fund long term investment lose relatively more of their output. Their empirical results illuminate the effect of banking crises on the cost of capital, but they leave open how this exposure translates into a drop in output.

The empirical findings in this paper are complemented by independent work by Tong and Wei (2009). Using data from emerging market firms, the authors show that a high inventory-to-sale 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 high inventory-to-sale 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.

The paper proceeds as follows: Section 2 uses a simple partial equilibrium example to lay out the link between theory and data. In particular, it shows that if production time is allowed for then firms which normally hold a higher inventory-to-cost ratio will respond more strongly to interest rate shocks. Section 3 contains the data analysis. It documents the cross-industry correlation between the inventory-to-cost ratio and the change in value added during emerging market 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.

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7See for example Christiano et al. (2004), Mendoza (2006), Uribe and Yue (2006), Otsu (2007) and Calvo et al. (2008). An exception is Gertler et al. (2007), in that interest rate shocks affect production quickly through the impact of changes in the real exchange rate on capacity utilization decisions.

8Like here, the marginal cost of capital in Mendoza (2006) is the same for all firms. Implicitly, the balance sheet constraints in his model are the ones faced by domestic financial intermediaries as opposed to domestic productive units, as suggested by Krishnamurthy (2003).

9Markups vary less than inventories across firms, so that inventories to cost and inventories to sale ratios are normally closely linked.
2 Time to produce in Partial Equilibrium

The exposition below discusses the key cross-sectional prediction of the time to produce model in a partial equilibrium setup, that is, that shocks to the interest rate have an impact on sales that is largest for firms that have a large steady state inventory-to-cost ratio. In the exposition below, I focus on sales as a measure of economic activity, since these are more conceptually straightforward than value added. I discuss how the results change economic activity is measured using value added instead.

I construct the argument in two steps. First, I introduce the production function that underlies the analysis and show that, after a short transition period, the impact of a persistent interest rate shock on sales is increasing in the share of inputs that a firm has to acquire early on.

Second, I show that this share can be mapped into the ratio between inventories and variable costs. This is the key insight that drives the paper. It is because of this correspondence that it is possible to quantify the concept of production time. This quantification underlies the empirical analysis in section 3 and the calibration in section 4.

2.1 A one time shock to the interest rate

The production function is an application of Kydland and Prescott’s (1982) time to build technology. I use the term “time to produce” instead of “time to build” to emphasize the rather short-horizon process of transforming variable inputs into manufactured goods, as opposed to the more time-consuming process of building ships or factories. This same production function underlies the analysis throughout the paper. I take a broad view of production that includes the storage of inputs and finished goods in order to economize on logistics and avoid stock-outs. This is akin to Ramey’s (1989) suggestion that inventories can be usefully modeled as factors of production.

In order to sell output at \( t \), a firm must acquire inputs in \( t - 1 \) and \( t - 2 \). The production function is Cobb-Douglas with decreasing returns to scale, as follows:

\[
Y_t = \left( [Z_{t-1}(1)]^{1-\omega} [Z_{t-2}(2)]^{\omega} \right)^{\phi}, \quad \phi < 1
\]

Where \( Z_t(v) \) is a composite of inputs acquired in \( t \) to generate a sale \( v \) periods ahead.

Consider the perfect foresight path of sales after a one time, unexpected shock to the interest rate. Suppose firms are in steady state and at \( t = 0 \) they find that the future path of interest rate will change. The new interest rate path is a perturbation around the old steady state that decays geometrically, at a rate \( \eta \). By assumption, the prices of output and inputs do not change. As a consequence, this is a partial equilibrium exercise.

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\(^{10}\)However, the production function approximates the treatment in more closely in that it emphasizes the role of flows of goods into production, rather than stocks

\(^{11}\)The decreasing returns to scale may stem from fixed inputs. This is a minor omission since the share of variable inputs in manufacturing production is typically above 80%. In the calibrated model I allow for constant returns to scale at the firm level.
I assume that $Z_t(v)$ is the same irrespective of the horizon to which it is assigned, so that the price of $Z_t(v)$ is equal to $q_t$ for all $v$. The problem of the firm at $t = 0$ is:

$$\max_{Z_t(v), Y_t} \sum_{t=0}^{\infty} \prod_{s=0}^{t} \frac{1}{R_s} [p_t Y_t - q_t Z_t (1) - q_t Z_t (2)]$$

s.t. : 

$$Y_t = \left( [Z_{t-1} (1)]^{1-\omega} [Z_{t-2} (2)]^{\omega} \right)$$

$$Z_{-1} (1) = z_{11}, \quad Z_{-1} (2) = z_{12}, \quad Z_{-2} (2) = z_{22}$$

Where $q_t$ and $p_t$ are, respectively, the price of the composite of inputs and of the final goods, both at $t$, and $R_t$ the interest rate between periods $t$ and $t + 1$. The last three constraints make explicit that input choices made before $t = 0$ cannot be changed.

I can rewrite the problem as a sequence of maximization problems:

**t=0:**

$$\max_{Y_0} p_0 Y_0$$

s.t. : 

$$Y_0 = \left( z_{11}^{1-\omega} z_{12}^{\omega} \right)$$

The firm is unable to make any choice in as far as the output in $t = 0$ are concerned, since input choices were made in $-1$ and $-2$.

**t=1:**

$$\max_{Z_0 (1), Y_0} p_1 Y_1 - R_1 q_0 Z_0 (1)$$

s.t. : 

$$Y_0 = \left( Z_0 (1)^{1-\omega} z_{12}^{\omega} \right)$$

The cost of inputs acquired at $t = -1$ is sunk, but not in $t = 0$. The profit maximizing output is:

$$Y_1 = \chi_1 z_{12}^{\omega} \left( \frac{R_0 q_0}{p_1} \right)^{-\frac{(1-\omega)\phi}{1-(1-\omega)\phi}}$$

Where $\chi_1$ is a constant term. Everything else constant,

$$\frac{dY_1}{Y_1} = -\frac{(1 - \omega) \phi}{1 - (1 - \omega) \phi} \frac{dR_0}{R_0}$$

The impact of the interest rate shock is decreasing in $\omega$. Firms that have to purchase inputs earlier on have relatively more sunk costs.
\( t \geq 2: \)

From \( t \geq 2 \) onward, the problem of the firm is:

\[
\max_{Z_t(v), Y_t^*} \ p_t Y_t - R_{t-1} q_{t-1} Z_{t-1} (1) - R_{t-1} R_{t-2} q_{t-2} Z_{t-2} (2) \\
\text{s.t.} \quad Y_t = \left( [Z_{t-1} (1)]^{1-\omega} [Z_{t-2} (2)]^{\omega} \right) ^{\phi}
\]

Now, the profit maximizing output is

\[
Y_t = \chi \left[ \frac{(R_{t-2} R_{t-1} q_{t-2})^\omega (R_{t-1} q_{t-1})^{1-\omega}}{p_t} \right]^{-\frac{\phi}{1-\phi}}
\]

Where again \( \chi \) is a constant term. This implies that

\[
\frac{dY_t}{Y_t} = -\frac{\phi}{1-\phi} \left( \omega \left( \frac{dR_{t-2}}{R_{t-2}} + \frac{dR_{t-1}}{R_{t-1}} \right) + (1-\omega) \frac{dR_{t-1}}{R_{t-1}} \right)
\]

Since \( \frac{dR_t}{R_t} = \eta \frac{dR_{t-1}}{R_{t-1}} \), I can write the relationship between current output and current interest rate as:

\[
\frac{dY_t}{Y_t} = -\frac{\phi}{1-\phi} \frac{\omega + \eta dR_t}{\eta^2 R_t}
\]

The impact is increasing in \( \omega \). Firms with higher \( \omega \) acquire a larger share of inputs early on. These firms will react more strongly to the interest rate, because its effect on the opportunity cost of early inputs is larger.

### 2.2 Inventory-to-Cost ratios and Time to Produce

I start out by defining some accounting concepts. These are ideal versions of the numbers in the data. I will point out some of the major ways in which the data differs from the ideal cases.

#### 2.2.1 Cost of Goods Sold

The cost of goods sold is the replacement cost of all variable inputs used to produce the goods sold in the measurement period. In the context of this model, this is:

\[
\text{COGS}_t = R_{t-2} R_{t-1} q_{t-2} Z_{t-2} (2) + R_{t-1} q_{t-1} Z_{t-1} (1)
\]

The spot prices are inflated by the opportunity cost of capital between the time they the firm acquires them and the time the final good is sold. This conforms to the convention that accounting
numbers be priced at replacement cost.

Note that cost of goods sold is a flow variable, so that it is measured as dollars per unit of time.

### 2.2.2 Inventories

Inventories include the value of all inputs that acquired by the firm whose corresponding output has not yet been sold:

\[
\text{Inv}_t = q_t Z_t (2) + q_t Z_t (1) + R_{t-1} q_{t-1} Z_{t-1} (2)
\]

The first two terms are the cost of inputs that the firm purchases at \( t \) in order to enable sales in \( t + 2 \) and \( t + 1 \), respectively. The third term are inputs that the firm purchased at \( t - 1 \) in order to enable production at \( t + 1 \). Again the prices are in terms of date \( t \) goods, which is consistent with valuation at current replacement costs.

The following identity links cost of goods sold and inventories:

\[
\text{Inv}_t = \text{Inv}_{t-1} - \text{COGS}_t + \text{acquisition of inputs}_t
\]

While in practice the valuation of costs and inventories deviates from the ideal represented above in many ways, firms do these consistently, so that the accounting identity above is respected.

Note that inventories are a stock variable, so that they are measured in dollars.

### 2.2.3 Inventory-to-Cost Ratio

The inventory-to-cost ratio is:

\[
\frac{\text{INV}_t}{\text{COGS}_t} = \frac{q_t Z_t (2) + q_t Z_t (1) + R_{t-1} q_{t-1} Z_{t-1} (2)}{R_{t-2} R_{t-1} q_{t-2} Z_{t-2} (2) + R_{t-1} q_{t-1} Z_{t-1} (1)}
\]

Under perfect foresight, the Cobb-Douglas assumption implies that:

\[
\frac{\text{INV}_t}{\text{COGS}_t} = \frac{\omega \phi Y_{t+2} + \phi Y_{t+1}}{\phi Y_t}
\]

This is a forward looking variable, since inventories reflect future production plans. It will fluctuate with the business cycle as firms change their production plans. Note that since inventories are a stock

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12Suppose the firm is not vertically integrated but that, instead, a separate firm first processes \( Z_{t-1} (2) \) and in the following period sells it to the firm who produces the final output. If the upstream firm operates under zero profits, under perfect foresight the price of the processed intermediate input at \( t \) would be exactly \( R_{t-1} q_{t-1} \).
variable, measured in dollars, and the cost of goods sold is a flow variable, measured in dollars per unit of time, the inventory-to-cost ratio is measured in units of time.

For the purposes of this paper, the interesting quantity is the steady state inventory-to-cost ratio, that is, the one obtained when \( Y_t = Y_{t-1} \) for all \( t \). This satisfies:

\[
\frac{\text{INV}}{\text{COGS}} = \frac{(1 + R) q Z(2) + q Z(1)}{R^2 q Z(2) + R q Z(1)}
\]

Again, applying the Cobb-Douglas assumption:

\[
\frac{\text{INV}}{\text{COGS}} = \frac{\omega \phi Y + \phi Y}{\phi Y} = 1 + \omega
\]

Recall that \( \omega \) plays an important role in characterizing the impact of the interest rate shock on sales. In particular, from \( t \geq 2 \) onwards, the impact was increasing in \( \omega \). This implies that the impact of an interest rate shock is, everything else constant, increasing in the inventory-to-cost ratio.

If the persistence parameter \( \eta \) is close to 1, then

\[
\frac{dY_t}{Y_t} \approx \frac{\text{INV}}{\text{COGS}} \frac{\phi}{1 - \phi} \frac{dR_t}{R_t}
\]

So that the impact of interest rate on output is, everything else constant, directly proportional to the inventory-to-cost ratio. This latter result generalizes to arbitrary convex production functions that allow for multiple periods. The discussion of is in Appendix B.

### 2.2.4 Caveats

A few caveats are worth mentioning. First, inventory and costs rarely if ever account for financing costs. This problem is not particularly important if the period of time considered is not very large. In the data, inventory turnover ratios for the manufacturing sector are around 2 months. This implies that the financing costs are fairly small.

Second many important costs may not be accounted for in the cost of goods sold and in inventories, notably maintenance cost of capital and administrative labor. However, it is normally the case that whatever costs are accounted for under “cost of goods sold”, they are also included in inventories, including direct labor costs. This implies that the ratio is approximately correct if the omitted costs have a time profile similar to the included ones.

Third, the actual measurements of productive activity are based on value added and not on sales. Because value added data includes the change in inventories, it has a forward looking component. This implies that the reaction of value added to interest rate shocks should be faster than the reaction of sales. However, as the economy evolves along the perfect foresight path, the two measures become tightly linked, as demonstrated in Appendix A.
3 Data Analysis

This section presents the empirical results. It shows that during emerging market crises there was a strong reallocation towards sectors with lower inventory-to-cost ratio. The data analysis in this section shows that the reallocation does not reflect other plausible explanations and is a robust feature of emerging market crises, having occurred in the 80’s and the 90’s, in Latin America and in other continents. Last, this section shows that the reallocation was persistent, so that it was not a mere reflection of short run inventory adjustment dynamics.

3.1 Events

The analysis centers on events that Calvo et al. (2006) identify as output collapses following Systemic Sudden Stops. The list of episodes is in table 1. These are restricted to emerging market economy, and consist of large output drops that occurred together with unusually large reversals in current account. In order to isolate “systemic” episodes, the authors focus on periods when the interest rates faced by these countries were relatively high. This filter helps assure that the episodes were somehow linked to the difficult foreign financial environment. The dates picked by the authors are broadly consistent with independent identifications of financial crises based on domestic credit (Mendoza and Terrones 2008) and banking crises (Caprio and Klingebiel 1996). This suggests that there is a causal or at least starkly amplifying effect from the increase in cost of capital to aggregate output. Table 1 lists the events. They concentrate in the early eighties, the late nineties and, to a lesser extent, the mid nineties. This clustering of events provides further indication of the exogenous timing of the shock.

3.2 Empirical Specification

I run the following OLS regression:

$$y_{i,k,t^*} - y_{i,k,t^*-h} = \beta \tau_k + \gamma X_{ik} + \delta (y_{i,k,-h} - y_{i,k,t^*-h-6}) + \varepsilon_{ik} + \alpha_i$$

Where $y_{i,k,t^*-h}$ is log value added in industry $k$, episode $i$, $h$ years from the trough of the crisis (Example: value added in the production of apparel in South Korea 1998 episode, as measured in 1995). On the right hand side the constant term varies with the episode, $\tau_k$ is inventory-to-cost ratio for industry $k$, $X_{ik}$ is a vector of controls, the values of which varies by episode and industry. The last term is a control for prior trend. The hypothesis is that $\beta < 0$, so that firms with longer production time do relatively worse.

Value added data is taken from the data-set compiled by UNIDO. These are originally produced by statistical offices of UN member countries and then brought together by UNIDO. The industries

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13See the above mentioned paper and Calvo et al. (2004) for further details of how exactly these events were selected.
are classified according to three digit ISIC Rev. 2, three digit classification. In the benchmark regressions, I set $h = 3$ because the start of the crisis is not always clear cut and in some instances multiple years may pass between the initial shock and the trough of GDP. As part of the robustness checks, I experiment with different values for $h$. Errors may be correlated both within episodes or within industries. To account for these, the standard errors are robust to overlapping clusters at both the industry and episode level, as proposed by Cameron et al. (2006). Thus the error term for shoes in the Korea, 1998 episode may be correlated both with machinery in Korea 1998 and shoes in Argentina, 2001. Because it allows for more widespread correlation between error terms, this technique typically produces standard errors which are more conservative than the more usual one way clustering procedures.

I remove all observations where the log change in value added was larger than 1 in absolute value. Also, when using the Annual Survey of Manufacturing data, I do not include the tobacco industry. The reason is that tobacco has a ratio between inventories and costs equal to 8 months. This is more than twice the value for the non-metallic mineral products, the industry with the second highest inventory-to-cost ratio.

### 3.3 Inventory-to-Cost Ratio

As emphasized in section 2.2.3, to a first order approximation the sensitivity of a firm to an interest rate shock is increasing in the steady-state inventory-to-cost ratio. This is the hypothesis I test. However, it is impossible to get reliable measures of inventory-to-cost ratios for most countries in the sample. For this reason, I use measures based on US firms. The idea is that their inventory-to-cost ratios should reflect the underlying production technology, so that it should be a reasonable proxy for inventory-to-cost ratios in other countries. Moreover, since the business cycle in the US is relatively milder, inventory-to-cost ratios measured at particular periods are more likely to be close to their steady state levels. To the extent that the proxy is imperfect the measurement error will tend to attenuate the results.

The benchmark measure of production time is based on the 2005 and 2006 Annual Survey of Manufactures of the US Census Bureau. It is the ratio between total inventories and production costs as measured by the value of materials plus the cost of production labor. Together, these account for the bulk of the cost of goods sold as it usually appears in firm’s balance sheets. The main advantage of this survey is that it is representative of the manufacturing sector as a whole. However, the main disadvantages is that, with data from two years, the observations hardly qualify as a steady state measure. Furthermore, because the data is not directly based on accounting documents, there is

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14I do not include non crisis data in the left hand side of 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 specially 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 three digit level ISIC Rev. 2 classification allows me to have data for the early 80’s

15I implement these in STATA using the cgmreg.ado file produced by the authors.
no guarantee that costs and inventories are valued consistently. In particular, it is possible that inventories include cost components beyond materials and production labor or otherwise take into account a different definition of production labor. Finally, privately owned firms may at times to manipulate inventory numbers for tax efficiency purposes and, for this reason, may choose not to answer the survey accurately.

An alternative measure is based on firm level balance sheet data from COMPUSTAT, which guarantees that the accounting measures are consistent. The inventory-to-cost ratio for a given industry is the median of the ratio across firms and years. I first take medians over data disclosed in December and June separately. The final number is an arithmetic average of the two. This procedure minimizes the role of seasonal bias. Because COMPUSTAT includes observations spanning over twenty years of data, business cycle fluctuations are smoothed out, giving extra credibility to the steady state assumption. The disadvantage of COMPUSTAT is that it only includes listed firms, so that its sample is hardly representative of all firms.

The two measures previously discussed focus on American firms and the working assumption is that the technological characteristics of US firms are sufficiently informative about the technological characteristics of firms in crisis countries. In order to have some indication on whether this is the case, I also use a measure of inventory turnover from the Korean Financial Survey Analysis. In contrast to the measure based on the Annual Survey of Manufacturing, this gives equal weight to firms of different sizes. The main advantage is that this avoids measurement error associated with idiosyncratic decisions of very large producers, a particular problem in South Korea given its high rate of industrial concentration. The turnover measure is defined as inventories/sales as opposed to inventories/costs, which means that the numbers should be slightly smaller since sales are typically larger than costs. Table 2 has the descriptive statistics for the three variables. The average production time is highest in the COMPUSTAT sample, at 2.5 months, with a slightly smaller number for the Korean data.

Figure 5 shows the joint distribution between the Korean data (in the horizontal axis) and the two US based measures (in the vertical axis). There is a reasonable amount of correlation between them, between 0.5 and 0.6, summarized in Table 3. The correlation between the Korean and American data implies that taking US numbers as representative of other countries may not be so off the mark.

### 3.4 Controls

In this section I describe the controls. I include controls that account for a large range of alternative forces that may lead to a sectoral reallocation. These are important to the extent that they are correlated both with the inventory turnover ratio and the change in value added in the crisis period. Table 2 has the descriptive statistics for the control variables. Table 3 has the correlations with the dependent variables. In what follows, I discuss each one of them in detail.

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16By far most of the observations are in December, so that such a correction is helpful.
3.4.1 Demand Side

Industries that specialize on investment or durable goods should be more impacted in a crisis since the demand for these products is more pro-cyclical. On the other hand, firms that are export oriented should experience a smaller drop in output.

I infer the share of output that is destined to the production of exports, investment goods and durable consumer goods using input-output matrices made available by OECD. To measure the demand for durable consumer goods consumption, I assume that all the consumption from certain sectors is durable. I use country specific input-output matrices whenever possible, otherwise I use an average for the region. I allow for indirect demand effects through the supply chain. Hence, even if all basic metals are sold as inputs, their demand is heavily affected by the demand for investment goods.

3.4.2 Cost

During a sudden stop, there are massive realignments in relative prices. One particular case of interest are imported inputs, which usually become more expensive. In the opposite direction, the reduced demand for labor in a crisis should reduce wages. To capture these effects I include the share of labor and imported inputs into production. For completeness, I also include a control for material share. This is interesting since firms with high share of materials will have less sunk costs and will be more willing to adjust its production to new circumstances.

3.4.3 Normal Cyclicality

The results may not capture the particular effect of the sudden stop, but just the usual effect of a downturn. To proxy for the typical cyclicality of an industry, first I regress the growth in output of each country/industry on GDP using overlapping three year windows as my observations but excluding the 3 year period included in the left hand side of the main regression. I then collect the coefficients and average them over industries.

3.4.4 External Dependence

Rajan and Zingales (1998) define External Financial Dependence as

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17see, for example, the behavior of investment described by Calvo et al. (2006).
18Thus basic metals are destined to the production of investment goods even though this only occurs indirectly. The Leontief inverse gives the indirect destinations of output.
19I define as durable consumption all the consumption of wood products, furniture, non-metallic mineral, machinery and equipment and likewise use the Leontief inverse to account for indirect effects.
20Thus, for example, the input-output structure for Malaysia is the average between South Korea and Indonesia.
21I also experimented with a measure of cyclicality based only on US data. The results are largely similar, and are available upon request.
External Dependence = \( \frac{\text{capital expenditure} - \text{cash flow}}{\text{capital expenditure}} \)

They calculate averages of this ratio for listed firms in the US. 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 do relatively worse. Dell’Ariccia et al. (2007) 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) and Dell’Ariccia et al. (2007).

### 3.4.5 Size

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

### 3.5 Results

Table 4 shows the regression results with the turnover ratio from the Annual Survey of Manufacturing as the dependent variable. Each column corresponds to a different measure of the turnover ratio. The results are consistent and, for the measures based on US firms, statistically significant. The coefficient on the turnover ratio of Korean firms is slightly higher. This is because for Korean firms the data corresponds to inventory-to-sale ratio and sales are larger than costs.

The results for the controls are interesting in themselves. Most of them have the expected sign, with exception of external dependence, which is positive, and the wage share, which is negative. The coefficient on wage share is surprising, since it is highly statistically and economically significant. A standard deviation change in the wage share implies a drop of 4.3% in output, which is an effect of the same order as the inventory turnover. The exact reason for this coefficient constitutes a puzzle. One possible explanation is that there are lags between the training and hiring of workers and production of goods which are not adequately captured by inventories. Also, the evidence also sits in nicely with the suggestion by Neumeyer and Perri (2005) that an interest rate shock increases primarily the cost of labor input.

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22See 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.

23See Melitz (2003).

24I also experiment with the employment/establishment ratio in the year before the crisis. The results are virtually identical.
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 80’s and the other half between the mid to late nineties (and Argentina in 2001). Geographically, about half of the crises were in Latin America and the rest distributed between Asia, Africa, Russia and the Middle East. I assess whether the coefficient on the inventory-to-cost ratio is robust to splitting the sample in different ways.

The results are in Table 5. The point estimate of the coefficient on inventory-to-cost ratios is remarkably robust. It remains non-significant when it comes to the measure based on Korean firms. For the US based measures, the coefficient is robust in 5 out of 8 cases. Given that samples are half the size, it is not surprising that the statistical significance is reduced.

The robustness of the coefficients is specially interesting, since in the early 80’s, the crises were followed by a much larger increase in inflation than in the 90’s. The results provide further evidence that cash-in-advance constraints were not playing an important role in production decisions.

3.5.2 Alternative time windows and persistence

A further robustness check involves changing the window over which I consider the drop in output. The results are summarized in Table 6. In the first rows I shorten the window by using a year closer to the trough as the benchmark. The coefficients are robustly negative, although they tend to be less significant and the coefficient smaller. As mentioned above, shorter time windows include cases where the crisis was already under way in the initial year. Furthermore, a growth rate over a year is likely to be more noisy than over three years, which by itself should imply larger standard errors.

The windows in the last two rows compare value added three years before the trough of the crisis with, respectively, one and five years after the trough. The coefficients provide information about the persistence in the reallocation once the recovery has taken place. The somewhat surprising result is that the reallocation is quite persistent. This is important 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 and an even smaller number as far as finished goods inventories are concerned, these dynamics should have been exhausted once the recovery is under way.

\[25\] I have also run regressions that only include East Asian countries. However, there are only four of those in the sample, Korea, Malaysia, Thailand and Indonesia. The standard errors become even larger and the results unstable.

\[26\] In particular Alessandria et al. (2008) study the implications of inventory adjustment dynamics for the response of imports and import prices in the aftermath of devaluations. They find large effects which, however, exhaust themselves in less than a year.
4 Quantitative Model

4.1 Model Setup

4.1.1 Household

Let $s_t$ denote the exogenous state at date $t$ and $s^t$ the history of exogenous states up to date $t$, so that $s^t = \{s^{t-1}, s_t\}$. There is a representative household who takes prices as given and is able to borrow and lend abroad at an exogenous riskless gross 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 period utility given by

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

Where $C(s^t)$ is non-durable consumption and $D(s^t)$ is the stock of durable goods held by the household, $L(s^t)$ is labor supply.

This utility function follows Greenwood et al. (1988). Its essential property is that the labor supply does not respond to wealth of the household, only to wages. 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.\footnote{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 is a clear increase in labor force participation in emerging market economies. See, for example, Young (1995) for the Asian Tigers.}

4.1.2 Production

There are three sectors. The first sector (sector 0) produces non-tradable services. The other two sectors (labeled 1 and 2) represent tradable manufactures. The production functions for each of these sectors is:

$$Y_0(s^t) = Z_0(s^t)$$
$$Y_1(s^t) = Z_1(s^{t-1}; 1)$$
$$Y_2(s^t) = (Z_2(s^{t-1}; 1))^{1 - \omega} (Z_2(s^{t-2}; 2))^{\omega}$$

Where $Y_i$ is the production of the input $i$. $Z_i(s^{t-v}; v)$ denotes a composite of goods acquired in period $t - v$ to produce the finished good ready for sale $v$ periods ahead:
\[ Z_k (s^t, v) = \gamma_k e^{\alpha(s^t)} (u_k (s^{t-1}; v) K_k (s^{t-1}; v) \alpha_k (L_k (s^t; v))^{\alpha_k} (M_k (s^t; v))^{1-\alpha_k-\alpha_k} \]

Where \( u_k (s^{t-1}; v) \) denotes the rate of utilization of fixed capital at \( t \). Capital utilization is chosen one period in advance.\(^{28}\)

Capital is sector specific and is produced by combining old capital and investment goods.\(^{29}\)

\[ K_k (s^t) = \left[ (1 - \delta^K) (K_k (s^{t-1}))^{\frac{\zeta^{t-1}}{\zeta}} + (\delta^K)^{\frac{1}{\zeta}} (I_k (s^t))^{\frac{\zeta^{t-1}}{\zeta}} \right]^{\frac{\zeta}{\zeta^{t-1}}} \]

Durable consumer goods are produced in a similar fashion:

\[ D (s^t) = \left[ (1 - \delta^D) (D (s^{t-1}))^{\frac{\zeta^{t-1}}{\zeta}} + (\delta^D)^{\frac{1}{\zeta}} (J (s^t))^{\frac{\zeta^{t-1}}{\zeta}} \right]^{\frac{\zeta}{\zeta^{t-1}}} \]

Non-durable consumption \( C(s^t) \), fixed investment \( I(s^t) \), durable consumption good investment \( J(s^t) \) and materials \( M^i(s^t) \) are composites of the goods produced in the three sectors and imports. These composites are represented by nested CES aggregates. At the highest level of aggregation, a composite of domestically produced goods is combined with imports:

\[ X(s^t) = \left[ (\gamma_{X}^*)^{\frac{1}{\lambda}} (X^* (s^t))^{\frac{\lambda^{t-1}}{\lambda}} + (1 - \gamma_{X}^*)^{\frac{1}{\lambda}} (X^H (s^t))^{\frac{\lambda^{t-1}}{\lambda}} \right]^{\frac{1}{\lambda^{t-1}}} \]

Where \( X \) stands in for \( C, I, J \) or \( M_i \). \( X^* (s^t) \) is the amount of imported goods used for the production of \( X \) and \( X^H (s^t) \) is the domestic composite. This, in turn, is given by:

\[ X^H (s^t) = \left[ \sum_{i \in \{0,1,2\}} (\gamma_{X}^i)^{\frac{1}{\lambda}} (X^i (s^t))^{\frac{\lambda^{t-1}}{\lambda}} \right]^{\frac{\lambda}{\lambda^{t-1}}} \]

With \( \sum \gamma_{X}^i = 1 \). The functional forms allow for different shares of domestic and imported inputs in the production of the different goods, hence the subscripts in the \( \gamma \)'s.

While the economy is small with respect to capital markets, it is large relative to product market. This is the case, for example, if countries produce different varieties that are not perfect substitutes.\(^{30}\)

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\(^{28}\)This is a technical assumption to avoid swings in capacity utilization calculated to take advantage of very short-term changes in relative prices. This assumption is specially important when there is no production time, since the time to produce assumption introduces a natural lag between production and prices.

\(^{29}\)Let \( K_k(s^t) = \tilde{K} (I(s^t), K(s^{t-1})) \). The parametrization below is such that \( G \) satisfies the following conditions:

\[ K = \tilde{K} (\delta K, K), \frac{\partial \tilde{K} (\delta K, K)}{\partial I} = 1, \frac{\partial \tilde{K} (\delta K, K)}{\partial K} = 1 - \delta \]

\(^{30}\)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.
This assumption implies that tradable sectors have to respond at least somewhat to changes in domestic demand.

4.1.3 Foreign Trade

The two tradable sectors face the following inverse demand function:

\[ p_k (s^t) = \chi_k e^{J(s^t)} EXP_k (s^t)^{-\theta} \]

Where \( p_k (s^t) \) is the price of good \( k \in \{1, 2\} \) with respect to the foreign good and \( EXP_k (s^t) \) are exports of sector \( k \) good. These exports are identical to the total output from sector \( k \) minus the sum of the domestic demands for this good:

\[ EXP_k (s^t) = Y_k (s^t) - C^k (s^t) - I^k (s^t) - \sum_{k' \in \{0,1,2\}} M_{k'}^k (s^t) \]

Total imports are the sum of foreign inputs in the production of all the final goods.

\[ IMP (s^t) = C^* (s^t) + I^* (s^t) + J^* (s^t) + \sum_k M_k^* (s^t) \]

The current account identity is:

\[ B (s^t) - R(s^{t-1}) B (s^{t-1}) = IMP (s^t) - \sum_{k \in \{1,2\}} p_k (s^t) EXP_k (s^t) \]

Where \( B (s^t) \) is the amount of net foreign debt held by domestic households.

4.1.4 Resource Constraints

While capital is sector specific, its utilization can be shuffled around for the production of goods to be finalized at different horizons. This implies the following resource constraint for capital stock for sector \( k \):

\[ \sum_v u_k (s^t; v) K_k (s^t; v) \leq u_k (s^t) K_k (s^t) \]

Raw Materials respect an analogous resource constraint:

\[ \sum_v M_k (s^t, v) \leq M_k (s^t) \]
In contrast, labor is perfectly mobile between sectors. This implies the following labor market clearing condition

\[
\sum_{k=\{0,1,2\}} \sum_v L_k(s^t, v) \leq L(s^t)
\]

The firm is subject to maintenance costs. Maintenance requires purchase of investment goods at a rate which is proportional to capital stock and increasing in its utilization. It implies the following resource constraint for aggregate investment:

\[
\sum_{k=\{0,1,2\}} \left[ I_k(s^t) + \frac{\mu}{1+\xi} \left( (u_k(s^t))^{1+\xi} - 1 \right) K_k(s^t) \right] \leq I(s^t)
\]

There is market clearing condition in the non-tradable sector. This is:

\[
C^0(s^t) + J^0(s^t) + I^0(s^t) + G + \sum_{k \in \{0,1,2\}} M^0_k \leq Y^0(s^t)
\]

Where \(G\) are government purchases, assumed to be exogenous and constant over time.

4.1.5 The instantaneous production benchmark

In order to assess the role of time to produce, I build a benchmark economy that is identical to the one just described, except that production is instantaneous. In this economy,

\[
Y^0(s^t) = Z^0(s^t)
\]
\[
Y^1(s^t) = Z^1(s^t)
\]
\[
Y^2(s^t) = Z^2(s^t)
\]

4.1.6 Equilibrium

The economy has a representative household and there are no frictions or missing markets. This implies that the allocation can be computed as the solution to a planner’s problem. However, this has to be modified so that the planner does not internalize the impact of choices on \(p^i(s^t)\). Otherwise, the planner would use market power in the foreign goods market to increase the welfare of home households at the expense of foreign households. Such coordination is unlikely to occur in a decentralized equilibrium.

The equilibrium is defined as follows: The social planner takes the functions \(\{p^1(s^t), p^2(s^t)\}\) 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 \(\{p^1(s^t), p^2(s^t)\}\) so that for all \(s^t\), \(\{p^1(s^t), p^2(s^t)\} = \{\bar{p}^1(EXP^1(s^t)), \bar{p}^2(EXP^2(s^t))\}\).
4.2 Calibration

4.2.1 Sectors

The first task is to assign empirical counterparts to the different sectors. To that end, I use the same input-output tables as in the empirical part. I normalize the entries in each of the tables to total production in the country. I then average over all of them. This “average” input-output table has 48 sectors which I aggregate into three.

First I rank the manufacturing sectors in increasing order according to the inventory-to-cost ratios calculated using the Annual Survey of Manufacturing. I assign the upper 50% to sector 2 and the lower 50% to sector 1. In the non-tradable sector, I include all service sectors, construction, utilities and agriculture.

The average inventory-to-cost ratio in the two manufacturing sectors as per the Annual Survey of Manufacturing data are, respectively, 1.8 and 2.6 months. I set the time period to 1.5 months, so that the steady state inventory-to-cost ratios in sectors 1 and 2 are, respectively, 1.5 and 1.5 \times (1 + \omega). I choose \omega to match the 0.8 difference in inventory-to-cost ratios between the two sectors.

I rescale 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 0.7, which is the norm of developed countries. Also, I do not allow explicitly for indirect taxes in the model, so that I split them between labor and capital income.

Tables 8 and 9 show the input-output table with, respectively, the columns and the rows summing to one. First one shows how much of each input is used by each sector/final demand category. Three observations are particularly important: First, the manufacturing sectors make a much more intensive use of materials when compared to the service sector. Second, the manufacturing sector with long production time uses labor more intensively. Third, sectors with long production time sell a relatively larger share of their output as investment and durable consumer goods. The last two facts conform with the correlations between sectors documented in table 3.

4.2.2 Household

For the household preferences, there are three parameters to be calibrated, \( \psi \), \( \sigma \), \( \rho \). I follow Mendoza (1991) and Uribe and Yue (2006) and take \( \psi = 1.44 \) and \( \sigma = 2 \). I assume \( \rho = 0.75 \), so that durable and non-durables are complements. This is consistent with the calibration for the elasticity of substitution.

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31 I treat mining as a foreign sector since it is highly tradable and employs very little. I also experimented with treating agriculture the same way as mining. The results are not sensitive to this assumption. The sectors assigned to the non-tradable block do, as a matter of 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 rescaling the size of the non-tradable sector and of domestic absorption.

32 For an interesting account of how heterogeneity in indirect taxes provides a foundation for fluctuations in TFP, see Benjamin and Meza (2009).
between the output of three sectors (see discussion below). The household discounts the future at a rate $\beta$. I set that to be equal to $\frac{1}{R}$ in steady state, and choose $R$ so that the steady state interest rate is 3.5%.

For the capital accumulation equations, I need to calibrate the depreciation rate and the curvature parameter $\zeta$. I set the depreciation of fixed capital $\delta^K$ equal to 6% yearly and the depreciation of durable consumer goods $\delta^D$ to 13%, which is in the ball-park of the rate used by the Bureau of Economic Analysis to depreciate stock of consumer durables.

There is no consensus in the empirical literature on the correct value for $\zeta$. I set $\zeta = 3$, which a relatively mild adjustment cost to capital.

### 4.2.3 Export demand and maintenance cost

The crucial parameter in the demand for net exports is $\theta$. 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, $\theta \rightarrow \infty$. Not much help is available as far as econometric estimates are concerned. Studies 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. For this reason, I present the results of the experiments with $\theta = 2$, $\theta = 20$ and $\theta = 200$.

To calibrate maintenance cost, I set $\xi = 0.5$ and $\mu$ set such that in steady state $u^i(s') = 1$.

### 4.2.4 Exogenous processes

The exogenous state determines the path of interest rates, productivity, and foreign demand for domestic inputs. These are described by the following auto-regressive processes:

\[
\begin{align*}
r(s') &= (1 - \eta_r) \bar{r} + \eta_r r(s'^{-1}) + \varepsilon^r(s_t) \\
f(s') &= \eta_f f(s'^{-1}) + \varepsilon^f(s_t) \\
a(s') &= \eta_a a(s'^{-1}) + \varepsilon^a(s_t)
\end{align*}
\]

I calibrate the processes so that they are comparable to the literature. Neumeyer and Perri (2005) estimate an auto-correlation coefficient of close to 0.8 per quarter for the spread between Argentinean and US government bonds.\(^{33}\) I pick the steady state interest rate $\bar{r}$ to match the ratio between investment and total output. For the terms of trade shock, I also pick $\eta_f = 0.8$ per quarter. This is consistent with the findings in Mendoza (1994) for the persistence of terms of trade shocks. Finally,\(^{33}\)

\(^{33}\)The spread is given by the EMBI series for Argentina calculated by JP-Morgan. See Neumeyer and Perri (2005) for details.
for TFP shock, I use \( \eta_r = 0.95 \). This is consistent with the value typically calibrated for the US and was used by Neumeyer and Perri (2005) in their quantitative exercise.\(^{34}\)

### 4.3 The Effect of Shocks

This section studies the effect of exogenous shocks in the economy described above. I show the results for aggregate and sectoral output. The main emphasis is on the effects of interest rate shocks, but I also discuss the impact of shocks to total factor productivity and demand for exports.

Figure 3 shows the effect of a 10% increase in the interest rate on output with and without production time. The last three quadrants show the effect on sectoral output. Output declines in the non-tradable sector and increases in the tradable sectors. This reallocation reflects the reduction in demand for consumption and investment that accompany an interest rate shock. The tradable sectors are relatively less constrained by domestic demand, and take advantage of the lower wages to increase their production. This reallocation pattern is consistent with the findings of Tornell and Westermann (2002) and Kehoe and Ruhl (2008).

With time to produce, the boom in the tradable sectors is smaller, since the interest rate shock implies an increase in the cost of variable inputs for these sectors. Interestingly, the output in the non-tradable sector also decreases. This is in part a reflection of the complementarities between the sectors. On the one hand, demand for non-tradable decreases because part of the non-tradable output is used as materials for production of tradables. On the other hand, because non-tradables use tradables as inputs, the cost increase in the tradable sector is partly transmitted to non-tradable production.

The first quadrant shows the behavior of total GDP. Without time to produce, output declines only slowly. The immediate impact is a reduction in the demand, which is fully met by a sectoral reallocation. With time to produce, there is a cost shock on top of the demand effect. This induces a large reduction in aggregate output.

Table 10 shows the drop in output in the first quarter after the impact of the interest rate shock for different parametrizations of the model. The essential message is that changes in the price elasticity of exports mean relatively little about the ability of the model with time to produce to generate such a drop, but are extremely important for the model without time to produce. It is not hard to grasp the intuition. Without time to produce, all the contemporaneous effect comes from the demand side. If the economy is more open, this becomes comparatively less important.

Figure 4 shows the effect of a 10% drop in TFP. The main difference between the models with and without time to produce is in the first two quarters. With production time, the response to the TFP shock is more hump-shaped. The reason is that, when the shock hits, firms have already committed inputs into production, so that they do not react as strongly. Interestingly, the hump-shaped response is discernible two quarters after the shock, at which point prior input decisions do not constraint production directly. This reflects an indirect effect through the production chain.

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\(^{34}\)I convert all these quarterly auto-correlations to semi-quarterly frequency by taking the square roots.
requires the use of domestic inputs, firms optimally choose to produce more if more of these inputs are available. This propagation is reminiscent of Long and Plosser (1982).

Finally, figure 5 shows the effect of a 10% drop in the foreign demand for domestic products. Now production falls relatively less in the model with time to produce, particularly so in the manufacturing sector with longer production lags. This is the opposite of what happens with the interest rate shock. The intuition is that after the shock, prices of domestic goods drop relative to imported goods but then slowly revert to the mean. From the perspective of domestic producers, this relative price inflation is akin to a drop in the interest rate.

4.4 Experiments

In this section, I simulate a crisis in order to check whether the model is able to generate a cross-sectional reallocation comparable to the one in the data. The crisis is a simultaneous shock to the interest rate, to total factor productivity and to export demand.

To discipline the experiments, I choose the amplitude of the shocks so that, in the trough of the crisis, the model reproduces exactly the average deviations from trend of aggregate GDP, exports and fixed capital formation prevalent in the data. The numbers I calibrate to are deviations from linear trends estimated by OLS on the years from $t^* - 10$ to $t^* - 3$, where $t^*$ is the trough of the crisis. The targets for GDP, exports and investment are, respectively, $-17\%$, $-5\%$ and $-52\%$.

I compare the difference between the two manufacturing sectors implied by the experiments to the differences implied by the data. To construct the reallocation implied by the data I take advantage of the disaggregated information. I proceed as follows: I take the level of output in each industry three years before the crisis as my benchmark. Then I regress the change in value added in the different industries on the inventory-to-cost ratio calculated using the Annual Survey of Manufacturing, the trend term and country dummies. I do this exercise taking different years around the trough as the terminal data, in order to get a time series of implied reallocation. The estimated coefficient tells me the expected difference in output levels between two industries whose inventory-to-cost ratios differ by a month. I apply this estimate to the calibrated difference between the two sectors in order to get the reallocation implied by the data.

While the model is semi-quarterly (so that there are 8 periods per year), the data is annual. This requires time aggregating the results. The results are averages starting in different times of the year. Since the first year includes cases where the shocks do not hit until late in the year, the trough of the crisis is in the second year.

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The trend is linear, and is estimated using data from $t^* - 10$ to $t^* - 3$, where $t^*$ is the trough of the crisis. I pick these over measures of TFP, terms of trade and interest rates because an accurate measurement of these quantities is conceptually consistent with the model is necessarily more indirect and data intensive and, therefore, more dependent on judgment calls. The problem is compounded by the number of countries under analysis, since it may be hard to get comparable data on interest rates, international prices or hours worked. In contrast, GDP, exports and investment are well established national accounting concepts with large degree of cross country standardization and that in any reasonable macroeconomic model are closely related to the shocks under consideration.
I solve the model by log-linear approximation around the non-stochastic steady state. This is necessary because of the large number of state variables.\footnote{I solve the model using Dynare.}

### 4.4.1 Results

Figure 6 shows the time series behavior of aggregate and sectoral output in the three years following the onset of the crisis. The shocks are calibrated for the model with time to produce so that the results for this model perfectly matches the value of aggregate output in period 0. Without time to produce, the same shocks imply a smaller drop in aggregate output, although not overwhelmingly so. The reason is that the interest rate shock accounts for only a fraction of the total drop in GDP.

Time to produce implies a relatively larger drop in sector 2, so that the difference between sector 1 and sector 2 is only large and positive if time to produce is allowed for. This is true in spite of the fact that sector 2 is more specialized in the production of investment goods.

The last quadrant shows the sectoral reallocation compared to the prediction in the data. In the model with time to produce, the amount of reallocation falls squarely within the 95% interval, whereas without time to produce it does not. The results are virtually identical if I recalibrate the size of the shocks in the model without time to produce to match the aggregate variables.

Table 11 presents the sensitivity analysis. It shows the difference between the two sectors at the trough of the crises given different values of the price elasticity of exports. Here, I recalibrate the size of the shocks in each experiment so as not to give any setup an advantage. The difference between the two sectors is largest in the model with time to produce for larger elasticities of export demand. The model with instantaneous production does not generate a difference between the two sectors with the right sign, even for a price elasticity of exports close to 2.

The other panels show the sensitivity of the results to other parameters. The strong negative coefficients on wage share imply that a model which allows producers to take advantage of a drop in wages will not perform well. For this reason I experiment with an alternative that has an elasticity of labor supply equal to 10. Compared to the benchmark, there is an increase in the difference between the two manufacturing sectors across the board. In particular, the difference is positive in the model without time to produce. However even at such a high elasticity, the model without time to produce does not do a good job in generating a difference between sectors that comes close to the data.

The last panel shows results given a lower elasticity of investment to the replacement cost of capital. This comes closer to the extremely low elasticities often used in the small open economy business cycle literature.\footnote{For example, the calibration in Neumeyer and Perri (2005) implies values much below 1} One consequence is that the model requires a higher interest rate shock in order to generate the same drop in investment (see the implied interest rate shocks for each experiment in table 12). The up-shot is that there is an even larger relative loss of the high production time sector.
5 Conclusion

This paper proposes that production time is an important propagation mechanism for interest rate changes. It accounts for two observations about emerging market economies: that shocks to the interest rate have a strong and swift impact on output and that in crisis episodes there is a substantial reallocation towards industrial sectors that use few inventories relative to their costs. It is similar to Neumeyer and Perri’s (2005) payment-in-advance constraint in so far as the aggregate implications are concerned, but it is also able to account for cross-sectional facts.

The paper opens up some important avenues for research. The first is a detailed exploration of the role of heterogeneity in production times. The results of the three sector model already point to some possibilities. Because of complementarities between sectors, production in the non-tradable sector drops more with production time than without, even though production is instantaneous in that sector. More broadly, time to produce allows for propagation stemming from cross-sectoral linkages, in the style of Long and Plosser (1982). An interesting question is the extent to which a realistic calibration of these production times using data from inventory-to-costs illuminates the nature of this mechanism.

Second, the regression results imply that labor intensive industries did relatively worse in the crises, when everything else is constant. This is a counter-intuitive finding, that deserves further exploration. One possibility, which is in line with the argument in this paper, is that labor includes administrative work, which has a longer time horizon than labor directly applied to the production process. More generally, the need to train new workers and other costs of hiring may have similar implications. Allowing for a richer labor market structure appears to be an interesting way forward.

The third avenue is an exploration of the links to the credit friction literature. In the paper, I take the cost of capital as given and look at the effects on production, while much of the literature does the opposite. The question is whether there is some important insight to be gained by combining the two. This is specially likely to yield interesting results if credit frictions operate at the level of the firm, as in currency mismatch models. In particular, Christiano et al. (2004) point out that a payment in advance constraint affect the calculus of optimal policy to deal with these frictions. It would be interesting to check whether introducing production time affects the result. More fundamentally, because production time can be traced to inventories and production technology this would allow for a quantitative assessment of Christiano et al.’s (2004) mechanism.

Lastly, it is worth asking what the results tell us about developed economies. There is nothing, in principle, that makes the mechanism more relevant to emerging markets than for developed countries. Understanding whether there are important differences to be considered is in itself an important area for further research.
Appendix A: Value Added Accounting with Time to Produce

This appendix shows the implications of time to produce for value added accounting. The framework is an extension of the partial equilibrium model in section 2. Because value added includes wages, suppose the production function is

\[ Y_t = \left( [Z_{t-1} (1)]^{1-\omega} [Z_{t-2} (2)]^{\omega} \right)^{\phi} \]

\[ Z_t(v) = (M_t(v))^{1-\alpha_L} (L_t(v))^\alpha_L \]

The numbers in parenthesis 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

\[ VA_t = Y_t - q_t (M_t (1) + M_t (2)) + Inv_t - R_{t-1} Inv_{t-1} \]

Again, the definition above abides to the recommendation of the 1993 System of National Accounts that inventories should be valued at current price.

Substituting in the various definitions:

\[ VA_t = Y_t - COGS_t + w_t L_t (2) + w_t L_t (1) \]

Thus, value added is the sum of the profits of the firm and the wages dispensed to workers at time \( t \).

Note that, given perfect foresight, profit maximization implies that:

\[ VA_t = (1 - \phi) Y_t + \phi \alpha_L \left( (1 - \omega) Y_{t+1} + \omega Y_{t+2} \right) \]

While sales are determined by prior input choices, value added is not since it incorporates the income of workers involved in the production of future output. Thus, the reaction of value added to an interest rate shock is actually even quicker than that of sales. From \( t \geq 2 \) onwards, if the interest rate shock is persistent enough, value added behaves very much like sales and the comparative statics on \( \omega \) apply as before.

Appendix B: Inventory Turnover and Interest Exposure with generic production function

This section extends the framework in section 2 to allow for generic production functions. Suppose
\[ y_t = f \left( \{ Z_{t-v}(v) \}_{v=0}^N \right) \]

With \( f \) strictly increasing and concave. Consider the problem of a firm under perfect foresight. The firm is deciding how much to produce at \( t \) with enough time to choose all the \( Z_{t-v}(v) \).

To study the production decision of this firm, it is useful to define the accumulation function. This is the appropriate rate to inflate past costs so that they are comparable with present gains. Call the numeraire good a "dollar". If \( R(u) \) is the dollar interest rate between periods \( u \) and \( u+1 \), then, under perfect foresight, the accumulation function is

\[
\Gamma_{t-v}(v) \equiv \prod_{u=t-v}^{t-1} R(u)
\]

The cost minimization problem for the firm is:

\[
\min \sum_v \Gamma_{t-v}(v) q_{t-v} M_{t-v}(v)
\]

s.t. : \( f \left( \{ M_{t-v}(v) \}_{v=0}^N \right) \geq y_t \)

Consider the impact of a permanent interest rate shock (that is, with \( \eta \to 1 \)). This will affect \( \Gamma_{t-v}(v) \). Application of the chain rule combined with Shephard’s lemma implies that:

\[
\frac{dC}{dy_t, \{ \Gamma_{t-v}(v), q_{t-v} \}_{v=0}^{N}} = \sum_v \frac{\Gamma_{t-v}(v) q_{t-v} z_{t-v}(v) v}{\sum_u \Gamma_{t-u}(u) q_{t-u} z_{t-u}(u) R} \frac{dR}{R}
\]

It is straightforward to show that, in steady state, coefficient multiplying \( \frac{dR}{R} \) in the right hand side is exactly equal to the ratio between inventories and costs.
References


Change in value added averaged across crises episodes against inventory turnover for each industry

The change in value added is the log change in the three years leading to the trough of the crisis. The turnover ratio is the ratio between total inventories and variable costs, calculated with data from the Annual Manufacturing Survey for 2006. Industry data are published by UNIDO and refer to 3 digit classifications according to ISIC Rev. 2.
Figure 2: Inventory Turnover Measures

The change in value added is the log change in the three years leading to the trough of the crisis. Time to produce is the ratio between total inventories and production costs calculated based on data from the Annual Manufacturing Survey for 2006. Industry data are published by UNIDO and refer to 3 digit classifications according to ISIC Rev. 2.

<table>
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<tr>
<th>Country</th>
<th>Year</th>
<th>N</th>
<th>Country</th>
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<td>South Korea</td>
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<td>Russia</td>
<td>1998</td>
<td>28</td>
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<td>Cote d'Ivoire</td>
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<td></td>
<td></td>
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<td>2002</td>
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Table 1: Crises Episodes

The episodes are the same ones selected by Calvo et al. (2006), see text for details.
Table 2: Descriptive Statistics

Inventory Turnover (Survey of Manuf.) is the ratio of aggregate inventories to the sum of aggregate cost of materials and production labor for each sector in the Annual Survey of Manufacturing, averaged over 2005 and 2006. The data for Tobacco industry (ISIC 314) is excluded. Inventory Turnover (COMPUSTAT) is the median ratio of inventories to cost across firms and years in the COMPUSTAT database using data since 1980. Inventory Turnover (Korea) 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 in 33, 36 and 38 (wood products, non-metallic minerals and machinery and equipment). Export, Investment and Durable Consumption are calculated using the Leontief Inverse. The source data are input output matrices for Argentina, Brazil, Indonesia, Nigeria, Russia, South Africa, South Korea and Turkey compiled by OECD. The data for missing countries is imputed based on regional averages. Cyclicality is the coefficient of a regression of growth in the sector on growth in aggregate GDP using overlapping 3 year growth rates as data and excluding the three years before the trough of the crisis. Shares of materials, labor and imports are taken from the same input output matrices as above. External Dependence is the dependence on external finance 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.
<table>
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<tr>
<th>Change in Value Added</th>
<th>Inventory Turnover (Survey of Manuf.)</th>
<th>Inventory Turnover (COMPUSTAT)</th>
<th>Inventory Turnover (Korea)</th>
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<td>0.4152</td>
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<td>0.2352</td>
<td>0.4571</td>
<td>0.3557</td>
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<tr>
<td></td>
<td>0.0823</td>
<td>0.0191</td>
<td>-0.1988</td>
</tr>
</tbody>
</table>

**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.
<table>
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<tr>
<th></th>
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<th>(3)</th>
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<tr>
<td>Annual Survey of Manuf.</td>
<td>COMPUSTAT</td>
<td>South Korea</td>
<td></td>
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<td>Inventory-to-Cost</td>
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<td>-0.0307*</td>
<td>-0.0519</td>
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<td>(0.0177)</td>
<td>(0.0157)</td>
<td>(0.0408)</td>
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<td>Exports</td>
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<td>-0.184</td>
<td>-0.153</td>
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<tr>
<td></td>
<td>(0.126)</td>
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<td>Investment</td>
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<td></td>
<td>(0.0824)</td>
<td>(0.0673)</td>
<td>(0.0760)</td>
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<tr>
<td>Durable Consumption</td>
<td>-0.396**</td>
<td>-0.311</td>
<td>-0.287</td>
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<tr>
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<td>(0.201)</td>
<td>(0.220)</td>
<td>(0.215)</td>
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<td>Cyclicality</td>
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<td>(0.0343)</td>
<td>(0.0384)</td>
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<td>-0.733*</td>
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<td>(0.393)</td>
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<td>(0.197)</td>
<td>(0.198)</td>
<td>(0.217)</td>
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<td>Import Share</td>
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<td>(0.144)</td>
<td>(0.157)</td>
<td>(0.149)</td>
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<td>External Dependence</td>
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<td>0.0509</td>
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<td>(0.0395)</td>
<td>(0.0416)</td>
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<td>0.0992**</td>
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<td>Previous Growth</td>
<td>0.109</td>
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<td>Observations</td>
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<td>433</td>
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<tr>
<td>R-squared</td>
<td>0.458</td>
<td>0.468</td>
<td>0.464</td>
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</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Regressions: Change in Value added from $t^* - 3$ to $t^*$
The dependent variable is the log change in value added in the three years leading to the trough of GDP. The columns refer to inventory-to-cost ratios based on different sources (see table 2 for a description of all variables, the “South-Korea” column refers to inventory-to-sale data). Previous growth refers to the growth between 9 and 3 years before the trough of GDP. Regressions include country fixed effects (omitted). Standard errors are robust to overlapping clusters on country and industry (Cameron et al. 2006)
<table>
<thead>
<tr>
<th></th>
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<th>(3)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Annual Survey</td>
<td>COMPUSTAT</td>
<td>South Korea</td>
</tr>
<tr>
<td>Eighties</td>
<td>-0.0329</td>
<td>-0.0295*</td>
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<td>(0.0176)</td>
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<td>Observations</td>
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<td>R-squared</td>
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<td>Nineties</td>
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<td>(0.0489)</td>
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<td>Observations</td>
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<td>R-squared</td>
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<td>0.488</td>
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<tr>
<td>Latin America</td>
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<td>-0.0351*</td>
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<tr>
<td>Inventory-to-Cost</td>
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<td>(0.0523)</td>
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<td>Observations</td>
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<tr>
<td>R-squared</td>
<td>0.430</td>
<td>0.438</td>
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<tr>
<td>Other Continents</td>
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<td>Inventory-to-Cost</td>
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<td>R-squared</td>
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<td>0.525</td>
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Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Sub-samples
Cells are the estimated coefficient on inventory-to-cost ratios (inventory-to-sale for South Korea). The dependent variable is the log change in value added in the three years leading to the trough of GDP. The columns refer to measures of time to produce based on different sources. Regressions include the same controls as in table 4 and country fixed effects, see table 2 for description of all variables. Standard errors are robust to overlapping clusters on country and industry (Cameron et al. 2006)
<table>
<thead>
<tr>
<th>Time Window</th>
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<th>Observations</th>
<th>R-squared</th>
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<td>t*-3 to t*</td>
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<td>t*-2 to t*</td>
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<td></td>
<td>COMPUSTAT</td>
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<td>(0.0139)</td>
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<td>t*-1 to t*</td>
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<td>t*-3 to t*+1</td>
<td>Annual Survey of Manuf.</td>
<td>-0.0621*</td>
<td>(0.0331)</td>
<td>446</td>
</tr>
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<td></td>
<td>0.363</td>
</tr>
<tr>
<td></td>
<td>COMPUSTAT</td>
<td>-0.0444**</td>
<td>(0.0222)</td>
<td>431</td>
</tr>
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<td></td>
<td>0.367</td>
</tr>
<tr>
<td></td>
<td>South Korea</td>
<td>-0.0432</td>
<td>(0.0461)</td>
<td>431</td>
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<td>0.358</td>
</tr>
<tr>
<td>t*-3 to t*+5</td>
<td>Annual Survey of Manuf.</td>
<td>-0.0299</td>
<td>(0.0241)</td>
<td>432</td>
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<td></td>
<td>0.402</td>
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<tr>
<td></td>
<td>COMPUSTAT</td>
<td>-0.0484***</td>
<td>(0.0165)</td>
<td>417</td>
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<td></td>
<td>0.408</td>
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<tr>
<td></td>
<td>South Korea</td>
<td>-0.0621</td>
<td>(0.0453)</td>
<td>417</td>
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<td>0.398</td>
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</tbody>
</table>

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

Table 6: Sensitivity to time window
The columns refer to measures of time to produce based on different sources. Regressions include the same controls as in table 4 and country fixed effects, see table 2 for description of all variables. Standard errors are robust to overlapping clusters on country and industry (Cameron et al. 2006)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>θ</td>
<td>Elasticity of demand for exports 2, 20 or 200</td>
</tr>
<tr>
<td>σ</td>
<td>Relative risk aversion 2</td>
</tr>
<tr>
<td>ψ</td>
<td>Elasticity of labor supply 2.3</td>
</tr>
<tr>
<td>β</td>
<td>Discount rate 0.97% p.y.</td>
</tr>
<tr>
<td>λ</td>
<td>Elasticity of substitution between home and foreign goods 2</td>
</tr>
<tr>
<td>ρ</td>
<td>Elasticity of substitution between home sectors 0.75</td>
</tr>
<tr>
<td>ζ</td>
<td>Elasticity of investment to marginal q 3</td>
</tr>
<tr>
<td>δ_{K}</td>
<td>Depreciation of capital 6% (per year)</td>
</tr>
<tr>
<td>δ_{D}</td>
<td>Depreciation of durables 13% (per year)</td>
</tr>
<tr>
<td>ξ</td>
<td>Elasticity of maintenance cost to utilization 0.5</td>
</tr>
<tr>
<td>η_{r}</td>
<td>Persistence of interest rate shock 0.8 (per quarter)</td>
</tr>
<tr>
<td>η_{a}</td>
<td>Persistence of TFP shock 0.95 (per quarter)</td>
</tr>
<tr>
<td>η_{f}</td>
<td>Persistence of Terms of Trade shock 0.8 (per quarter)</td>
</tr>
<tr>
<td>\bar{r}</td>
<td>Steady state interest rate 0.035 (per year)</td>
</tr>
</tbody>
</table>

Table 7: Benchmark Calibration

<table>
<thead>
<tr>
<th>M^0</th>
<th>M^1</th>
<th>M^2</th>
<th>C</th>
<th>J</th>
<th>G</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector 0</td>
<td>0.23</td>
<td>0.29</td>
<td>0.19</td>
<td>0.71</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Sector 1</td>
<td>0.08</td>
<td>0.22</td>
<td>0.09</td>
<td>0.20</td>
<td>0.43</td>
<td>0.00</td>
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<tr>
<td>Sector 2</td>
<td>0.04</td>
<td>0.04</td>
<td>0.24</td>
<td>0.05</td>
<td>0.27</td>
<td>0.00</td>
</tr>
<tr>
<td>Imports</td>
<td>0.03</td>
<td>0.15</td>
<td>0.12</td>
<td>0.04</td>
<td>0.31</td>
<td>0.00</td>
</tr>
<tr>
<td>Total Inputs</td>
<td>0.37</td>
<td>0.69</td>
<td>0.64</td>
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<td></td>
</tr>
<tr>
<td>Lab. compens.</td>
<td>0.44</td>
<td>0.20</td>
<td>0.28</td>
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<tr>
<td>Value Added</td>
<td>0.63</td>
<td>0.31</td>
<td>0.36</td>
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<td></td>
</tr>
</tbody>
</table>

Table 8: Factor Shares
Steady state share of inputs in production. Total inputs and value added sum to one

<table>
<thead>
<tr>
<th>M^0</th>
<th>M^1</th>
<th>M^2</th>
<th>Total Inputs</th>
<th>C</th>
<th>J</th>
<th>G</th>
<th>I</th>
<th>EXP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector 0</td>
<td>0.23</td>
<td>0.13</td>
<td>0.04</td>
<td>0.40</td>
<td>0.36</td>
<td>0.00</td>
<td>0.13</td>
<td>0.12</td>
</tr>
<tr>
<td>Sector 1</td>
<td>0.17</td>
<td>0.22</td>
<td>0.05</td>
<td>0.44</td>
<td>0.23</td>
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<td>Sector 2</td>
<td>0.16</td>
<td>0.08</td>
<td>0.24</td>
<td>0.48</td>
<td>0.12</td>
<td>0.05</td>
<td>0.00</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Table 9: Uses of sectoral output
Steady state fraction of the output of each sector used in the production of each different good. Columns starting from "Total Inputs" sum to 1
Figure 3: Effect of a 10% increase in the interest rate
Reaction of aggregate and sectoral output to a 10% increase in the annual interest rate. Calibration is the benchmark, given in table 7 with \( \theta = 20 \).
Figure 4: Effect of a 10% drop in total factor productivity

Reaction of aggregate and sectoral output to a 10% increase in the annual interest rate. Calibration is the benchmark, given in table 7 with $\theta = 20$. 

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Figure 5: Effect of a 10% decrease in foreign demand for exports
Reaction of aggregate and sectoral output to a 10% increase in the annual interest rate. Calibration is the benchmark, given in table 7 with \( \theta = 20 \).
Figure 6: Model and Data

The graph shows the behavior of aggregate and sectoral output around the trough of the crisis (year 0). The parametrization corresponds to table 7 and θ = 20. The simulated data are averages of crises starting in each of the 8 half-quarters of year -1. The shocks are calibrated so that the model with time to produce reproduces the trough values of output, investment and exports. The actual data is a sequence of predicted reallocations given estimated using all countries and industries and the 95% interval is calculated using the Cameron et al. (2006) method.
### Table 10: Short-term response of output to a 10% interest rate shock

Benchmark calibration is given by table 7.

<table>
<thead>
<tr>
<th></th>
<th>Benchmark Time to Produce</th>
<th>No Time to Produce</th>
<th>( \psi = 10 ) Time to Produce</th>
<th>No Time to Produce</th>
<th>( \zeta = 2 ) Time to Produce</th>
<th>No Time to Produce</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \theta )</td>
<td>-0.013</td>
<td>-0.018</td>
<td>-0.016</td>
<td>-0.010</td>
<td>0.000</td>
<td>0.005</td>
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</table>

Table 11: Differences in output between the two manufacturing sector in the trough of the crisis

Benchmark calibration of parameters is given by table 7. All numbers reflect values at the trough of the crisis. Values of model variables are averages over crises starting in different times of the year. Shocks in each version of the model are re-calibrated so that the model is able to match the mean deviation from trend of output, investment and exports in the trough of the crisis. The “data” the prediction from the regression of change in value added in the three years leading to the trough on the inventory-to-cost ratio as implied by the Annual Survey of Manufacturing and controlling only for lagged trend terms and country fixed effects. The confidence interval is calculated using the method proposed by Cameron et al. (2006)

<table>
<thead>
<tr>
<th></th>
<th>Sect. 1 minus Sect. 2</th>
<th></th>
<th></th>
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<th></th>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>( \theta )</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>0.050</td>
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<td>0.063</td>
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<tr>
<td>( \zeta = 2 )</td>
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</table>

Table 12: Interest Rate Shocks
Benchmark calibration is given by table 7. Numbers are correspond to the value of the annual interest rate on impact. Values of model variables are averages over crises starting in different times of the year. Shocks in each version of the model are calibrated to match the mean deviation from trend of output, investment and exports in the trough of the crisis.