Time to Produce and Emerging Market Crises *

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Abstract

This paper shows that industrial sectors with high inventory-to-cost ratio experience larger drops in output during emerging market crises than others. To explain these findings, it introduces production time in an open economy general equilibrium model. The model successfully generates a cross-sectional reallocation in reaction to a simulated crisis that is consistent with the data, while an otherwise identical model where production is instantaneous does not. Furthermore, the model economy with production time matches an important previous observation of emerging market business cycles: a quick and strong reaction of aggregate output to an interest rate shock.

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1 Introduction

In emerging markets, a tightening of financial conditions leads to an almost immediate drop in GDP. The two events often take place within the same quarter. This stylized fact was documented in case studies of emerging market crises (Mendoza (2001) for the Mexican crisis and Gertler et al. (2007) for the Korean crisis) and in time series studies involving multiple countries (Neumeyer and Perri (2005) find a contemporaneous correlations in detrended series, Uribe and Yue (2006) document the effect using an identified VAR).

This short lead is hard to account in a standard open economy model. Changes in demand mean little because the current account allows aggregate demand and aggregate supply to differ. On the supply side, the interest rate has an effect on capital accumulation. However, fixed capital moves too slowly to account for the short term relationship between interest rate and production.

The emerging market business cycle literature deals with this problem by stipulating that the cost of variable inputs depends on the interest rate. Numerous papers in the literature use some variation of this modeling device [1] In particular, Neumeyer and Perri (2005) propose that such a cost exists because of payment frictions. Mendoza (2008) and Benjamin and Meza (2009) assume that firms must finance a share of their inputs proportional to the short-term liabilities that they hold. [2]

Both of these interpretations stand on fragile ground. In particular, Chari et al. (2005) have criticized the payment-in-advance device for being a friction which is "subtle [and] for which so far there is little direct evidence" (p. 14). As for the use of short-term liabilities in calibration, it is problematic given the lack of an explicit theoretical grounding. For example, a firm may allow itself to hold more short term debt exactly because it is otherwise little exposed to interest rate shocks.

This paper proposes an alternative to the payment and financial frictions that have informed the literature so far. Instead, it applies Kydland and Prescott's (1982) time to build technology to the process of transforming variable inputs into goods for sale. The essential assumption is that there is a time lag between the acquisition of the inputs and the sale of the output[3]. This generates a short term financing need that links the cost of variable inputs to the interest rate. I use the term "time to produce" in order to emphasize the process of transforming variable inputs into manufactured goods, as opposed to the building ships and factories.

The time to produce theory of short term finance demand is empirically testable. A firm holds variable inputs in inventories for as long as it takes to sell the corresponding output [4]. Thus, the

[1]See Agenor and Montiel (2002) for a discussion of the inclusion of short term capital costs in the early literature. In the recent emerging business cycle literature, see for example Burnside et al. (2001), Neumeyer and Perri (2005), Mendoza (2008), Uribe and Yue (2006), Otsu (2007). A similar device has also been used in the nominal rigidity literature, notably Christiano et al. (2005). An exception is Gertler et al. (2007).

[2]In effect, Mendoza (2008) argues that the credit to GDP ratio is an upper bound, since short term credit is a sub-set of that.

[3]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 follows the inventory in the production function approach proposed by Ramey (1989) and followed by Maccini et al. (2004) among others.

[4]This includes direct labor costs, which are added to work-in-process inventories

ratio of inventories-to-costs (inventory turnover ratio) indicates the relative importance of short term finance for the production process. [5]This suggests the following empirical test: if production decisions respond to the cost of short term finance, it must be the case that firms that normally have higher inventory-to-cost ratio respond more than the others.

To test the theory, I focus on episodes when sudden stops in the flow of foreign finance occurred together with collapses in aggregate output. [6] These episodes are interesting experiments, since it is during these events that production decisions are most likely to be driven by changes in the cost of capital. As a consequence, they are particularly informative about any mechanism linking the two, including time to produce.

Figure 1 shows the main empirical finding of the paper: The graph depicts, for different manufacturing industries, the average loss of output against the ratio between inventories and the cost of variable input. The latter is calculated using data from counterparts in the US. This ratio is typically small, between one and three months. Nevertheless there is a steep correlation between the two variables: a standard deviation change in the inventory to costs ratio implies a loss of about 4.5% of value added.

I use the ratios between inventory and costs to calibrate a quantitative general equilibrium model with time to produce. I allow for two manufacturing sectors corresponding to the sectors with high and low inventory-to-cost ratio. I simulate sudden stops in the model and find that it generates a cross-sectional reallocation that is consistent with the data. An equivalent model without time to produce has a much harder time producing such a result. This reinforces the interpretation that, to a large extent, the correlation reflects differences in short term financing needs, as captured by the inventory-to-cost ratio.

Finally, I use the calibrated model to evaluate the extent to which time to produce enables an immediate output response to an interest rate shock. Under the benchmark calibration, a 10% increase in the annual interest rate implies a drop in output of approximately 1.3%. This compares to approximately 2% estimated by Uribe and Yue (2006) and is within their estimated 95% interval.[7]

I provide a consistent story that accounts both for the cross-sectional reallocation patterns in sudden stop episodes and the short term correlation between output and the interest rate documented elsewhere. To strengthen the case, I need to rule out some major alternatives regarding the cross-sectional pattern. To a large extent I deal with these in Section 3 by introducing a variety of controls in the regressions. These encompass import share of inputs, export orientation, specialization in investment or durable consumer goods, dependence on external finance, average establishment size and the usual sensitivity of each industry to variations in aggregate output.

[5]In fact, the ratio is given in time units. 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.

[6]The term "Sudden Stop" was coined by Calvo (1998). The events used in this paper correspond to the sample selected by Calvo et al. (2006a).

[7]Uribe and Yue (2006) do not allow for an immediate impact of the interest rate on output because they assume that no such impact exists in the identification of their VAR. The number cited above refers to the first quarter after the shock.

Whatever the controls, the empirical findings may reflect short term inventory adjustment dynamics. To account for that, I test whether the cross-sectional reallocation patterns persist into the recovery phase. This is informative because inventory holdings correspond to only a few months of production costs, so that a year into the recovery such adjustments should have already taken place. I find that the cross-sectional reallocation associated with the inventory-to-cost ratio does persist into the recovery, thus ruling out that alternative.

The results in the paper do not rule out an independent role for payment frictions or balance sheet concerns. They do imply that time to produce goes a long way in accounting for a substantial fraction of the short term effect of interest rate changes on aggregate output. The interaction between time to produce and these types of frictions is in itself an interesting area for future research.

There are two strands of literature that this paper brings together. The first is more theoretical, and seeks to understand the business cycle in emerging economies as well as the dynamics of crises episodes. The two papers which are closest to this one are Kehoe and Ruhl (2008) and Benjamin and Meza (2009). Both deal specifically with sectoral reallocation during sudden stop episodes, although their main focus is the reallocation from tradable to non-tradable goods. Of these two, only Benjamin and Meza (2009) impose interest rate cost of inputs. However, they base their calibration on the financial position of industries rather than on their inventory holdings.

The second strand is empirical and focuses on the stylized facts of emerging market business cycles. The literature is extensive, with many studies focusing primarily on aggregate variables, but others going as far down as firm level observations.[8] There are two recent empirical papers that focus explicitly on the role of short term finance. These are Raddatz (2006), who focuses on cross-industry differences in sectoral volatility and Tong and Wei (2009), who focus on the behavior of financial data during the recent global crisis. Both find increased volatility for firms or industries with high inventory-to-cost ratio. This paper expands the evidence in Tong and Wei (2009) by focusing on multiple crises and refines the one in Raddatz (2006) by showing that the relationship is particularly severe when there is a sudden stop in international financial flows. Furthermore, this paper adds to their findings by providing an explicit link between inventories and interest rate sensitivity of output and by evaluating its potency in a quantitative general equilibrium context.

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 time to produce 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. Using industry level data, it documents the correlation between the inventory-to-cost ratio and the change in value added during emerging market crises as well as the way this holds up to the introduction of various controls and 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.

[8]On the aggregate side, see Kaminsky and Reinhart (1999) Calvo et al. (2004),Calvo et al. (2006b),Calvo et al. (2006c), Tornell and Westermann (2002) and many others. For studies focusing on industry data, see Randall Kroszner and Klingebiel (2006) and Dell'Ariccia et al. (2007). For a study using firm level data, see for example Gilchrist and Sim (2007)

2 Time to produce in Partial Equilibrium

This section presents a few results in the context of a simple partial equilibrium model with perfect foresight. Its main purpose is to show some empirical implications of the time to produce technology.

2.1 The Production Technology

In order to sell output at t, a firm must acquire inputs in $t-1$ and $t-2$. The production function has a Cobb-Douglas form with decreasing returns to scale, as follows:[9]

$$Y_t = \left([M_{t-1}(1)]^{1-\omega} [M_{t-2}(2)]^{\omega} \right)^{\rho}, \ \rho < 1$$

$M_t(v)$ are materials acquired in period t to generate a sale v periods ahead.

2.2 A one time shock to the interest rate

Let's consider the effects of 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 η. Keeping with the partial equilibrium assumption, suppose the path of wages and input prices does not change.

The effects on output are as follows:

$t = 0:$ All inputs have been chosen, so there is no change in output.

$t = 1:$

Let p_t^m and p_t^y be, respectively, the price of materials and finished goods at time t and R_t the interest rate between periods t and $t+1$. The cost of inputs acquired at $t = -1$ is sunk, but not in $t = 0$. The profit maximizing output is:

$$Y_1 = Z_{-1}(2)^{\alpha\omega} \left(\frac{R_0 p_0^m}{p_1^y} \right)^{-\frac{(1-\omega)\rho}{1-(1-\omega)\rho}}$$

So that

$$\frac{dY_1}{Y_1} = -\frac{(1-\omega)\rho}{1-(1-\omega)\rho} fracdR_0R_0$$

$t \geq 2$:

From $t \geq 2$ onward, the profit maximizing output is

[9] The decreasing returns to scale may stem from fixed inputs. This is a minor omission since the main focus is on variable inputs and 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.

$$Y_t = \left[\left(\frac{R_{t-2}R_{t-1}p^m_{t-2}}{p^y_t}\right)^{\omega}\left(\frac{R_{t-1}p^m_{t-1}}{p^y_t}\right)^{1-\omega}\right]^{-\frac{\rho}{1-\rho}}$$

This implies that

$$\frac{dY_t}{Y_t} = -\frac{\rho}{1-\rho}\left(\omega\frac{dR_{t-2}}{R_{t-2}} + \frac{dR_{t-1}}{R_{t-1}}\right)$$

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

$$\frac{dY_t}{Y_t} = -\frac{\rho}{1-\rho}\frac{\omega+\eta}{\eta^2}\frac{dR_t}{R_t}$$

Note that for η close to 1,

$$\frac{(1-\omega)\,\rho}{1-(1-\omega)\,\rho}\frac{1}{\eta} < \frac{\rho}{1-\rho}\frac{\eta+\omega}{\eta^2}$$

So that in $t=1$ the output co-moves less with the interest rate than for $t \geq 2$.

Summing up, the interest rate shock only has its full impact on output once firms are not tied by previous decisions. Given that the inventory turnover ratios are relatively small, the transition is likely to be swift. This is confirmed by the results presented in the calibrated model.

2.3 From theory to data

I first define 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.

2.3.1 Cost of Goods Sold

The cost of goods sold is

$$\text{COGS}_t = R_{t-2}R_{t-1}p^m_{t-2}M_{t-2}\,(2) + R_{t-2}p^m_{t-1}M_{t-1}\,(1)$$

Cost of goods sold is the sum of the cost all inputs needed to enable production at t. The spot prices are inflated by the opportunity cost of capital between the time they were puchased and the time the good is sold. In practice these financial costs are usually omitted.

If there are no surprises between the choice of inputs and the sale of output, it will be the case that

$$\text{COGS}_t = \rho Y_t$$

2.3.2 Inventories

Inventories include all inputs that were acquired by the firm but which have not yet been completely transformed into final output:

$$\begin{aligned} \text{Inv}_t &= p_t^m M_t(2) + p_t^m M_t(1) \\ &\quad + R_{t-1} p_{t-1}^m M_{t-1}(2) \end{aligned}$$

The first two terms are the cost of inputs that the firm purchased 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. Given perfect foresight, this is consistent with the recommendations in the 1993 System of National Accounts that inventories should be priced at their current replacement cost.[10] Business accounting does not follow this practice, instead pricing inventories at historic cost. Given the short spans of time involved, this is only a second order difference.

Given perfect foresight:

$$\text{Inv}_t = \rho\omega Y_{t+2} + \rho Y_{t+1}$$

2.3.3 Inventory Turnover Ratio

Define the inventory turnover ratio:

$$\tau_t = \frac{\text{INV}_t}{\text{COGS}_t}$$

Under perfect foresight:

$$\tau_t = \frac{\omega Y_{t+2} + Y_{t+1}}{Y_t}$$

In steady state

$$\tau = 1 + \omega$$

[10]To see this, suppose there are multiple firms that make use of the $Z_{t-1}(2)$ composite good and that they can freely trade it among themselves to use it in their production processes. Let $p_t^{z_{t-1}(2)}$ be the price of $Z_{t-1}(2)$ at t. Since $Z_{t-1}(2)$ is produced from labor and materials using a constant returns to scale function, the zero profit condition implies that $E\left[p_t^{z_{t-1}(2)}\right] = R_{t-1}$.

In section 2.2 above we characterized the relationship between output and interest rate at $t \geq 2$ in response to a mean reverting interest rate shock

$$\frac{dY_t}{Y_t} = \frac{\rho}{1-\rho}\frac{\eta+\omega}{\eta^2}\frac{dR_t}{R_t}$$

If the persistence parameter η is close to 1, then

$$\frac{dY_t}{Y_t} \cong \tau\frac{\rho}{1-\rho}\frac{dR_t}{R_t}$$

If interest rate shocks are persistent, the contemporaneous relation between output and the interest rate is approximately proportional to the inventory turnover ratio.

2.3.4 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 time period in the model is below two months so that the financing costs will be 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 cost of goods sold and inventories include the same costs. This implies that the ratio will not be off the mark so long as the omitted costs do not have a time profile which is very different from the ones which are actually included[11].

Third, in the data analysis below, the observations are not output, but value added. Appendix A discusses in detail how these should be computed. Because value added data includes change in inventories, it will have a forward looking component. This implies that it reacts much more quickly to shocks than output.

3 Data Analysis

3.1 Events

The analysis centers on events that Calvo et al. (2006a) identify as output collapses following Systemic Sudden Stops.[12] 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 and in periods of high international interest rates. They 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

[11]This will not be the case for administrative labor, for example. However, this is certainly not a variable input.
[12]See the above mentioned paper and Calvo et al. (2004) for further details of how exactly these events were selected.

amplifying effect from the increase in cost of capital to aggregate output. Table 1 lists the events. They concentrate in the early eighties, in the late nineties and, to a lesser extent, in the mid nineties. This clustering of events provides further indication of the exogenous nature of the shock.

In the benchmark regressions I look at the drop in output in the three years leading to the trough of GDP. I adopt the three year window 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 robustness checks, I experiment with other windows.

3.2 Inventory Turnover

The benchmark measure of time to produce 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 materials plus the cost of production labor. The main advantage of this survey is that it is representative of the manufacturing sector as a whole. 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 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. Last, privately owned firms may be prone to manipulate inventory numbers for tax avoidance purposes and, for this reason, may chose not to answer the survey accurately.

An alternative measure is based on firm level balance sheet data from COMPUSTAT, which guarantees the that the accounting measures are consistent. Time to produce 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 possible seasonal bias[13]. 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 above 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 measure 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 industria 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.

[13]By far most of the observations are in December, so that such a correction is needed.

Graph 2 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. Somewhat surprisingly, the Korean data and COMPUSTAT are more correlated with one another than the Annual Survey of Manufacturing with the other two. 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. Table 2 has the descriptive statistics for the three variables. The average time to produce is highest in the COMPUSTAT sample, at 2.5 months. The number for South Korea is lower than the others because the denominator is not costs, but sales.

3.3 Empirical Specification

I run the following OLS regression:

$$y_{i,k,t^*} - y_{i,k,t^*-h} = \alpha_i + \beta\tau_k + \gamma X_{ik} + \delta\left(y_{i,k,-h} - y_{i,k,t^*-9}\right) + \varepsilon_{ik}$$

Where y_{i,k,t^*-h} is log value added in industry k, episode i, h years from the trough of the crisis (Example: shoes in the Korea 1998 episode measured 3 years before the trough). On the right hand side the constant varies with the episode, τ_k is inventory turnover ratio for industry k, X_{ik} is a vector of controls that varies by country and industry. The last term is a control for prior trend. The hypothesis is that $\beta < 0$, so that firms with longer time to produce do relatively worse[14].

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)[15]. 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 a larger span of correlation 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.

[14] I 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.

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

3.4 Controls

In this section I describe the controls. 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. These correlations are depicted in table 3. Table 2 has the descriptive statistics for these variables.

3.4.1 Demand Side

Around crisis events, investment drops much more strongly than GDP. [16] Thus, industries that specialize on investment goods will have to either switch to exporting or reduce their production. Also, exports drop much less than overall output, which implies that industries that have higher export orientation probably did relatively better. Finally, the aggregate data does not distinguish between non-durable and durable consumer goods, but it is probably the case that the latter behaves similarly to investment. It is therefore important to control for the composition of demand and the export orientation of the different sectors.[17].

From an input-output matrix it is possible to infer the share of output that is directly or indirectly destined to the production of exports or investment goods[18]. To construct an equivalent measure of durable consumer goods, I assume that all the consumption from certain sectors is durable. These are roughly the sectors whose goods the Bureau of Economic Analysis adds to the aggregate stock of durable consumer goods. I include wood products, furniture, non-metallic minerals and all machinery and equipment sectors.

I use country specific input-output matrices made available by OECD whenever possible. When no input output table was available, I used an average for the region. Thus, for example, the input-output structure for Malaysia was taken to be an average between South Korea and Indonesia. An important observation is that a good may be linked to the production of investment goods even if it is not directly used this way.

The correlation between the demand side variables and both time to produce and the average drop in output are depicted in table 2. Industries that specialize in the production of investment or durable consumer goods are more likely to have long time to produce and also more likely to experience a loss in output. This suggests that these are important controls.

3.4.2 Cost

During a sudden stop, there are massive realignments in relative prices. This implies that firms may face important changes in their input costs. One particular case of interest are imported inputs. The latter play an important role in some models of emerging market crises (Mendoza 2008).

[16]see, for example Calvo et al. (2006a)

[17]I 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.

[18]Thus 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.

In the opposite direction, an industry may benefit from relying strongly on labor as opposed to capital or materials. The reduced demand for labor in a crisis would reduce wages, giving these industries an advantage. Furthermore, if there is a strong wealth effect on labor supply, workers may be willing to work a same number of hours for a reduced wage. Note from the correlation matrix that sectors with high time to produce normally hire more workers so that this effect would imply a less pronounced raw correlation between time to produce and the drop in output.

For completeness, I include a control for material share. This is potentially interesting in that a high materials (and labor) share implies that a firm will have less sunk costs and will be more willing to adjust its production to the new circumstances. dependence and size

3.4.3 Normal Cyclicality

Even after controlling for demand and cost components, the results may not be capturing the particular effect of the sudden stop, but just the usual effect of a downturn. To control for that, I include a proxy for the typical cyclicality of an industry. First, I regress the growth in output of each country/industry on output growth using overlapping three year windows as my observations. I include in this regression all available observations but the 3 year period included in the left hand side of the main regression. I then collect the coefficients and average them over industries. As the correlation matrix in table 3 shows, more pro-cyclical industries did experienced a larger drop in output, but there is not a robust association between this variable and inventory turnover[19].

3.4.4 External Dependence and Size

Rajan and Zingales (1998) define Dependence on External Finance as:

$$\text{External Dependence} = \frac{\text{capital expenditure - cash flow}}{\text{capital expenditure}}$$

They calculate averages of this ratio for listed firms in the US. Rajan and Zingales argue that, these firms have ample access to credit, the ratio captures technological aspects of production rather than frictions. In particular, they argue, external dependence measures the extent to which investment is front loaded when compared to production. Everything else constant, if access to finance is easier, industries that require more up-front investment should do better.

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).

External dependence captures differences in the demand for external finance. The empirical corporate finance has often focused on size as a determinant of differences in the supply of finance available

[19] I also experimented with a measure of cyclicality based only on US data. The results are largely similar, and are available upon request.

to different firms [20]. Firm size may matter because as larger firms may have an easier time exporting[21]. The UNIDO dataset has data on employment and number of establishments by industries. I calculate for each country/industry pair the average employement/establishment ratio[22].

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 broadly 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 not surprising, since the turnover ratio for Korean firms is calculated with sales as opposed to the cost of goods sold in the denominator.

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 specially interesting, since it is highly statistically and economically significant. A standard deviation change in the wage share implies a drop of xx% 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 story is that there are lags between the training and hiring of workers and production of goods which are not adequately captured by inventories. The evidence also sits in nicely with the suggestion by Neumeyer and Perri (2005) that the interest rate shock increases primarily the cost of labor input. What is clear, in any case, is that a model that allows firms to benefit from a large drop in wages during the crisis will have trouble matching the essential cross-sectional facts.

3.6 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). On the other hand, 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 effect of time to produce is robust to splitting the sample in different ways.

The results are in table 5. The coefficient on time to produce is mostly not statistically significant given that samples are now half the size. However, the point estimates are highly stable, reinforcing the result. I also split the sample between Latin American countries and the rest. Again, the results are remarkably robust[23].

[20] See Fazzari et al. (1988) for the seminal paper and Gertler and Gilchrist (2007) for an application specific to interest rate shocks. However, see also Kaplan and Zingales (1997) for a critique.

[21] See Melitz (2003)

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

[23] 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.

3.7 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. The results are robustly negative, although they tend to be less significant and the coefficient less strong. As mentioned above, shorter time windows will include cases where the crisis was already under way in the initial year. Also, a growth rate over a year is likely to be more noisy than over three years. This by itself should imply larger standard errors.

The results are specially interesting in so far as the terminal date is concerned. Persistence of the coefficient into the recovery indicates that the findings are most likely not associated with short-term inventory adjustment. As it turns out, the results imply that the reallocation is in fact fairly persistent. The somewhat surprising result is that the reallocation is detectable in as much as five years after the trough of the crisis.

4 Quantitative Model

4.1 Model Setup

Let let s_t denote the exogenous state at date t and s^t the history of exogenous states up to date t, so that $s^t = \left\{s^{t-1}, s_t\right\}$. 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 $e^{r\left(s^t\right)}$. 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

$$u\left[h\left(C\left(s^t\right), D\left(s^t\right)\right) + g\left(L\left(s^t\right)\right)\right]$$

Where $C\left(s^t\right)$ is non-durable consumption and $D\left(s^t\right)$ is the stock of durable goods held by the household, $L\left(s^t\right)$ is labor supply and $g' < 0$

This utility function has the property that there is no inter-temporal substitution in labor supply. This is a feature the utility function proposed by **?**. One motivation for this functional form is that g measures the 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 [24].

There are three sectors. The first sector (sector 0) produces non-tradable services. The two other the sectors (labeled 1 and 2) represent tradable manufactures. The output of these sectors are combined with each other and with imports to produce consumption goods, investment goods and raw materials for future production:

[24]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.

$$
\begin{aligned}
C\left(s^t\right) &= \tilde{C}\left(\left\{X^{i,C}\left(s^t\right)\right\}_{i\in\{0,1,2,*\}}\right) \\
I\left(s^t\right) &= \tilde{I}\left(\left\{X^{i,I}\left(s^t\right)\right\}_{i\in\{0,1,2,*\}}\right) \\
J\left(s^t\right) &= \tilde{J}\left(\left\{X^{i,J}\left(s^t\right)\right\}_{i\in\{0,1,2,*\}}\right) \\
M^h\left(s^t\right) &= \tilde{M}^h\left(\left\{X^{i,h}\left(s^t\right)\right\}_{i\in\{0,1,2,*\}}\right),\ h\in\{0,1,2\}
\end{aligned}
$$

Where $X^{i,k}$ is the use of input i for production of good k, M^h are materials used for production in sector h and C, I and J are respectively non durable consumption, investment in fixed capital and investment in durable consumption goods. The superscripts on the inputs Y^{ik} follow the convention of the input-out matrix. The first (row) index refers to the input and the second (column) to the output.

The inputs are produced by the individual sectors with the production function:

$$
Y^i\left(s^t\right) = \tilde{Y}^i\left(\left\{Z^i\left(s^{t-v};v\right)\right\}_{v=0}^{n}\right)
$$

Where Y^i is the production of the input i. $Z^i\left(t-v;v\right)$ denotes a composite of goods acquired in period $t-v$ to produce the finished good ready for sale v periods ahead:

$$
Z^i\left(s^t;v\right) = \tilde{Z}\left(\begin{array}{c} u^i\left(s^{t-1};v\right)K^i\left(s^{t-1};v\right), \\ L^i\left(s^t;v\right), M^i\left(s^t;v\right); s^t \end{array}\right)
$$

Where $u\left(s^{t-1};v\right)^i$ denotes the rate of utilization of fixed capital at t. Capital utilization is chosen one period in advance. This is a technical assumption to avoid swings in capacity utilization calculated to take advantage of very short-term changes in relative prices[25].

Capital is sector specific and is produced by combining old capital and investment goods:

$$
K^i\left(s^t\right) = \tilde{K}\left(K^i\left(s^{t-1}\right), I^i\left(s^t\right)\right)
$$

Durable consumer goods are produced in a similar fashion:

$$
D\left(s^t\right) = \tilde{D}\left(D\left(s^{t-1}\right), J\left(s^t\right)\right)
$$

While capital is sector specific, its utilization can be freely shuffled around between different stages of production. This implies the following resource constraint for capital stock:

[25] This assumption is specially important when there is no time to produce, since the time to produce assumption introduces a natural lag between production an prices. Not also that u is not indexed by the stage of production v, so that it is constrained to be the same across all stages of production in a given sector and moment in time.

$$\sum_v u^i\left(s^t;v\right)K^i\left(s^t;v\right)\leq u^i\left(s^t\right)K^i\left(s^t\right)$$

An analogous resource constraint is available for materials

$$\sum_v M^i\left(s^t,v\right)\ \leq M^i\left(s^t\right)$$

In contrast, labor is perfectly mobile between sectors. This implies the following labor market clearing condition

$$\sum_{i=\{0,1,2\}}\sum_v^n L^i\left(s^t,v\right)\leq L\left(s^t\right)$$

So that the left hand side is summed over not only stages of production, but also over industries.

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:

$$\sum_{i=\{0,1,2\}}\left(I^i\left(s^t\right)+\tilde{\zeta}\left(u^i\left(s^t\right)\right)K^i\left(s^t\right)\right)\leq I\left(s^t\right)$$

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 [26]. This assumption implies that tradable sectors have to respond at least somewhat to changes in domestic demand. The two tradable sectors face an inverse demand function

$$p^i\left(s^t\right)=\tilde{p}^i\left(EXP^i\left(s^t\right)\right)$$

Where $p^i\left(s^t\right)$ is the price of good i with respect to the foreign good and EXP^i are exports from sector i. These are given by total output from sector i minus the sum of the domestic demands for its good by the different uses:

$$EXP^i\left(s^t\right)=Y^i\left(s^t\right)-\sum_{k\in\{0,1,2,C,I,J\}}X^{ik}\left(s^t\right)$$

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

$$IMP^i\left(s^t\right)=\sum_{k\in\{0,1,2,C,I,J\}}X^{*,k}\left(s^t\right)$$

[26]It is a common assumption in the literature. See Gertler et al. (2007) and Kehoe and Ruhl (2008). Note that this does not imply monopolisitic 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.

The current account identity is:

$$B\left(s^{t}\right)-R\left(s^{t-1}\right)B\left(s^{t-1}\right) = IMP^{i}\left(s^{t}\right) - \sum_{i\in\{1,2\}} p^{i}\left(s^{t}\right)EXP^{i}\left(s^{t}\right)$$

The last resource constraint is market clearing in the non-tradable sector. This is:

$$\sum_{k\in\{0,1,2,C,I,J\}} X^{0k}\left(s^{t}\right)+G\leq Y^{0}\left(s^{t}\right)$$

Where G are government purchases, assumed exogenous and constant over time. Non-tradable production is allocated to G or to any of the uses.

4.1.1 Equilibrium

The economy has a representative household. 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 $p^{i}\left(s^{t}\right)$. Otherwise, the planner would be making use of market power to increase the welfare of home households at the expense of foreign households. Such coordination is unlikely in a decentralized equilibrium, and is ruled out for this reason.

The social planner takes the functions $\left\{p^{1}\left(s^{t}\right),p^{2}\left(s^{t}\right)\right\}$ as given and choses all remaining functions of s^{t} to maximize household welfare subject to technological and resource constraints described above.

The social lanner immersed in a larger, "world equilibrium". This is given by the functions $\left\{p^{1}\left(s^{t}\right),p^{2}\left(s^{t}\right)\right\}$ and a solution to the planner's problem so that for all s^{t}, $\left\{p^{1}\left(s^{t}\right),p^{2}\left(s^{t}\right)\right\} = \left\{\tilde{p}^{1}\left(EXP^{1}\left(s^{t}\right)\right),\tilde{p}^{2}\left(EXP^{2}\left(s^{t}\right)\right)\right\}$.

4.2 Parametrization and calibration

4.2.1 Household

The period utility function is

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

There are four parameters to be calibrated, ψ, σ, ρ and A. I follow Mendoza (1991) and Uribe and Yue (2006) and take $\psi=1.44$ and $\sigma=2$. I assume t$\rho=0.75$. This is consistent with the calibration for the elasticity of substitution between the output of two sectors. The household discounts the future at a rate β. I set that to be equal to $\frac{1}{R}$ in steady state, and chose R so that the steady state interest rate is 3.5%.

4.2.2 Final goods production

Production of final goods is done by combining inputs produced in the three different sectors with imports. This takes place in two stages. First inputs from the three domestic sectors are aggregated in a single domestic composite:

$$\begin{aligned}
C^H\left(s^t\right) &= \left[\sum_{i\in\{0,1,2\}}\left(\gamma^{iC}\right)^{\frac{1}{\rho}}\left(Y\left(s^t\right)^{i,C}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \\
I^H\left(s^t\right) &= \left[\sum_{i\in\{0,1,2\}}\left(\gamma^{iI}\right)^{\frac{1}{\rho}}\left(Y\left(s^t\right)^{i,I}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \\
J^H\left(s^t\right) &= \left[\sum_{i\in\{0,1,2\}}\left(\gamma^{iJ}\right)^{\frac{1}{\rho}}\left(Y\left(s^t\right)^{i,J}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \\
M^{H,k}\left(s^t\right) &= \left[\sum_{i\in\{1,2,3\}}\left(\gamma^{ik}\right)^{\frac{1}{\rho}}\left(Y\left(s^t\right)^{i,k}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}, \ k\in\{0,1,2\}
\end{aligned}$$

Where the superscript H stands for "home", and $\sum\gamma_k = 1$ for $\in \{0,1,2,C,I,J\}$. The elasticity of substitution is 0.75, consistent with the usual calibrations for substitution between home sectors. The shares are calibrated using data from input-output matrices, as discussed below.

The final goods are a composite of home and foreign:

$$\begin{aligned}
C\left(s^t\right) &= \left[\left(\gamma^{*C}\right)^{\frac{1}{\lambda}}\left(X^{*,C}\right)^{\frac{\lambda-1}{\lambda}} + \left(1-\gamma^{*C}\right)^{\frac{1}{\lambda}}\left(X^{H,C}\right)^{\frac{\lambda-1}{\lambda}}\right]^{\frac{\lambda}{\lambda-1}} \\
I\left(s^t\right) &= \left[\left(\gamma^{*I}\right)^{\frac{1}{\lambda}}\left(X^{*,I}\right)^{\frac{\lambda-1}{\lambda}} + \left(1-\gamma^{*I}\right)^{\frac{1}{\lambda}}\left(X^{H,I}\right)^{\frac{\lambda-1}{\lambda}}\right]^{\frac{\lambda}{\lambda-1}} \\
J\left(s^t\right) &= \left[\left(\gamma^{*I}\right)^{\frac{1}{\lambda}}\left(X^{*,J}\right)^{\frac{\lambda-1}{\lambda}} + \left(1-\gamma^{*I}\right)^{\frac{1}{\lambda}}\left(X^{H,J}\right)^{\frac{\lambda-1}{\lambda}}\right]^{\frac{\lambda}{\lambda-1}} \\
M^k\left(s^t\right) &= \left[\left(\gamma^{*I}\right)^{\frac{1}{\lambda}}\left(M^{*,k}\right)^{\frac{\lambda-1}{\lambda}} + \left(1-\gamma^{*I}\right)^{\frac{1}{\lambda}}\left(M^{H,k}\right)^{\frac{\lambda-1}{\lambda}}\right]^{\frac{\lambda}{\lambda-1}}
\end{aligned}$$

I set $\lambda = 2$, which is within the ball-park of the usual calibrations for the elasticity of substitution between home and foreign goods.

4.2.3 Fixed capital and consumer durables

Capital production technology is[27]

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

The parameter ζ corresponds to the elasticity of investment to the marginal value of capital and δ^K is the amount of investment as a fraction of capital that needed to keep the capital stock constant. The depreciation parameter δ is set equal to 6% yearly[28][29].

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

Production of durables has a similar functional form:

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

I keep by same curvature parameter ζ, but set $\delta^D = 13\%$, which is in the ball-park of the rate used by the Bureau of Economic Analysis to depreciate stock of consumer durables.

4.2.4 Sectoral production

The production functions for the three different goods are:

$$\begin{aligned}
Y^0\left(s^t\right) &= Z^0\left(s^t\right)\\
Y^1\left(s^t\right) &= Z^1\left(s^{t-1};1\right)\\
Y^2\left(s^t\right) &= \left(Z^2\left(s^{t-1};1\right)\right)^{1-\omega}\left(Z^2\left(s^{t-2};2\right)\right)^{\omega}
\end{aligned}$$

Note that production in the service sector takes place instantaneously whereas production in sectors 1 and 2 take an average of 1 and $1+\omega$ periods respectively. This is somewhat conservative, since the "service" sector actually includes construction.

The model period is taken to be half a quarter, which is slightly below the average for the quickest manufacturing sectors and ω is calculated so that the ratio of time to production between the two

[27] This function has the property that $K_t^i = K_{t-1}^i$ if $I_t^i = \delta K_t^i$ and that close to steady state $\frac{\partial K_t}{\partial I_t} = 1$.

[28] In the model, the maintenance cost is set so that it is equal to zero in steady state. This is a matter of normalization. Note, however, that unlike Greenwood et al., I do not require all the depreciation to stem from costs associated with capital utilization.

[29] The production function satisfies the following conditions:

$$K = G\left(\delta K, K\right), \frac{\partial G\left(\delta K, K\right)}{\partial I} = 1, \frac{\partial G\left(\delta K, K\right)}{\partial K} = 1-\delta$$

sectors is the same as $1+\omega$. This yields an ω of about 0.44.

The finished good composite $Z^i\left(s^t;v\right)$ is defined by:

$$Z^i\left(s^t,v\right)=\gamma_i e^{a\left(s^t\right)}\left(u^i\left(s^{t-1};v\right)K^i\left(s^{t-1};v\right)\right)^{\alpha^i_K}\left(L^i\left(s^t;v\right)\right)^{\alpha^i_L}\left(M^i\left(s^t;v\right)\right)^{1-\alpha^i_L-\alpha^i_K}$$

Where α^i's are sector specific and also calibrated with use of the input-output matrix.

4.2.5 Maintenance costs and export demand

Demand for net exports has an iso-elastic form, with

$$p^i\left(s^t\right)=\chi_i e^{f\left(s^t\right)}EXP^i\left(s^t\right)^{-\theta}$$

θ is a very important parameter in so far as the cross-sectional dispersion is concerned and it is not clear how it should be calibrated. In fact, the literature on emerging market business cycles has diverged dramatically, with some papers setting it as low as 1 or 2 and many other papers assuming that the economy is small in the goods markets, so that, effectively, $\theta\to\infty$. Not much help is available as far as econometric estimates are concerned. Microeconomic studies tend to focus on the elasticity of substitution between foreign and domestic goods, but as far as θ is concerned, the most relevant number would be how agents in third countries substitute between two foreign goods. Macroeconomic 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 $\theta=200$[30].

Maintenance cost is

$$\xi\left(u^i\left(s^t\right)\right)K^i\left(s^t\right)=\mu\left[\frac{1}{1+\xi}\left(u^i\left(s^t\right)\right)^{1+\xi}-1\right]K^i\left(s^t\right)$$

With $\xi=0.5$ and μ set such that in steady state $u^i\left(s^t\right)=1$.

4.2.6 Shares

I need to calibrate the shares of inputs into the production of the various goods. I use the same input-output tables as in the empirical part. First, 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 these into three. I proceed as follows: First, I treat mining as a foreign sector, since it is relatively small, employs very little and produces an extremely tradable output. I include into non-tradables all service sectors, construction, utilities and agriculture. The remaining

[30] It is important to emphasize that the model pertains to a small economy, so that it should be above the price elasticity of export demand for US goods.

sectors are all manufacturing, which I rank according to their time to produce and split into two groups, which I then aggregate.

The sectors included in non-tradables 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.

I do not allow explicitly for indirect taxes in the model, and I share them between labor and capital share[31]. Finally 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 whose income is counted as capital income rather than wages. This brings the aggregate labor share close to 0.7, which is the norm of developed countries.

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

4.2.7 Exogenous processes

The exogenous state determines the path of interest rates and productivity. These are described by the following auto-regressive processes:

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

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 Argentinian and US government bonds[32]. 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,

[31]For an interesting account of how heterogeneity in indirect taxes provides a foundation for fluctuations in TFP, see Benjamin and Meza (2009)

[32]The spread is given by the EMBI series for Argentina calculated by JP-Morgan. See Neumeyer and Perri (2005) for details.

for TFP 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.

4.2.8 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,

$$\begin{aligned} Y^0\left(s^t\right) &= Z^0\left(s^t\right) \\ Y^1\left(s^t\right) &= Z^1\left(s^t\right) \\ Y^2\left(s^t\right) &= Z^2\left(s^t\right) \end{aligned}$$

4.3 Experiments

The experiments consist of giving the model economy a simultaneous shock to the interest rate, productivity and export demand. All shocks follow the AR(1) process described in the calibration section and I trace the perfect foresight path in response to these shocks. 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 over crises occurring over 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

To discipline the experiments, I chose the amplitude of the shocks so that, in the trough of the crisis, the model reproduces exactly the average deviations from trend of GDP, exports and investment prevalent in the data[33].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, -0.17%, -0.05% and -0.52%. I recalibrate the size of the shocks for each version of the model so as not to give an unfair advantage to either of them.

I compare the difference between the two manufacturing sectors implied by the experiments to the differences implied by the data. I construct the empirical counterpart of the sectoral data as follows: I split the 28 industries available in the UNIDO database in two groups according to the time to produce and I calculate for each country an aggregate for each group. These are weighted averages from the log deviation of each industry/country observation from its own trend. The weights are given by the ratio between the value added of a given industry and the value added for its group in $t^* - 3$.

[33] 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 that is conceptually consistent with the model is necessarily more indirect and data intensive and, therefore, more dependent on judgement 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.

For each experiment, I report the difference in output between the two manufacturing sectors in the trough of the crisis, which I also compare to the data.

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[34].

4.3.1 Results

Graph 3 shows the time series behavior of aggregate and sectoral output in the three years following the on-set of the crisis with an intermediate level of price elasticity of foreign trade. While the both the models with and without time to produce matches the trough of GDP by construction, it is comforting to see that it also does a good job in the periods before and after the trough. The lack of a level effect does not mean that the model with time to produce lacks amplification since the size of the shocks are recalibrated from one model to the other. All this means that, in principle, both models are able to reproduce the dynamics of output.

What is most interesting is the behavior of sectoral output in the two models. In particular, 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 first panel in Table 10 shows the difference between the two sectors at the trough of the crises given different values of the price elasticity of exports. As one would expect, the difference between the two sectors is largest in the model with time to produce for larger elasticities. However, 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 that allows producers to take advantage of a drop in wages will not perform well. Furthermore, it has been suggested that in developing countries there is a large pool of under-employed workers involved in subsistence activities that can easily enter and exit the labor force cite. 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 short and long time to produce 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 to the sectors that comes close to the data.

The last panel shows results with 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. One effect of a lower elasticity 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 11. The up-shot is an even larger relative loss of the high time to produce sector.

[34] I solve the model using Dynare.

4.3.2 The impact of the interest rate shock

Last, I consider the impact of an interest rate shock in isolation. This provides the link to the broader literature. Graph 4 shows the response of GDP and sectoral output to a 10% shock to the interest rate when the price elasticity of exports is equal to 20. The model with time to produce is able to generate a swift drop in output whereas the model actually generates a small boom. With time to produce, the model implies a drop in GDP of 1.3% in the quarter after the shock hits. This compares with the estimate by Uribe and Yue of a reaction of GDP to an equivalent shock of about 2% [35]

The sectoral decomposition provides some clues about what is going on. When the interest rate shock hits there is a strong reallocation from the non-tradable sector to the tradable sector. This implies a strong boom in tradables. With instantaneous production, the boom in tradables is large enough that overall GDP actually increases in response to the shock. However, with time to produce, this boom is somewhat checked, since tradables have longer production lags.

Table 12 shows the drop in output in the first quarter after 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 to 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 open, this becomes comparatively less important.

5 Conclusion

I propose a small change to an otherwise standard small open economy model. This is to require that production takes time. The model is calibrated to match the following facts:

1) The inventory/cost ratio of manufacturing sectors approximate the ratios in the data

2) The drops in output, investment and exports during the crisis match the ones in the data

Given the calibration, it has the following two implications, both of which conform to the data:

a) The manufacturing sector with long time to produce drops substatially more in the crisis than the sector with short time to produce

b) A shock to the interest rate generates a swift and sizeable drop in aggregate output, accounting for about than 60% of the short-term impact identified in the literature.

The results are complemented by reduced form regressions that essentially rule out a role for alternative candidates that are not explicitly accounted for in the model, such as short-term inventory adjustment dynamics, financial frictions and effects of firm size.

While the results do not account for the full force of the identified empirical patterns, the overall strategy was conservative in two aspects: First, it took the time to produce within firms as a proxy

[35] Uribe and Yue consider both shocks to international and to domestic interest rates. Since my model does not distinguish between the two, I am taking their estimate to a shock to the domestic interest rate as the relevant one.

for the time to produce over the whole economy. The two would differ if some firms are specialized in producing inputs that they can only sell to other domestic firms. From that perspective, the model results are a lower bound on the full potential effect of an interest rate shock on production. Second, the model takes the inventory turnover ratios at face value. This does not include leads and lags in hiring and training of labor force that could have a very similar effect to time to produce.

The most important identifying assumption in the paper is that the interest rate shock is homogeneous for all agents in the economy. This would not be the case if firms are credit constrained. An explicit treatment of the role of time to produce in a framework with credit frictions is a sure path for further research.

Finally, on a methodological note, the use cross-sectional information to discipline macro-economic models is a very promising route, specially given the increasing availability of good sectoral and microeconomic data.

Appendix: 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 now

$$\begin{aligned} Y_t &= \left([Z_{t-1}(1)]^{1-\omega} [Z_{t-2}(2)]^{\omega} \right)^{\rho} \\ Z_t(v) &= (M_t(v))^{1-\alpha_L} (L_t(v))^{\alpha_L} \end{aligned}$$

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 $L_t(v)$

Then value added is defined as

$$VA_t = Y_t - p_t^m (M_t(1) + M_t(2)) + \text{Inv}_t - R_{t-1}\text{Inv}_{t-1}$$

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 foresigh, profit maximization implies that:

$$VA_t = (1-\rho) Y_t + \rho\alpha_L ((1-\omega) Y_{t+1} + \omega Y_{t+2})$$

One important observation is that while output is determined by prior output choices, value added is not since it incorporates the income of workers involved in the production of future output. If I extended the model to allow for fixed capital, it would also include the rental rate of capital used for production of future

Appendix: Inventory Turnover and Interest Exposure with generic production function

This section extends the framework in section 2 to allow for generic production functions. Suppose

$$y_t = f\left(\{M_{t-v}(v)\}_{v=0}^{N} \right)$$

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 chose all the $M_{t-v}(v)$.

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:

$$\begin{aligned} &\min \sum_{v} \Gamma_{t-v}(v)\, q_{t-v} M_{t-v}(v) \\ s.t. \quad : \quad & f\left(\{M_{t-v}(v)\}_{v=0}^{N}\right) \geq y_t \end{aligned}$$

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:

$$\frac{dC\left(y_t, \{\Gamma_{t-v}(v), q_{t-v}\}_{v=0}^{N}\right)}{C\left(y_t, \{\Gamma_{t-v}(v), q_{t-v}\}_{v=0}^{N}\right)} = \sum \frac{\Gamma_{t-v}(v)\, q_{t-v} z_{t-v}(v)\, v}{\sum_u \Gamma_{t-u}(u)\, q_{t-u} z_{t-u}(u)} \frac{dR}{R}$$

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.

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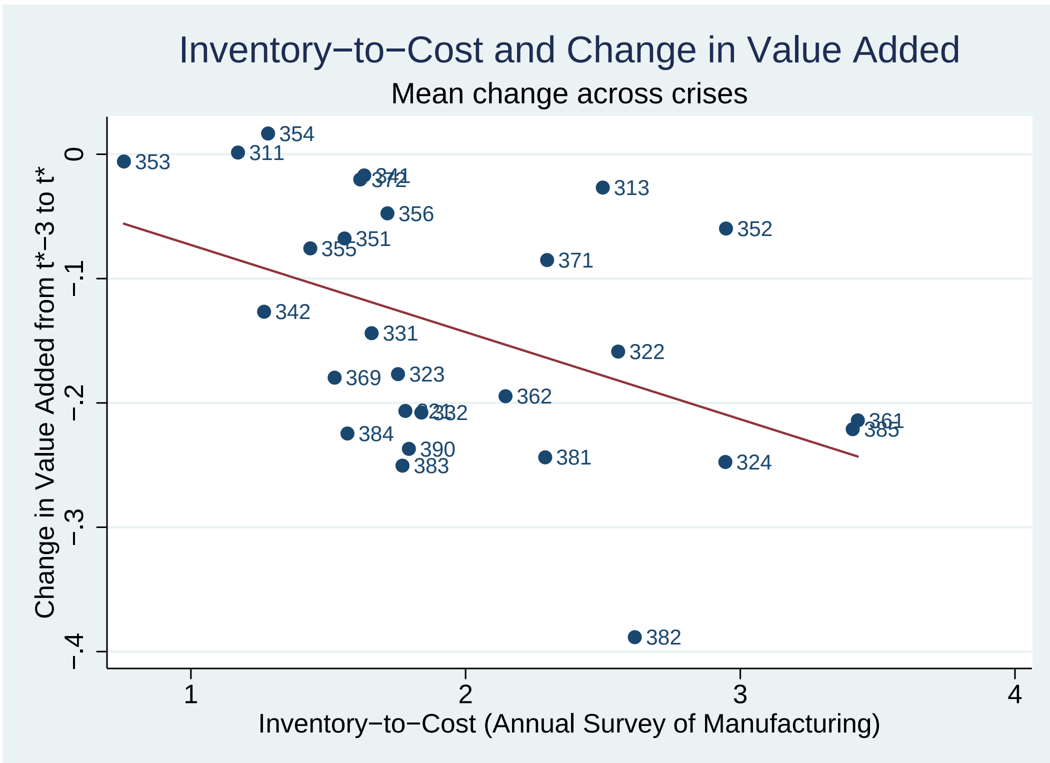

Figure 1: Change in value added averaged across crises episodes against inventory turnover for each industry

The change in value added is measured between as the log change in value added in the three years leading to the trough of the crisis. The turnover ratio is the ratio between total inventories and production 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.

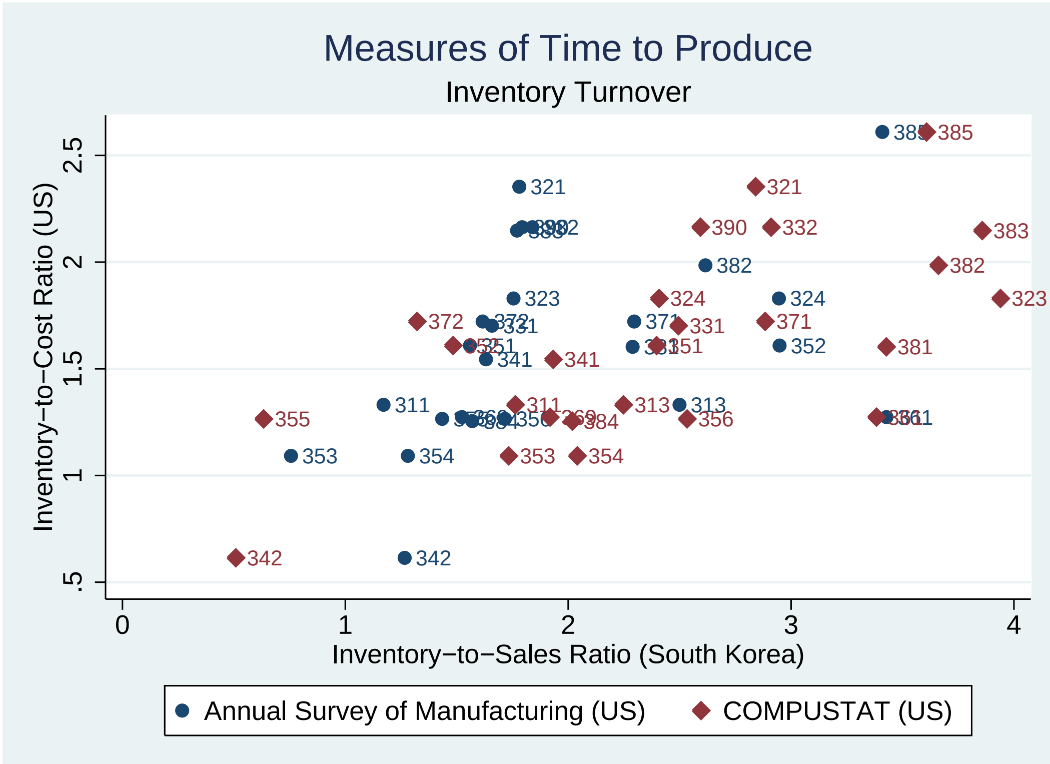

Figure 2: Inventory Turnover Measures
The change in value added is measured between as the log change in value added in the three years leading to the trough of the crisis. Time to produce is the ratio between total inventories and production costs calculated based on data from the Annual Manufacturing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

Country	Year	N	Country	Year	N
Argentina	1982	28	Turkey	1994	28
El Salvador	1982	27	Marocco	1995	27
Brazil	1983	26	Mexico	1995	28
Chile	1983	28	Indonesia	1998	27
Mexico	1983	28	South Korea	1998	28
Peru	1983	28	Malaysia	1998	28
South Africa	1983	28	Russia	1998	28
Cote d'Ivoire	1984	20	Thailand	1998	8
Nigeria	1984	8	Ecuador	1999	28
Uruguay	1984	28	Turkey	1999	28
			Argentina	2002	28

Table 1: Crises Episodes
The episodes are the same ones selected by Calvo et al. (2006a), see text for details.

	mean	median	min	max	stdev
Inventory Turnover (Survey of Manuf.)	1.97	1.77	0.76	3.43	0.66
Inventory Turnover (COMPUSTAT)	2.46	2.45	0.51	3.94	0.91
Inventory Turnover (Korea)	1.60	1.61	0.61	2.61	0.44
Export	0.25	0.19	0.04	1.03	0.16
Investment	0.22	0.13	0.00	0.87	0.21
Durable Cons.	0.08	0.03	0.00	0.41	0.09
Cyclicality	1.36	1.38	0.49	2.43	0.47
Labor Share	0.14	0.14	0.02	0.31	0.06
Materials Share	0.66	0.67	0.50	0.86	0.07
Import Share	0.12	0.10	0.02	0.75	0.08
External Dependence	0.24	0.22	-0.45	1.14	0.33
Size	1.44	1.50	0.49	1.97	0.28

Table 2: Descriptive Statistics

The change in value added is the change between three years from the trough of the crisis to the trough itself. It is calculated based on the volume index for value added made available by UNIDO. The data-set includes industry observations at the three digit classification ISIC Rev. 2. All observations lying more than three interquartile ranges from the median were removed. Inventory Turnover (Survey of Manuf.) is the ratio of aggregate inventories to 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 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.

	Change in Value Added	Inventory Turnover (Survey of Manuf.)	Inventory Turnover (COMPUSTAT)	Inventory Turnover (Korea)
Inventory Turnover (Survey of Manuf.)	-0.4522	1		
Inventory Turnover (COMPUSTAT)	-0.6234	0.4841	1	
Inventory Turnover (Korea)	-0.535	0.4328	0.6549	1
Export	0.0185	-0.1866	0.0842	0.2352
Investment	-0.4799	0.2652	0.3664	0.0823
Durable Cons.	-0.6206	0.1082	0.3937	0.4571
Cyclicality	-0.2797	0.0379	0.1691	0.0191
Labor Share	-0.66	0.4152	0.3061	0.3557
Materials Share	0.4516	-0.3991	-0.1761	-0.1988
Import Share	0.0957	-0.2635	-0.0443	-0.0228
External Dependence	-0.1671	0.0506	0.2496	0.3428
Size	0.3603	-0.1328	-0.1581	-0.0907

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.

	(1)	(2)	(3)
	Annual Survey of Manuf.	COMPUSTAT	South Korea
Inventory Turnover	-0.0404**	-0.0307*	-0.0519
	(0.0177)	(0.0157)	(0.0408)
Exports	-0.203	-0.184	-0.153
	(0.126)	(0.137)	(0.147)
Investment	-0.0872	-0.0479	-0.0927
	(0.0824)	(0.0673)	(0.0760)
Durable Consumption	-0.396**	-0.311	-0.287
	(0.201)	(0.220)	(0.215)
Cylicality	-0.0291	-0.0401	-0.0424
	(0.0342)	(0.0343)	(0.0384)
Wage Share	-0.738**	-0.733**	-0.733*
	(0.352)	(0.344)	(0.393)
Materials Share	0.122	0.273	0.181
	(0.197)	(0.198)	(0.217)
Import Share	-0.144	-0.156	-0.140
	(0.144)	(0.157)	(0.149)
External Dependence	0.0296	0.0509	0.0614*
	(0.0395)	(0.0416)	(0.0372)
Size	0.0759	0.0992**	0.0935**
	(0.0543)	(0.0486)	(0.0474)
Previous Growth	0.109	0.106	0.108
	(0.0715)	(0.0708)	(0.0730)
Observations	449	433	433
R-squared	0.458	0.468	0.464

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 measures of time to produce based on different sources (see table 2 for a description of all variables). 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)

		(1)	(2)	(3)
		Annual Survey of Manuf.	COMPUSTAT	South Korea
Eighties	Inventory Turnover	-0.0329	-0.0295*	-0.0525
		(0.0235)	(0.0176)	(0.0624)
	Observations	215	208	208
	R-squared	0.464	0.478	0.475
Nineties	Inventory Turnover	-0.0414*	-0.0273	-0.0398
		(0.0236)	(0.0188)	(0.0489)
	Observations	234	225	225
	R-squared	0.504	0.494	0.488
Latin America	Inventory Turnover	-0.0390*	-0.0351*	-0.0561
		(0.0222)	(0.0200)	(0.0523)
	Observations	223	215	215
	R-squared	0.430	0.438	0.429
Other Continents	Inventory Turnover	-0.0534**	-0.0168	-0.0754
		(0.0228)	(0.0173)	(0.0577)
	Observations	226	218	218
	R-squared	0.515	0.520	0.525
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10				

Table 5: Sub-samples

Cells are estimated coefficient on inventory turnover ratios. 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 2 for description of all variables. Standard errors are robust to overlapping clusters on country and industry (Cameron et al. 2006)

		Annual Survey of Manuf.	COMPUSTAT	South Korea
t*-3 to t*	Inventory Turnover	-0.0443**	-0.0323*	-0.0520
		(0.0173)	(0.0168)	(0.0380)
	Observations	435	420	420
	R-squared	0.453	0.461	0.456
t*-2 to t*	Inventory Turnover	-0.0127	-0.0232*	-0.0277
		(0.0153)	(0.0139)	(0.0350)
	Observations	281	272	272
	R-squared	0.385	0.418	0.411
t*-1 to t*	Inventory Turnover	-0.00970	-0.0151	0.00651
		(0.0110)	(0.0116)	(0.0302)
	Observations	278	270	270
	R-squared	0.389	0.393	0.382
t*-3 to t*+1	Inventory Turnover	-0.0621*	-0.0444**	-0.0432
		(0.0331)	(0.0222)	(0.0461)
	Observations	446	431	431
	R-squared	0.363	0.367	0.358
t*-3 to t*+5	Inventory Turnover	-0.0299	-0.0484***	-0.0621
		(0.0241)	(0.0165)	(0.0453)
	Observations	432	417	417
	R-squared	0.402	0.408	0.398

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 2 for description of all variables. Standard errors are robust to overlapping clusters on country and industry (Cameron et al. 2006)

	Parameter	Value
θ	Elasticity of demand for exports	2, 20 or 200
σ	Relative risk aversion	2
ψ	Elasticity of labor supply	2.3
β	Discount rate	0.97% p.y.
λ	Elasticity of substitution between home and foreign goods	2
ρ	Elasticity of substitution between home sectors	0.75
ζ	Elasticity of investment to marginal q	3
δ^K	Depreciation of capital	6% (per year)
δ^D	Depreciation of durables	13% (per year)
ξ	Elasticity of maintenance cost to utilization	0.5
η_r	Persistence of interest rate shock	0.8 (per quarter)
η_a	Persistence of TFP shock	0.95 (per quarter)
η_f	Persistence of Terms of Trade shock	0.8 (per quarter)
$\bar{r}$	Steady state interest rate	0.035 (per year)

Table 7: Benchmark Calibration

	M^0	M^1	M^2	C	J	G	I
Sector 0	0.23	0.29	0.19	0.71	0.00	1.00	0.67
Sector 1	0.08	0.22	0.09	0.20	0.43	0.00	0.09
Sector 2	0.04	0.04	0.24	0.05	0.27	0.00	0.09
Imports	0.03	0.15	0.12	0.04	0.31	0.00	0.16
Total Inputs	0.37	0.69	0.64				
L compens	0.44	0.20	0.28				
Value Added	0.63	0.31	0.36				

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

	M^0	M^1	M^2	Total Inputs	C	J	G	I	EXP
Sector 0	0.23	0.13	0.04	0.40	0.36	0.00	0.13	0.12	0.00
Sector 1	0.17	0.22	0.05	0.44	0.23	0.04	0.00	0.04	0.25
Sector 2	0.16	0.08	0.24	0.48	0.12	0.05	0.00	0.07	0.28

Table 9: Uses of sectoral output
Steady state Fraction of the output of each sector used in the production of the good in each column. Columns starting from "Total Inputs" sum to 1

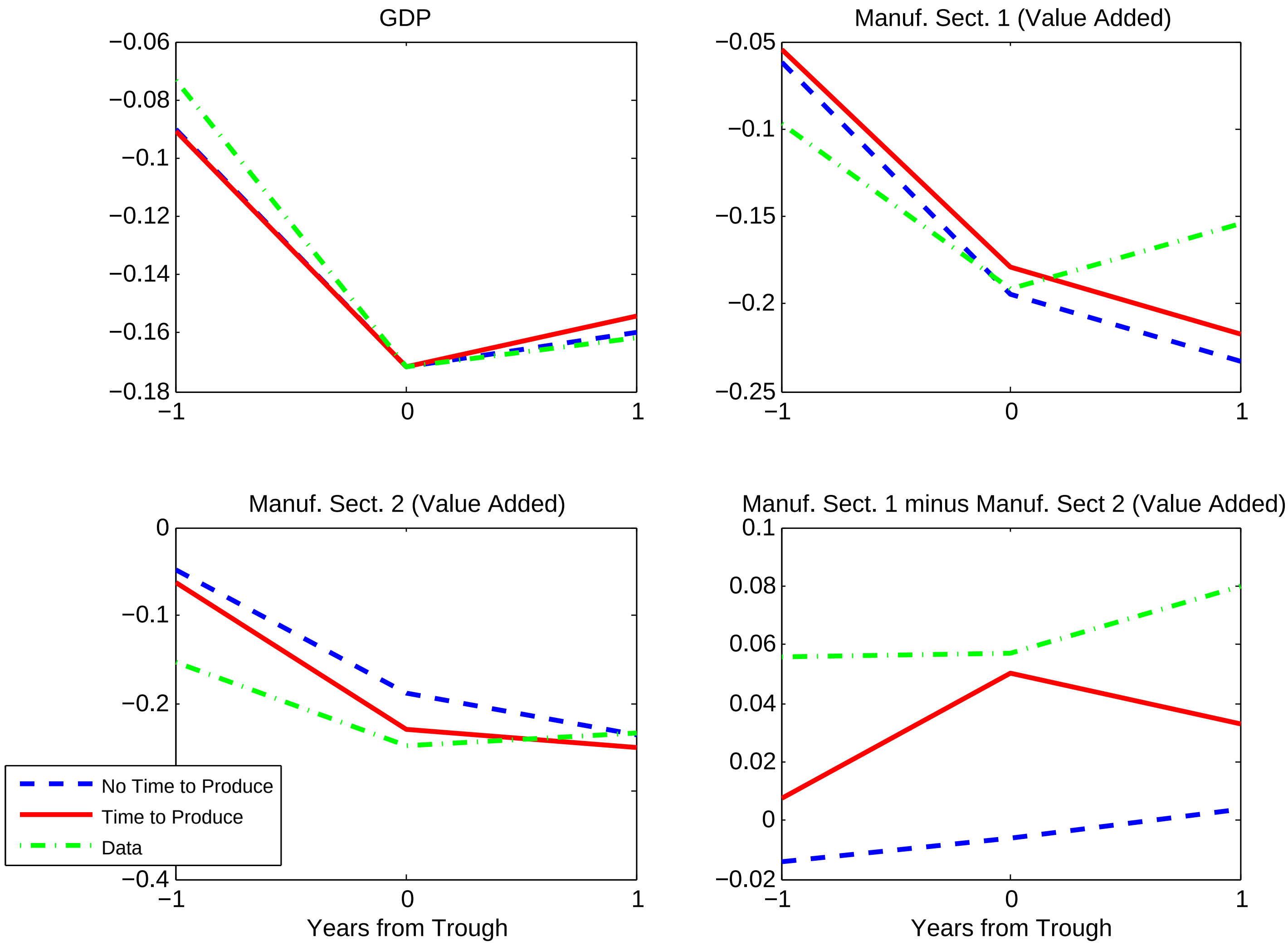

Figure 3: Model and Data The graph shows the behavior of aggregate and sectoral output around the trough of the crisis (year 0). The parametrization corresponds to table 7 and $\theta = 20$ The simulated data are averages of simulations starting in all 8 half-quarters of year 1. The actual data are deviations from a linear trend calculated based on years t-10 to t-3, where t is the trough of the crisis. Sectoral data are aggregated based on shares of value added in t-3

		Sect. 1 minus Sect. 2		
	θ	2	20	200
Benchmark	Time to Produce	0.005	0.050	0.194
	No Time to Produce	0.000	-0.006	-0.023
$\psi = 10$	Time to Produce	0.014	0.063	0.220
	No Time to Produce	0.010	0.012	0.023
$\zeta = 2$	Time to Produce	0.006	0.071	0.277
	No Time to Produce	-0.004	-0.014	-0.042
	Data		0.057	

Table 10: Differences in output between the two manufacturing sector in the trough of the crisis Benchmark calibration 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 calibrated to match the mean deviation from trend of output, investment and exports in the trough of the crisis. The "data" benchmark is constructed by, for each country, constructing deviations of each manufacturing sector from its pre-crisis trend (finishing three years before the trough). These detrended values are aggregated in two sectors using shares of value added three years before the trough. The top number is the average difference between the two sectors.

		Interest Rate on Impact		
	θ	2	20	200
Benchmark	Time to Produce	1.18	1.14	1.14
	No Time to Produce	1.18	1.13	1.11
$\psi = 10$	Time to Produce	1.19	1.16	1.16
	No Time to Produce	1.19	1.15	1.13
$\zeta = 2$	Time to Produce	1.33	1.30	1.30
	No Time to Produce	1.33	1.30	1.28

Table 11: Interest Rate Shocks

Benchmark calibration is given by 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.

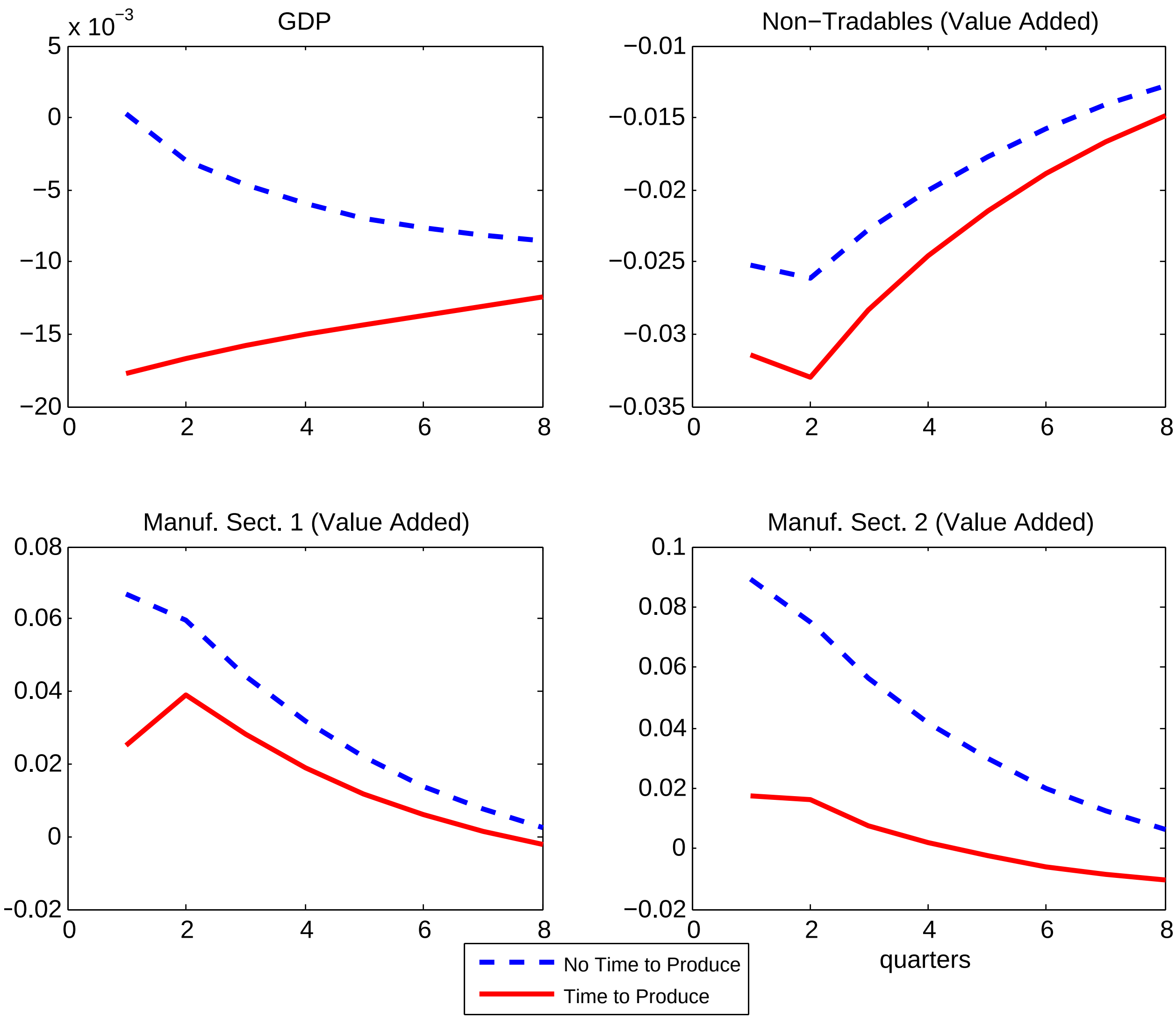

Figure 4: Effect of a 10% increase in the interest rate
Reaction of aggregate and sectoral output to a 10% increase in the interest rate. Calibration is the benchmark, given in table 7 with $\theta = 20$.

		GDP one quarter after impact		
Benchmark	Time to Produce	-0.0082	-0.013	-0.0127
	No Time to Produce	-0.0055	0.0003	0.0027
$\psi = 10$	Time to Produce	-0.019	-0.0258	-0.023
	No Time to Produce	-0.0167	0.0028	0.0131
$\zeta = 2$	Time to Produce	-0.0072	-0.0105	-0.0097
	No Time to Produce	-0.0045	0.0009	0.003

Table 12: Short-term response of output to a 10% interest rate shock
Benchmark calibration is given by 7.