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Just-in-Case Inventories

A Cross-Country Analysis

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Abstract

Guasch and Kogan find that raw materials inventories in the manufacturing sector in the 1970s and 1980s were two to three times higher in developing countries than in the United States, despite the fact that in most developing countries real interest rates were at least twice as high. Those significantly high levels of inventories are a burden and an obstacle to country competitiveness and need to be addressed. Poor infrastructure and ineffective regulation, as well as deficiencies in market development, rather than the traditional factors used in inventory models (such as interest rates and uncertainty), are the main determinants and explain these differences. Cross-country estimations show that a one standard deviation worsening of infrastructure increases raw materials inventories by 11 percent to 37 percent, and a one standard deviation worsening of markets increases raw materials inventories by 18 percent to 37 percent. These findings are robust across a number of different proxies and specifications, including an industry-level specification that controls for fixed country effects.

This paper—a product of the Finance, Private Sector, and Infrastructure Unit, Latin America and the Caribbean Region—is part of a larger effort in the region to improve country competitiveness. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Joy Troncoso, room I5-118, telephone 202-473-7826, fax 202-522-2106, email address jtroncoso@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. Luis Guasch may be contacted at jguasch@worldbank.org. April 2003. (31 pages)

Just-in-Case Inventories: A Cross-Country Analysis

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1. Introduction

Although anecdotal evidence and some case studies (Quirós [1996], Gulyani [2000]) suggest that inventories are higher in developing countries, there are almost no systematic studies that have documented and quantified the difference and attempted to explain this phenomenon. This is relevant because high inventory levels impact adversely unit cost and competitiveness. This study uses newly-assembled data for 51 countries in the early 1970s and 1980s to draw out some stylized facts about the pattern of inventory holdings. The summary statistics from that data set illustrating the high inventory levels in developing countries and their significant cost to the economy is the motivation for this paper.

U.S. businesses typically hold inventories equal to about 15% of GDP while inventories in many developing countries, as we document here, are often twice as large, and in raw materials, are often three times as large. The impact of those inventory levels on firm unit costs and on country competitiveness is extraordinarily significant. First are the financial cost associated with inventories, and those can be quite high since cost of capital in developing countries is usually well above 15 percent. Second are the other associated costs of inventories, such as taxes, insurance, obsolescence and storage, that can add another 5 percentage points. Table 1 illustrates the magnitude of those cost indicating an average cost of 19.25 percent, and standard range for those costs between 9 and 50 percent, pointing the urgency of lowering inventory levels. Putting things into perspective, if the interest rate for financing inventory holdings is 15%-20%, a conservative estimate in most developing countries, then the cost to the economy of the additional inventory holdings is greater than 2% of GDP. Suppose that firms in developing countries keep high inventories in response to poor infrastructure, which we find in this study to be a key determinant. Then, as an example, consider that the total transport infrastructure stock in Bangladesh is about 2% of GDP (World Bank [1994]) while this figure is about 12% in the United States (Munnell [1992]). One year's worth of savings in inventory holding costs would be enough to double Bangladesh's infrastructure stock; the infrastructure improvement could pay for itself.

Table 1 : Inventory Carrying Cost Components

Component	Average (%)	Range (%)
Capital Cost	15.00	8-40
Taxes	1.00	0.5-2
Insurance	0.05	0-2
Obsolescence	1.20	0.5-2
Storage	2.00	0-4
Total	**19.25%**	**9-50%**

Source: Bowersox and Closs (1996)

These calculations are merely a lower bound on the cost of the additional inventory as a result of three other types of costs that we have not measured. First is the missing economic activities costs; there are certain transactions that would have been worthwhile were it not for the high inventory holdings necessary to complete them effectively. It is difficult to estimate the size of these lost transactions. Second, firms in developing countries will take costly steps to mitigate the institutional or structural factors creating a need for high inventories. Gulyani [2000] describes how Maruti, an Indian automaker, tries to decrease inventory costs by encouraging its suppliers to locate nearby through government-sponsored incentive packages and the building of supplier parks. Fisman and Khanna [1998] describes co-location by business group affiliates to overcome infrastructure shortages. A numerical example helps to clarify this point. Suppose that for a particular firm, 30 days of inventory are sufficient when transportation networks are well developed but 90 days of inventory are required when transportation networks are poor. The firm might choose to reduce these 90 days to 60 days by requiring suppliers to locate nearby. Additional costs due to poor infrastructure as measured by increased inventory would be 30 days while the actual costs are higher. Third, high inventories can obscure efficiency problems. Current thinking in the manufacturing and operations research field suggests that low inventories make it easier to trace problems in the production process as Nahmias [1997] states in a discussion of just-in-time inventory management:

> A popular analogy is to compare a production process with a river and the level of inventory with the water level in the river. When the water level is high, the water will cover the rocks. Likewise, when inventory levels are high, problems are masked. However, when the water levels (inventory) is low, the rocks (problems) are evident. Because items are moved through the system in small batches, 100 percent inspection is feasible.

The objective of this paper is to report systematically the high inventory holdings in developing countries and to impute their determinants, pointing to policy interventions to considerably reduce the required inventories and so to improve country competitiveness. Section 2 of this paper provides a brief theoretical overview of why firms hold inventory. A model of firm inventory holdings is presented to motivate the empirical work. Section 3 describes the inventory data we have collected. Section 4 contains the estimations, which show that inventories are significantly higher in developing countries due to poor infrastructure and market interference. Section 5 concludes.

2. Theoretical Overview

Two characteristics of economies in developing countries lead us to expect them to have higher inventories. First, a poorly functioning market can lead to shortages of certain goods; firms expecting these shortages would stock up on inventories in anticipation. In the Soviet Union, for example, firms were known to maintain a high ratio of raw materials inventories to finished goods inventories for this reason. Chikan [1991] has shown empirically that socialist countries held a larger ratio of raw materials inventories to finished goods inventories. Second, poor infrastructure increases uncertainty in delivery schedules and increases the time it takes for an order to arrive, causing firms to stock up in anticipation.

We examine the effects of these two factors in language commonly used by economists and operations researchers in studying the behavior of inventories. We first explain intuitively the reasons why firms hold inventory at all. We then model mathematically the optimization decision that the firm faces. This model is useful for understanding how poor infrastructure and poor markets will affect inventory decisions. The model also motivates the empirical specifications.

The economics literature typically cites three theoretical reasons for why businesses hold inventory: production smoothing, stockout avoidance, and reduction of transaction costs. Blinder [1991] gives examples of other reasons such as holding inventories for display purposes or to speculate on or hedge against price movements, but the above three explanations are the most prevalent.

In the production smoothing model, firms have a rising marginal cost curve. Firms seeking to minimize production costs in the face of sales that vary predictably over time will produce a constant amount every month, accumulating inventories when sales are below production and depleting inventories when sales exceed production. Firms select their inventory levels by weighing storage and financing costs against potential savings from production optimization. (See Blinder [1991] and Fukuda and Teruyama [1988] on the empirical validity of this model.)

The stockout motive presumes that demand varies unpredictably over time and that the firm faces penalties in the form of loss of goodwill or loss of potential sales if it cannot satisfy demand immediately out of inventory. Firms hold inventory to meet this unanticipated demand. While the production smoothing motive only explains why manufacturers would keep finished goods inventories, the stockout motive explains the existence of retail inventories and raw materials inventories as well. The stockout motive applies also if the uncertainty occurs not in demand but in the timing of deliveries. Firms concerned about stockout optimize inventory levels by trading off holding costs against the likelihood of stockout and the expected cost of a stockout.

The transaction cost motive assumes that there are certain fixed costs to placing an order or that there are economies of scale in ordering in large batches. When faced with uncertain demand as in the stockout model, firms follow an (S,s) strategy. As soon as the inventory falls below s, the firm places an order of a lot size necessary to bring the inventory back to S. In determining the optimal lot size, firms weigh inventory holding costs against savings from large orders. According to Mosser [1991], retail inventories are usually managed by an (S,s) rule, as evidenced by its presence in textbooks on purchasing, retailing, and merchandising as well as in trade journals and business reviews which describe implementations of the (S,s) rule using computers.

We present a variant of the (S,s) model called the (Q,R) model following the notation and description in Nahmias [1997] in order to motivate the empirical work According to this (Q,R) model, whenever the firm's inventory reaches a level R, it orders a quantity equal to Q. This model differs from the (S,s) model in that inventory position is assumed to be known at all times such that an order can be placed at exactly the time at which inventory reaches R so that the order quantity is always exactly Q. The firm chooses Q and R in order to minimize the sum of three costs: holding cost, transaction cost, and stockout cost. In order to simplify the model in Nahmias, we assume that the ratio of Q to annual inventory is fixed such that every firm places orders at equal intervals. This simplification allows us to focus on the portion of inventory most relevant to this analysis: the buffer stock. We also modify the model to include the value added, which is necessary for our empirical analysis.

We show below how the firm chooses the optimal buffer stock in a (Q,R) setting by weighing holding cost against stockout or penalty cost.

The holding cost of the buffer stock during the year is the value of the buffer stock multiplied by the interest rate. In the (Q,R) model, an order is placed when the inventory level reaches R and the new inventory arrives after some time T expressed as a fraction of a year. This new inventory is then expected to arrive when the inventory level reaches R-λT. Assume that each final good sells for $1 and it takes one unit of raw materials with a value of (1-v), where v is value added, to produce one final good. Holding cost is then i*(1-v)*(R-λT), where i is the interest rate for borrowing working capital.

Penalty costs are incurred whenever inventory level reaches zero and total penalty costs are proportional to the value of the items that are not immediately available for sale due to the shortage. Under the (Q,R) model, inventory position is continually reviewed and a new order is placed as soon as inventory reaches the R level. Stockouts only occur when the demand between the time when an order is placed and when the order is received turns out to be greater than R. If annual demand has a normal distribution with mean λ and standard deviation σ, then the distribution of demand over the lead time is normal with mean λT and standard deviation $\sigma\sqrt{T}$. To simplify the notation, the standardized variate z is defined as $(R-\lambda T)/\sigma\sqrt{T}$. The expected value of the shortage n(R) is given by:

$$n(R)=\sigma\sqrt{T}\int_{z}^{\infty}(x-z)\phi(x)dx$$

where ϕ(x) is the normal density function. The shortage in a year will be the shortage incurred in one cycle, n(R), multiplied by the number of cycles λ/Q. Assuming that the firms pays a penalty p for each unit of stockout in raw materials, the expected annual penalty cost will be pλn(R)/Q.

The sum of these two costs G(R) is:

$$G(R) \quad = \quad i(1-v)(R-\lambda T) \quad + \quad p\lambda n(R)/Q$$

Differentiating this cost with respect to R and setting the derivative equal to zero, we find that the optimal solution must satisfy the following equation:

$$1 - \Phi\left(\frac{R - \lambda T}{\sigma\sqrt{T}}\right) = \frac{Qi(1 - v)}{p\lambda}$$

where $\Phi()$ is the cumulative normal distribution.

This solution has three basic implications which are tested in the empirical work. First, the buffer inventory R-λT is an increasing function of T and an increasing function of the variance in T if T is stochastic. It is easy to see from the second equation that any increase in T will lead to an increase in R-λT. The intuition is that a higher T increases the distribution of demand during the lead time and the firm must maintain a higher reserve R. It can also be shown that if T is stochastic, the demand variance σ used in the model can be replaced with a weighted sum of the variance of lead time and the variance of demand. It is evident from the equations that increases in this σ, holding Q constant, will lead to a corresponding increase in R-λT. Firms keep more of a buffer stock in response to the uncertainty surrounding demand and deliveries during the lead time. We interpret poor infrastructure and poor functioning markets as either increasing the lead time T or the variance of lead time and expect, for this reason, that these country characteristics would lead to higher raw materials inventory.

Second, the optimal solution depends on value added. High value added firms will maintain higher inventory positions than low-valued added firms. This results from the fact that holding costs of raw materials as a fraction of the value of the final product are smaller for high value added firms. For example, high-end restaurants probably never run out of onions and computer manufacturers do not stock out of nuts and bolts.

Third, and more importantly for the empirical analysis, there is an interaction effect between value added and lead time or variance of lead time. Any change in σ or $\sqrt{T}$ must be offset by an equivalent percentile change in R-λT. The higher R-λT was before the change, perhaps as a result of low v, the higher will be gross change in R-λT. This type of interaction effect is predicted in most models of inventory behavior. By testing for this interaction effect explicitly, we are able exclude the effect of other variables omitted in our empirical analysis. For example, suppose we find that inventories are correlated with poor functioning markets. It is possible, however, that poor functioning markets are correlated with subsidized low interest rates for firms and it is these low interest rates that are driving the results. If we also find an interaction effect between poor markets and value added, then we can exclude the low interest rate explanation since the predicted interaction effect between interest rates and value added would be in the opposite direction. (A change in interest rates has more of an effect when value added is low, while a change in market function has more of an effect when value added is high.) Similarly, variables that affect p will lead to an interaction affect of the opposite sign as well. For example, p might depend on the production technology used because it is costlier to stop production in a continuous process rather than a batch process. By looking for an interaction effect rather than a main effect, we can be confident that differences in production technology across countries do not drive our results.

In this way, we exclude any omitted variables except those whose effect increases with value added, namely those that would affect T or σ directly. There are two such factors. First, developing countries which import intermediate goods as manufacturing inputs are likely to have higher inventory levels because the import of raw materials involves longer and more uncertain delivery times. We know, from a separate analysis we have done of plant-level inventory data in the 1980s for few Latin American countries[1] that require firms to account separately for domestic and imported inputs, that inventories of imported inputs are much higher. Second, demand may be more volatile and less predictable in some countries, leading to a higher σ. We try to explicitly control for both of these factors in our regressions.

There are a number of additional factors that ideally should be included in the country-level analysis but cannot due to a lack of cross-country data. First, the extent of informatics technology and telecommunications development in any given country can also affect the level and management of inventories by allowing a closer tracking of levels, demand and trends. Second, if developing countries were more likely to use FIFO accounting while developed countries used LIFO[2] accounting, their inventory stocks would appear to be higher, especially in cases of high inflation. Although we do not have evidence by country on this issue, our research on this topic indicates that LIFO, although allowed in the United States for tax purposes, is rare in both developing and other developed countries (Nobes and Parker [1995]). Other relevant factors are the degree of vertical integration, the concentration of upstream suppliers, production to stock vs. production to order, and the type of production technology. Our test using the interaction effect approach should eliminate the effects of some of these.

Our approach in this paper is that high inventories are an optimal response to particular characteristics of a developing country. An alternative approach is that high inventories represent firm inefficiency, a result of poor management perhaps. Even after controlling for level of development, it is possible that poor management of inventories would be correlated with poor functioning markets because managers in such countries are likely to focus on rent seeking activities rather than productive activities. By examining interaction effects and also looking for correlations between our poor market proxies and finished/process inventories, we check that our results do not result from this factor.

3. Data Description

It is difficult to obtain accurate data on inventory holdings for developing countries. The aggregate data reported in the national accounts are change in inventories rather than the stock of inventories; often these data are based not on an inventory survey but on the difference between production and sales. Since production and sales are measured with errors, inventory data based on the difference between these figures are

[1] This data on Chile, Colombia, and Mexico was provided to us for use at the World Bank by James Tybout. A description of the data is in Roberts and Tybout [1996].

[2] In LIFO (Last-In First-Out) accounting when a good or raw material is removed from inventory, the accounting cost is the cost at which the last good or raw material was purchased. In FIFO (First-In First-Out) accounting, the cost of the oldest unit is used.

highly inaccurate. Nevertheless, our initial results from work with aggregate inventory levels computed from the National Accounts data were not inconsistent with the stylized observation that developing countries hold more inventory than developed countries. For this study, we use more accurate and disaggregated data on inventories collected by national statistics agencies. Most national statistics agencies do have inventory stock data but do not publish it. In order to report the size of the country's industrial production, the statistics agency typically carries out a firm survey or census, which asks about total inventory holdings at the beginning or end of the year. More detailed surveys break down inventories into three or more categories: raw materials inventory, goods-in-process inventory, and finished goods inventory. Surveys also request data on gross sales and on the gross value of inputs consumed. A few countries do not provide data on raw materials consumption and these countries were not included in the analysis of raw materials inventory.

Rather than surveying these statistics agencies ourselves to collect inventory data, we rely on a broad survey completed by the United Nations. The UN, in its World Programme of Industrial Statistics, surveyed the statistics departments of countries around the world, requesting industrial data for 1973 and 1983. Unfortunately, this program was discontinued after 1983. In some cases, these data were provided for an adjacent year but not the year requested. Table 2 lists the countries and the type of data provided. 31 countries provided data on inventories for the 1973 survey and 43 countries provided data on inventories for the 1983 survey, yielding a database of inventory data for 51 countries for one or two years. Each country provided data according to 3-digit ISIC codes, which are listed in Table 3.

Table 2: Data Availability

Country	1973 Survey	1983 Survey	Raw Materials Coef.	Finished and Process Coef.
1. Australia	1973	*1984	0.183	0.105
2. Austria	1973	1983	0.192	0.119
3. Bangladesh		1982	0.265	0.134
4. Barbados		1983	0.222	0.082
5. Brazil	*1973			0.090
6. Canada	1973		0.156	0.111
7. Chile	*1973	1983	0.246	0.097
8. Colombia	1973	1983	0.203	0.108
9. Costa Rica		*1980		0.140
10. Cyprus	1972	1981	0.209	0.129
11. Czechoslov	1973	1983	0.233	0.138
12. Denmark	1973	1983	0.193	0.117
13. Ecuador		1983	0.280	0.132
14. Egypt		1979	0.354	0.148
15. El Salvador		1983	0.295	0.109
16. Fiji		1983	0.227	0.131
17. Finland		1983	0.272	0.146
18. Guatemala	1974	*1983	0.277	0.108
19. Honduras	1975		0.298	0.106
20. Hong Kong	1973	1983	0.135	0.058
21. Hungary	1973	1983	0.298	0.092
22. Iceland		1983	0.147	0.050
23. Iran		1983	0.304	0.129
24. Israel	1972	1982	0.211	0.113
25. Japan	1973		0.119	0.078
26. Korea	1973	1983	0.106	0.091
27. Kuwait	1974	1983	0.251	0.094
28. Luxembourg	1973		0.205	0.089
29. Macau		1983	0.137	0.087
30. Malaysia		1983	0.185	0.107
31. Malta		1983	0.257	0.109
32. Mexico		1983	0.151	0.097
33. Netherlands	1974		0.128	0.118
34. New Zealand		1983	0.181	0.113
35. Norway	1973	1983	0.169	0.145
36. Panama	1973	1981	0.287	0.092
37. Peru	1973	*1982	0.307	0.123
38. Philippines	1972	1983	0.232	0.115
39. Poland		1983	0.243	0.071
40. Portugal	1971		0.252	0.177
41. Puerto Rico	1972		0.162	0.088
42. Qatar		1983	0.221	0.082
43. Singapore	1973	1983	0.182	0.105
44. Sweden	1973	1983	0.183	0.166
45. Thailand		1982	0.236	0.118
46. Turkey	1970	1983	0.189	0.116
47. UK	1973	*1983	0.164	0.135
48. US	1972	*1982	0.112	0.112
49. Venezuela		1984	0.242	0.097
50. Zambia	1973		0.255	0.129
51. Zimbabwe		1983	0.305	0.124

* Indicates that a raw materials inventory ratio could not be calculated because of a lack of data on raw material consumption
Since the median industry coefficient is very close to zero, the country coefficients can be interpreted as inventory ratios for the median industry. For example, Korea has the lowest raw materials inventory ratio. The coefficient of 0.106 indicates that the median industry in the U.S holds about 0.106 of a year or 39 days of raw materials inventory.

Table 3: 3 Digit ISIC Codes

3	**MANUFACTURING**
31	**Food, Bevgs. & Tobacco**
311/2	Food products
313	Beverages
314	Tobacco
32	**Textiles, Apparel, Leather**
321	Textiles
322	Apparel, excl. footwear
323	Leather and prods. n.e.c.
324	Footwear
33	**Wood, Prods. & Furniture**
331	Wood & wood products
332	Furniture, etc., non-metal
34	**Paper & Prods., Printg., Pub.**
341	Paper and products
35	**Chemicals and Petrochem.**
351	Industrial chemicals
352	Other chemical products
353	Petroleum refineries
354	Petroleum, coal products
355	Rubber products
356	Plastic products n.e.c.
36	**Non-Metallic Minerals**
361	Pottery, china, etc.
362	Glass and products
369	Other non-metallic prods.
37	**Basic Metals**
371	Iron and steel
372	Non-ferrous metals
38	**Metal Prods., Mach., Equip.**
381	Metal prods. excl. machin.
382	Machinery excl. electric.
383	Electrical machinery
384	Transport equipment
385	Professional goods
39	**Other Manufacturing Ind.**
390	Other Manufacturing Ind.

Ideally, we want to know the average number of days of inventory held in each industry and country and compare this figure across countries. Such data, however, would be difficult to obtain even for the United States because collection of such data would require daily surveys of inventory holdings across firms. Instead, a good estimate (assuming the firm doesn't stock out often) of average days of inventory is the stock/flow ratio at a particular point in time. We calculate inventory ratios at the end of the year (EOY) as follows:

$$\text{Raw Materials Inventory ratio (EOY)} = \frac{\text{Raw Materials Stock (EOY)}}{\text{Raw Materials Consumed}}$$

$$\text{Final \& Process Inventory ratio (EOY)} = \frac{\text{Total Stock (EOY) - Raw Materials Stock (EOY)}}{\text{Sales}}$$

Beginning-of-year inventories were also reported, permitting the calculation of another set of inventory ratios.

Implicit in these calculations is the assumption that inventory levels at a particular point in time are representative of average inventory levels. Since the data are for the entire industry, inventory cycles of individual firms are not important. We do not have to worry that one firm places its orders early in the month as long as another firm orders late in the month. Nevertheless, if inventory cycles are correlated between firms, then the estimate of inventory levels would be inaccurate. For example, if firms consistently run out of inventory after Christmas, then using end-of-year inventory levels would underestimate average inventory levels. Empirically, inventories, at least in developed countries, are cyclical and measuring inventory at any particular time may underestimate or overestimate the average inventory level of that country; a country that appears to have high inventory levels may simply be at the top of the cycle.

The high rates of inflation in many developing countries lead to additional biases in the inventory level measurements. For example, under a constant annual inflation rate of 10%, real output of $100, an inventory level of 20% and a FIFO accounting system, nominal output would be about $105 and inventory levels, as measured by the above formulas, would be 19% in the beginning of the year and 21% at the end of the year.[3] We compensate for these problems in part by using both beginning-of-year and end-of-year inventories and also using two years for the same country when available.

4. Analysis of Determinants of Raw Materials Inventory

The statistical analysis of our inventory data consists of four parts. First, we confirm that inventories in developing countries are generally higher. This relationship is often assumed to be true, but to our knowledge, has never been shown systematically. Second, we analyze the determinants of high inventories in a cross-country framework. Controlling for level of development, we show that countries with poor functioning

[3] BOY inventory would be 20 and EOY inventory would be 22. 20/105 is about 19% and 22/105 is about 21%.

markets and poor infrastructure have higher raw materials inventories. Third, we show that these findings are robust to controls for country fixed effects by testing for the interaction effect predicted in the mathematical model. We use our industry level data to show that the inventories of higher value added industries are more affected by poor markets and poor infrastructure. Finally, we discuss the possibility that overall inventories are not affected because inventories are merely shifted upstream from finished good inventories to raw materials inventories. We find few significant correlations between finished goods inventories and our proxies for poor markets and infrastructure. This finding actually confirms our primary results because, theoretically, poor infrastructure and poor markets should primarily affect raw materials inventories. Since there are a number of omitted variables that should affect both types of inventories, the lack of a correlation between our independent variables and finished good inventories demonstrates that these omitted variables are not responsible for our results.

A. Inventories and level of development

Simple summary statistics of inventories provide an indication of the magnitude of the difference of inventories across countries. The median raw materials inventory ratio in our sample over all countries is .21 which means that the median industry holds enough inputs to cover two and a half months of production. For comparison, the median industry in the United States, the country which we expect to have one of the lowest inventories, had a raw materials inventory ratio of .11 in 1972 representing less than one and a half months of use.[4] For final and process goods inventory, the situation appears somewhat different, at least when the data are examined in aggregate. The median for the whole sample is .08 while this number is .09 for the United States. These two sets of inventory ratios, raw materials and finished goods, are only weakly positively correlated with a correlation coefficient of 0.25.

Rather than just looking at the median industry, we would like a country-level measure of inventories that takes all the data into account. The difficulty is that inventories are likely to vary by industry. For example, the food processing industry is likely to have low raw materials inventories because the raw materials for this industry are highly perishable. Since the distribution of industrial production across industries will vary from country to country, simply aggregating all inventories to the country level would produce misleading results. Instead, we model the inventory ratio to be a function of its industry and country and estimate the effect of country separate from industry. We regress inventory ratios on industry and country dummy variables as follows where i and c index industries and countries covered:

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[4] 10% of our dataset has raw materials ratios greater than .5 and 2% has ratios greater than 1. Lumpiness and volatility in commodity markets are the most likely explanations of these ratios. For most of our analysis we drop any data with raw materials greater than .5 although our results do not depend on the choice of this particular cutoff. More than half of the data for industry 314 (Tobacco processing) exceeded .5. Omitting industry 314 from the regressions entirely does not affect our results. The remainder of datapoints with raw materials inventory greater than .5 are broadly distributed over all industries. Egypt, Kuwait and Panama had a disproportionate share of these inventories, but excluding these countries also does not significantly affect the results. For the finished goods and process inventory ratios, 99% of this data are less than 0.35.

$$\text{Inventory ratio}_{I,C} = \sum_{I} \beta_i \cdot \text{IndustryDummy}_I + \sum_{c} \gamma_c \cdot \text{Country Dummy}_c + \varepsilon_{I,C}$$

We perform these estimations separately for raw materials inventory ratios and finished/process inventory ratios and report the two sets of resulting country coefficients in Table 2 (third and fourth columns). The range of coefficients for raw materials is quite large, with Korea having the lowest coefficient of 0.106 and Egypt having the highest ratio of 0.354. This range represents a difference in inventory stock of almost three months. For finished/process inventories, the differences in inventories is smaller. Iceland has the lowest country coefficient of 0.050 while Portugal has the highest coefficient of 0.177, representing a difference of about one and a half months.

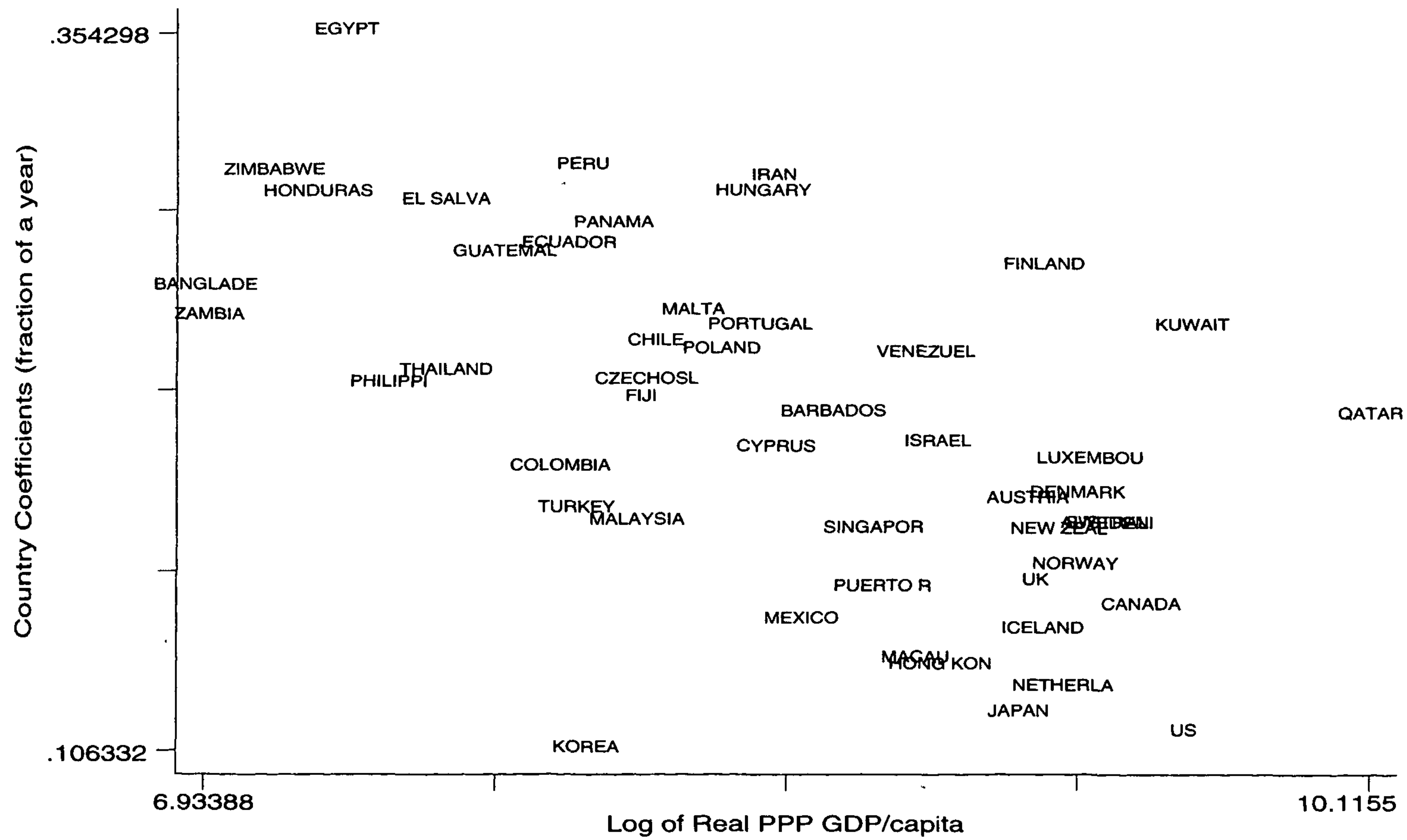
In order to assess the relationship between inventories and level of development, we graph the country coefficients γ against each country's GDP/capita in Figure 1, Panels A and B. For raw materials inventories, the graph shows that country coefficients are negatively correlated with GDP/capita. We confirm this relationship using a univariate regression with country coefficients as the dependent variable and log GDP/capita as the independent variable (See first row of Table 6.) The regression finds a coefficient with a negative sign that is significant at the 1% level. For finished\process inventories, the relationship from the graph is unclear. A univariate regression (not reported) finds a negative coefficient but the relationship is not statistically significant.

B. Cross-country analysis of the determinants of raw materials inventories

Controlling for level of development, there are differences in country coefficients. For example, Mexico and Hungary have drastically different raw materials inventories despite being very close in terms of GDP/capita. Which characteristics of developing countries lead them to maintain higher raw materials inventories? We hypothesize, as explained in Section 2, that poorly functioning markets and poor infrastructure are the primary causes. We use nine proxies for poorly functioning markets: bureaucratic delay index, corruption, business regulation, government consumption/GDP, state-owned enterprises in the economy, transfers & subsidies/GDP, public sector employment/population, bureaucratic quality, and taxes/GDP. For infrastructure, we use six proxies: telephone mainlines per person, infrastructure quality, paved road length/surface area, total road length/surface area, paved roads as % of total roads, and failed calls. Table 4 contains descriptions and sources for these variables and Table 5 presents summary statistics.

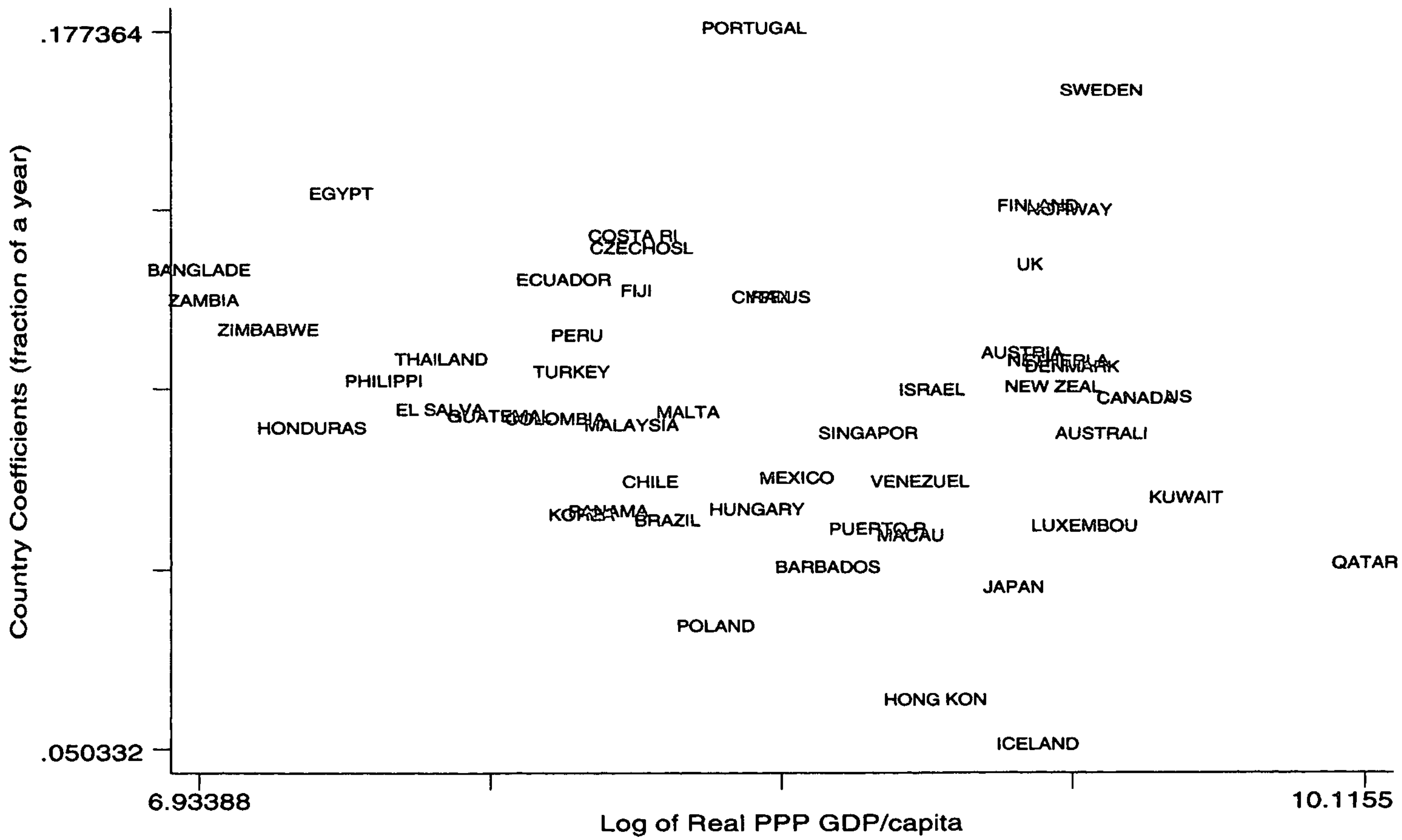
Figure 1: Graphs of Inventory Ratios vs. GDP/capita

Panel A: Raw Materials Inventory



The y-axis displays the country coefficients obtained from a regression of raw materials inventory ratios on country and industry dummy variables. The coefficients should be interpreted as representing relative ratios of inventory holdings. For example, the difference between inventory ratios in Egypt and Korea (0.379-0.104) indicates that manufacturing firms in Egypt hold on average 0 275 or about 3 months of raw materials stock more than firms in Korea.

Panel B: Final and Process Inventory



The y-axis displays the country coefficients obtained from a regression of finished goods and process inventory ratios on country and industry dummy variables. The coefficients should be interpreted as representing relative ratios of inventory holdings. For example, the difference between inventory ratios in Portugal and Iceland (0.169-0.055) indicates that manufacturing firms in Portugal hold on average 0.114 or about 1 months of raw materials stock more than firms in Iceland.

Table 4: Description of Explanatory Variables

Free Market Measures	
Bureaucratic delay Index	An indicator of bureaucratic delays (red tape). Low ratings indicate lower levels of red tape in the bureaucracy of the country. Scale from 0 to 10. The data are the average of the years between 1972 and 1995. Source: BERI's Operation Risk Index as used in La Porta et al [1999].
Corruption	Corruption in government index. Low ratings indicate "high government officials are likely to demand special payments" and "illegal payments are generally expected throughout lower levels of government" in the form of "bribes connected with import and export licenses, exchange controls, tax assessment, policy protection or loans." Scale from 0 to 10. Source: Political Risk Services (ICRG), 1985.
Business regulation	A rating of regulation policies related to opening a business and keeping open a business (on a scale from 1 to 5). Higher score means that regulations are straight-forward and applied uniformly to all businesses and that regulations are less of a burden to business. Source: Holmes, Johnson, and Kirkpatrick, 1997, as used in La Porta et al [1999].
Government consumption/GDP	General government consumption includes all current expenditures for purchases of goods and services by all levels of government, excluding most government enterprises. It also includes capital expenditure on national defense and security Data are averages over the years 1971-1985
SOEs in the economy	Index of State-Owned Enterprises as a share of the economy (scale from 0 to 10). Higher scores include countries with less government-owned enterprises which are estimated to produce less of the country's output. As the estimated size and breadth of the SOE sector increases, countries are assigned lower ratings. Average of the score for the years 1975-1995. Source: Gwartney, Lawson, and Block, 1996, as used in La Porta et al [1999].
Transfers and subsidies/GDP	Total government transfers and subsidies as a percentage of expenditure multiplied by government consumption as a percentage of GDP. "Subsidies and other current transfers include all unrequited, nonrepayable transfers on current account to private and public enterprises, and the cost of covering the cash operating deficits of departmental enterprise sales to the public Data are shown for central government only. General government consumption includes all current expenditures for purchases of goods and services by all levels of government, excluding most government enterprises. It also includes capital expenditure on national defense and security." Data are the average of available years over the period 1971-1985.
Public sector employment/population	Average for the ratio of public sector employment in general government to total population for the years 1976-1996. General government employment includes employment in "all government department offices, organizations and other bodies which are agencies or instruments of the central or local authorities whether accounted for or financed in, ordinary or extraordinary budgets or extra-budgetary funds. They are not solely engaged in administration but also in defense and public order, in the promotion of economic growth and in the provision of education, health and cultural and social services." Source: Schiavo-Campo, de Tommaso, and Mukherjee, 1997, as used in La Porta et al [1999].
Bureaucratic quality	ICRG data for 1985.
Taxes/GDP	Tax revenue comprises compulsory, unrequited, nonrepayable receipts for public purposes collected by central governments. It includes interest collected on tax arrears and penalties collected on nonpayment or late payments of taxes and is shown net of refunds and other corrective transactions. Data are shown for central government only.
Infrastructure Measures	
Telephone mainlines per person	Telephone mainlines are telephone lines connecting a customer's equipment to the public switched telephone network. Data are the averages of available years over the period 1971-1985.

Infrastructure quality	Assessment of the "facilities" for and ease of communication between headquarters and the operation, and within the country," as well as the quality of the transportation. Average data for the years 1972 to 1995. Scale from 0 to 10 with higher scores for superior quality. Source: BERI's Operation Risk Index as used in La Porta et al [1999].
Paved road length/surface area	Paved roads are roads that have been sealed with asphalt or similar road-building materials. Data are averages of available years over the period 1971-1985. Source: Canning [1998].
Total road length/surface area	Total roads are any public roads in the country. Data was obtained from international and national sources and are averages of available years over the period 1971-1985. Source: Canning [1998].
Paved roads, % of total	Paved roads are roads that have been sealed with asphalt or similar road-building materials. Data are averages of available years over the period 1971-1985.
Failed calls	Data are averages of available years over the period 1971-1985. Source: Canning [1998].
Control Variables	
Log GDP per capita	Logarithm of PPP GDP per capita measured in 1985 dollars. Data are the averages over the period 1971-1985. Source: Penn World Tables (Mark 5.6).
Export growth	Annual growth rate of exports of goods and services based on constant local currency. Aggregates are based on constant 1995 U.S. dollars. Exports of goods and services represent the value of all goods and other market services provided to the world. Included is the value of merchandise, freight, insurance, travel, and other nonfactor services. Factor and property income (formerly called factor services), such as investment income, interest, and labor income, is excluded. Data are the averages for available years over the period 1971-1985.
Lending interest rate	Lending interest rate is the rate charged by banks on loans to prime customers. Real lending rate is computed using GDP deflator. Data are the average over all available years in the period 1971-1985.
Imports/GDP	Imports of goods and services represent the value of all goods and other market services provided to the world. Included is the value of merchandise, freight, insurance, travel, and other nonfactor services. Factor and property income (formerly called factor services), such as investment income, interest, and labor income, is excluded. Data are the averages for available years over the period 1971-1985.

Data source for explanatory variables is the 1999 World Development Indicators on CD-ROM unless otherwise noted.
Descriptions of variables quoted from La Porta et al [1999], World Development Indicators, or Canning[1998]

Table 5: Summary of Explanatory Variables

Variable	Countries	Mean	Std. Dev.	Min	Max
Free Market Measures					
Bureaucratic delay index	31	5.06	1.33	2.68	7.49
Corruption	47	3.87	1.62	0.00	6.00
Business regulation	47	3.17	0.89	1.00	5.00
Gov. cons. / GDP	49	0.15	0.06	0.02	0.38
SOEs in the economy	45	4.91	2.35	0.00	10.00
Transfers & subsidies/GDP	43	10.55	7.99	0.90	29.00
Public sector emp./pop.	34	5.28	4.02	0.93	17.40
Bureaucratic quality	47	3.74	1.71	1.00	6.00
Taxes/GDP	46	0.21	0.10	0.05	0.46
Infrastructure measures					
Tel mainlines per person	51	0.15	0.15	0.00	0.57
Infrastructure quality	31	6.02	1.83	2.50	9.15
Paved road length/surface area	44	0.50	0.87	0.00	3.16
Total road length/surface area	48	0.68	0.98	0.03	3.73
Paved roads, % of total	50	0.57	0.33	0.00	1.00
Failed calls	35	0.19	0.21	0.00	0.69
Control Variables					
Log GDP per capita	51	8.50	0.77	6.93	10.12
Export growth standard deviation	42	10.53	7.49	2.67	41.83
Lending interest rate (real)	35	0.08	0.16	-0.17	0.81
Imports/GDP	48	0.38	0.29	0.09	1.74

We test the effects of these variables separately. We regress the country coefficients calculated previously on the log of GDP/capita and one of the nine poor market proxies or six poor infrastructure proxies. The results are shown in Table 6 Panel A. For the poor market proxies, all nine coefficients are of the expected sign and eight of them are significant at the 10%, 5%, or even 1% levels. The magnitude of the estimated coefficients that are significant indicate that a one standard deviation worsening in market function leads to a 11% to 37% increase in raw materials inventory ratios relative to U.S. levels. All six proxies for infrastructure are of the expected sign but only two are significant. Telephone mainlines per person is significant at the 10% level and infrastructure quality is significant at the 1% level. A one standard-deviation change in these two variables is estimated to increase raw materials inventories by 18% and 37%, respectively.

Not all the independent variables we use are available for every country in the sample. As a result, although the coefficients and predicted magnitudes differ between different proxies, we cannot be certain whether these differences are due to the different effects on inventories of these variables or the fact that the results are skewed by the use of different samples of countries. In order to clarify this issue, we repeat the regressions, restricting the sample to the set of countries for which all variables are available. We do this first for 24 countries for which we have all nine proxies for poorly functioning markets and then again for the 20 countries for which we have all six proxies for poor infrastructure. The results are show in Table 6 Panel B. Sample selection does not appear to be responsible for differences in coefficients across different proxies as evidenced by the fact that the relative magnitudes of the predicted coefficients are largely unchanged. Out of the nine poor market indicators, the bureaucratic delay index still has the largest effect on raw materials inventories. Taxes/GDP and government consumption/GDP have some of the lowest effects in both sets of regressions. Since these variables are probably the poorest proxies of poorly functioning markets, the results are not surprising. Out of the six infrastructure indicators, the infrastructure quality index still has the largest effect. In both sets of regressions, indicators related to total road length and paved road length have relatively smaller effects. These results suggest that the infrastructure shortcomings that lead to high inventories cannot be overcome by simply building more roads. We do not have data on the quality of roads, but it is possible that delays along existing roads due to poor management rather than the lack of sufficient roads are the primary problem.

Table 6 Panel A: Regressions on Raw Materials Country Coefficients: Baseline Univariate Regressions

		Exp. sign	Indep. Var	Log GDP/capita	R-Squared	Adj. R-Squared	Obs.	Magnitude
(1)	Log real PPP GDP/capita	-		-0.044*** (0.009)	0.3356	0.3214	49	-30%
	Free market indices							
(2)	Bureaucratic delay index	-	-0.031*** (0.010)	-0.002 (0.020)	0.4722	0.4331	30	-37%
(3)	Corruption	-	-0.011* (0 007)	-0.026* (0.013)	0.3773	0.3476	45	-16%
(4)	Business regulation	-	-0.019* (0.010)	-0.033*** (0.011)	0.4140	0.3861	45	-15%
(5)	Gov. cons. / GDP	+	0.210* (0.119)	-0 054*** (0.010)	0.4112	0.3844	47	11%
(6)	SOEs in the economy	-	-0.0055* (0.0031)	-0.051*** (0.009)	0.4632	0.4363	43	-12%
(7)	Transfers & subsidies/GDP	+	0.0025** (0.0011)	-0.0697*** (0.0117)	0 4922	0.4655	41	18%
(8)	Public sector emp./pop.	+	0.0059** (0.0026)	-0.0698*** (0.0131)	0.5111	0.4786	33	21%
(9)	Bureaucratic quality	-	-0.0164*** (0.0054)	-0.0193 (0.0115)	0.4550	0.4291	45	-25%
(10)	Taxes/GDP	+	0.0891 (0.0787)	-0 0509*** (0.0104)	0.3822	0.3521	44	8%
	Infrastructure measures							
(11)	Tel mainlines per person	-	-0.1315* (0.0732)	-0.0239* (0.0142)	0.3791	0.3521	49	-18%
(12)	Infrastructure quality	-	-0.0226*** (0.0081)	0 0008 (0.0222)	0.4440	0.4029	30	-37%
(13)	Paved road length/surface area	-	-0.0068 (0.0094)	-0 0458*** (0.0107)	0.3692	0 3368	42	-5%
(14)	Total road length/surface area	-	-0.0094 (0.0076)	-0.0412*** (0 0095)	0.3593	0.3294	46	-8%
(15)	Paved roads, % of total	-	-0.0263 (0.0266)	-0.0379*** (0.0109)	0.3484	0.3194	48	-8%
(16)	Failed calls	+	0.0584 (0.0363)	-0.0346*** (0.0111)	0.2922	0.2450	33	11%

* Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level
Magnitude is calculated as coefficient*std dev of indep variable/United States median inventory ratio
Each row represents a regression of the following form:
Raw materials country coefficient = $\beta 0 + \beta 1$*Independent variable + $\beta 2$*Log GDP/capita + ε

Table 6 Panel B: Univariate Regressions on Common Countries

		Exp. sign	Indep. Var	Log GDP/capita	R-Squared	Adj. R-Squared	Obs.	Magnitude
	Free market indices							
(1)	Bureaucratic delay index	-	-0.0370** (0.0132)	0 0117 (0 0235)	0.4605	0.4091	24	-44%
(2)	Corruption	-	0.0051 (0.0142)	-0 0521 (0 0307)	0.2617	0 1914	24	7%
(3)	Business regulation	-	-0.0393** (0.0174)	-0 0274* (0 0156)	0.4032	0 3464	24	-31%
(4)	Gov cons / GDP	+	0 3188 (0.2459)	-0 0549*** (0 0179)	0.3122	0 2467	24	17%
(5)	SOEs in the economy	-	-0.0120** (0.0044)	-0.0344** (0.0138)	0.4537	0.4017	24	-25%
(6)	Transfers & subsidies/GDP	+	0 0036** (0.0013)	-0.0661*** (0 0160)	0.4529	0.4007	24	26%
(7)	Public sector emp./pop	+	0.0064** (0 0029)	-0 0649*** (0.0175)	0 3949	0.3372	24	23%
(8)	Bureaucratic quality	-	-0 0168 (0.0129)	-0 0145 (0.0263)	0 3129	0.2475	24	-25%
(9)	Taxes/GDP	+	0.2565** (0.1002)	-0.0537*** (0.0144)	0.4339	0.38	24	23%
	Infrastructure measures							
(10)	Tel mainlines per person	-	-0 1417 (0.1253)	-0 0019 (0.0328)	0 2762	0.1911	20	-19%
(11)	Infrastructure quality	-	-0.0191** (0.0080)	0 0065 (0 0220)	0 4175	0 349	20	-31%
(12)	Paved road length/surface area	-	-0 0161 (0 0135)	-0.0274 (0.0164)	0 2824	0.1979	20	-12%
(13)	Total road length/surface area	-	-0 0164 (0 0103)	-0.0263 (0 0157)	0.3227	0.243	20	-14%
(14)	Paved roads, % of total	-	-0 0507 (0 0363)	-0 0193 (0.0186)	0 302	0.2198	20	-15%
(15)	Failed calls	+	0 1365*** (0.0443)	-0 0272* (0 0129)	0 501	0 4423	20	26%

* Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level
Magnitude is calculated as coefficient*std.dev of indep variable/United States median inventory ratio
Each row represents a regression of the following form:
Raw materials country coefficient = $\beta 0 + \beta 1$*Independent variable + $\beta 2$*Log GDP/capita + ε

Testing for Other Components.

i) *Import Intensity and Demand Uncertainty.* Two factors other than markets and infrastructure that might cause inventories to be large are import intensity and demand uncertainty. We repeat the regressions with controls for these two factors using as proxies imports/GDP and the standard deviation of export growth rates. The results of these regressions are shown in Table 6 Panel C1. These control variables are not available for all the countries for which we have inventory data. In order to be able to evaluate the effects of adding the control variables in a consistent sample of countries, we also show in Table 6 Panel C2 a regression on the restricted sample of countries but without the two control variables. In most regressions the coefficient on imports/GDP is not significant and often of the wrong sign. An exception is the regression that uses the bureaucratic delay index where the coefficient on imports/GDP is positive and significant at the 5% level; including this variable increases the predicted effect of bureaucratic delay from 42% to 64%. The coefficient for standard deviation of export growth rates is positive, as expected, in 14 of the 15 regressions and is significant at the 5% level in two of these regressions. In general, adding the two control variables do not seem to affect our primary results. We have also tried two alternate measures of demand uncertainty, the standard deviation of economic growth rates, and the inflation rate, a measure of general economic uncertainty. These variables were not significant and did not affect the results.

Table 6 Panel C1: Univariate Regressions with Control Variables

		Exp. sign	Indep. Var	Log GDP/capita	Imports/GDP	Standard Dev. Of export growth rates	R-Squared	Adj. R-Squared	Obs.	Magnitude
	Free market indices									
(1)	Bureaucratic delay index	-	-0 0543*** (0.0143)	0 0273 (0 0228)	0 0755** (0 0346)	-0 0009 (0 0014)	0 6044	0 5357	28	-64%
(2)	Corruption	-	0 0081 (0 0119)	-0 0577** (0.0227)	-0 0095 (0 0305)	0.0021 (0 0013)	0 4715	0.4093	39	12%
(3)	Business regulation	-	-0 0286** (0.0134)	-0 0274** (0 0132)	0.0354 (0 0316)	0.0011 (0.0013)	0.5165	0 4596	39	-23%
(4)	Gov cons / GDP	+	0 2026 (0 1247)	-0.0491*** (0 0111)	-0 0016 (0 0268)	0 0019 (0 0011)	0 5019	0 4450	40	11%
(5)	SOEs in the economy	-	-0 0058* (0 0032)	-0.0442*** (0 0109)	0 0041 (0 0283)	0 0018 (0 0011)	0 5169	0 4600	39	-12%
(6)	Transfers & subsidies/GDP	+	0 0031*** (0 0011)	-0 0635*** (0 0118)	0.0053 (0 0266)	0.0028** (0 0011)	0 5827	0 5322	38	22%
(7)	Public sector emp./pop	+	0 0063** (0 0029)	-0 0659*** (0 0149)	0 0016 (0 0314)	0 0017 (0 0020)	0 5397	0 4661	30	22%
(8)	Bureaucratic quality	-	-0 0106 (0 0077)	-0 0276 (0.0163)	0.0000 (0 0275)	0.0012 (0 0012)	0 4927	0.4330	39	-16%
(9)	Taxes/GDP	+	0 1930** (0.0842)	-0 0514*** (0 0109)	-0 0027 (0 0272)	0 0026** (0 0011)	0 5360	0.4814	39	17%
	Infrastructure measures									
(10)	Tel mainlines per person	-	-0 0763 (0 1001)	-0 0313 (0 0202)	-0.0017 (0 0275)	0.0015 (0.0012)	0 4731	0 4129	40	-10%
(11)	Infrastructure quality	-	-0 0223** (0 0101)	0 0015 (0 0253)	0 0206 (0.0341)	0 0006 (0 0015)	0 4695	0 3772	28	-36%
(12)	Paved road length/surface area	-	-0 0195 (0 0180)	-0 0397*** (0 0130)	0 0207 (0 0406)	0 0015 (0 0012)	0.4816	0 4148	36	-15%
(13)	Total road length/surface area	-	-0 0176 (0.0124)	-0.0402*** (0 0116)	0 0207 (0 0342)	0 0015 (0 0012)	0.4996	0.4408	39	-15%
(14)	Paved roads, % of total	-	-0.0146 (0 0332)	-0.0417*** (0 0124)	0 0044 (0 0307)	0 0017 (0.0012)	0.4673	0 4064	40	-4%
(15)	Failed calls	+	0 0464 (0 0384)	-0 0333** (0 0158)	-0 0226 (0 0253)	0.0025 (0 0018)	0 4799	0 3854	27	9%

* Significant at the 10% level; **Significant at the 5% level, ***Significant at the 1% level
Magnitude is calculated as coefficient*std dev of indep variable/United States median inventory ratio
Each row represents a regression of the following form
Raw materials country coefficient = $\beta 0 + \beta 1$*Independent variable + $\beta 2$*Log GDP/capita + $\beta 3$*Imports/GDP+ $\beta 4$*stddevgrowth + ε

Table 6 Panel C2: Univariate Regressions on Matched Countries

		Exp. sign	Indep. Var	Log GDP/capita	R-Squared	Adj. R-Squared	Obs.	Magnitude
	Free market indices							
(1)	Bureaucratic delay index	-	-0 0353*** (0.0104)	0.0032 (0.0209)	0.5222	0.484	28	-42%
(2)	Corruption	-	-0.0003 (0.0102)	-0.0516** (0.0216)	0.4297	0.3981	39	0%
(3)	Business regulation	-	-0 0230** (0.0109)	-0.0346*** (0.0123)	0.4859	0.4573	39	-18%
(4)	Gov. cons. / GDP	+	0.1883 (0.1258)	-0.0571*** (0.0102)	0.4619	0.4328	40	10%
(5)	SOEs in the economy	-	-0.0057* (0.0032)	-0.0521*** (0.0097)	0.4817	0.4529	39	-12%
(6)	Transfers & subsidies/GDP	+	0.0024** (0.0011)	-0.0702*** (0.0120)	0.5036	0.4752	38	17%
(7)	Public sector emp./pop.	+	0.0057** (0.0027)	-0.0704*** (0.0136)	0.527	0.492	30	20%
(8)	Bureaucratic quality	-	-0.0132* (0.0071)	-0.0282* (0.0161)	0.4794	0.4505	39	-20%
(9)	Taxes/GDP	+	0.1274 (0.0816)	-0.0589*** (0.0109)	0.4622	0.4323	39	11%
	Infrastructure measures							
(10)	Tel mainlines per person	-	-0.1097 (0.0961)	-0.0319 (0.0200)	0.4487	0 4189	40	-15%
(11)	Infrastructure quality	-	-0.0224** (0.0084)	-0.0010 (0.0237)	0.4574	0.414	28	-36%
(12)	Paved road length/surface area	-	-0.0161 (0.0131)	-0.0472*** (0.0116)	0.4508	0.4175	36	-12%
(13)	Total road length/surface area	-	-0.0154 (0.0102)	-0.0474*** (0.0105)	0 4691	0.4396	39	-13%
(14)	Paved roads, % of total	-	-0.0215 (0.0292)	-0.0473*** (0.0117)	0.4375	0.4071	40	-6%
(15)	Failed calls	+	0.0374 (0.0381)	-0.0487*** (0.0126)	0.4165	0.3678	27	7%

* Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level
Magnitude is calculated as coefficient*std.dev of indep variable/United States median inventory ratio
Each row represents a regression of the following form:
Raw materials country coefficient = $\beta 0 + \beta 1$*Independent variable + $\beta 2$*Log GDP/capita + ε

ii) Real Interest Rates. We have also tried including the real interest in the regressions. This variable is available for only 35 countries and thus significantly restricts the sample. Estimations (table omitted) found this variable to be of the expected sign in most regressions but not significant in any of them. Bureaucratic delay and infrastructure quality were still significant and had a large effect, but fewer of the other market proxies were significant. We found that this resulted from the restriction in sample size, not the actual effect of the control variable. Since, in many developing countries in the 1970s and 1980s, nominal interest rates were fixed and inflation rates could be one to ten times as large as the fixed interest rates, we expected to find a large range of interest rates resulting in a larger effect on inventory ratios. As Table 5 shows there was indeed a large range of interest rates. One explanation for the lack of an effect is that the interest rate we use, the official lending rate to prime customers as reported to international organizations, has little relation to the actual rates at which manufacturing firms can borrow. Many purchases of raw materials are characterized by the use of trade credit, the terms of which are complicated and may not closely follow market rates.

We also try to compare the effects of poor infrastructure versus the effects of poor markets. In many cases, the proxies for these two factors are highly correlated, making it difficult to disentangle the effects. The proxies for which we obtained the largest effects were bureaucratic delay and infrastructure quality; a standard deviation change in each of these increased inventories by 37% of U.S. levels. We run a multivariate regression to estimate the effects of each of these two variables (table omitted). In this regression, the magnitude of bureaucratic delay is 27% and the magnitude of infrastructure quality is 12%, but neither variable is significant and it is hard to draw definite conclusions. We also tried running regressions with other pairs of proxies as well as a separate test using factor analysis, but the results were inconclusive.

C. Inventories in high vs. low value added industries

As discussed in the theoretical overview, a number of variables may affect inventories for which we have not been able to control due to a lack of systematic cross-country data on these factors. We deal with these issues by running regressions that control for country fixed effects and take advantage of the industry level inventories data. As shown in the theoretical model of Section 2, there is an interaction effect between value added and delivery time and uncertainty in delivery time. We hypothesize that poorly functioning markets and poor infrastructure increase both delivery time and uncertainty in delivery time and, for this reason, we expect to find an interaction effect between our proxies for poor markets and infrastructure with value added. We run regressions of the following form:

$$\text{Inventory ratio}_{I,C} = \theta_1 \cdot \text{ValueAdded} + \theta_2 \cdot \text{ValueAdded} \cdot \text{Market/InfrastructureProxy} + \sum_I \beta_I \cdot \text{IndustryDummy}_I + \sum_c \gamma_c \cdot \text{Country Dummy}_c + \varepsilon_{I,C}$$

The results of these fixed country-effect regressions are shown in Table 7. As predicted by the theoretical model, the coefficient (θ_1) on value added is positive and significant at the 1% level in all 15 regressions. The coefficients we are primarily interested in are the θ_2s. Of the nine indicators for free markets, seven are significant with all but one significant at the 1% level. (Variables are highly significant due to the large number of observations.) Of these seven indicators, three are of the wrong sign: government consumption/GDP, taxes/GDP. The magnitudes (coefficient * standard deviation of variable) of the coefficients on these variables are all lower than the magnitudes of the coefficients for which we obtained the right sign. Our strongest result in the cross-country regressions came from the bureaucratic delay index and the interaction regressions finds the largest effect here as well. Other large effects of the right sign come from corruption, business regulation, and bureaucratic quality. The model fares better with the infrastructure proxies. We obtain significant results for 4 of the 6 proxies and all are of the correct sign. The strongest effect comes from the infrastructure quality index, just as in the cross-country regressions. Since we might also expect to find an interaction effect with import intensity and demand uncertainty, we have repeated the regressions (tables omitted) with these additional two interaction effects. Our results were not significantly affected. The general results from these fixed-country effect regressions confirm the importance of free markets and good infrastructure

D. Finished/Process Inventories

An important critique of the above analysis is that we are looking at inventory along merely one point of the supply chain. Perhaps inventories are merely shifted from one point in the chain to another. Under just-in-time inventory systems, for example, large firms are able to reduce their own raw materials inventory often at the expense of increasing their suppliers' finished goods inventories (Fandel and Reese [1991]). We test for this possibility by repeating the cross-country regressions, using as the dependent variable finished/process country coefficients rather than the raw materials country coefficients. A finding of a negative correlation between finished/process inventories and poor markets and poor infrastructure would indicate that these factors lead to shifting away from finished/process inventories towards raw materials inventories.

As shown in Table 8, we find evidence of shifting for only one out of the fifteen proxies, namely telephone mainlines per person. The coefficients on the proxies for which we obtained our strongest results on raw materials are small and not statistically significant. We find little to no evidence of shifting of inventories in these regressions.

Nevertheless, this check on shifting of inventories is incomplete in several ways. First, we do not have inventory data on non-manufacturing industries and therefore cannot check for the existence of shifting from upstream suppliers such as agriculture, mining, or forestry, or to downstream customers such as the wholesale and retail sectors. Second, we do not have data on the inventories of upstream suppliers and downstream customers abroad, and, for this reason, cannot test for shifting across country borders.

Table 7: Regressions on Raw Materials Inventory with Interaction Effect

		Exp. sign	Indep. Var	Value Added	R-Squared	Adj. R-Squared	Obs.	Magnitude
	Free market indices							
(1)	Bureaucratic delay index	-	-0.0705*** (0 0097)	0.5814*** (0.0554)	0.5236	0.5083	1868	-0.088
(2)	Corruption	-	-0.0368*** (0.0074)	0.3468*** (0.0324)	0.4766	0 4612	2552	-0.042
(3)	Business regulation	-	-0.0629*** (0.0111)	0.4405*** (0.0441)	0.4731	0.4575	2535	-0.051
(4)	Gov. cons. / GDP	+	-0.7387*** (0.1740)	0.3653*** (0.0294)	0.4779	0.4621	2556	-0.034
(5)	SOEs in the economy	-	0.0028 (0.0048)	0.1935*** (0.0272)	0.4802	0.4649	2495	0.004
(6)	Transfers & subsidies/GDP	+	-0.0021 (0.0014)	0.2768*** (0.0205)	0.4914	0.476	2353	-0.011
(7)	Public sector emp./pop.	+	-0.0093*** (0.0027)	0 2302*** (0 0186)	0.5237	0.5079	1905	-0.026
(8)	Bureaucratic quality	-	-0.0315*** (0.0074)	0.3151*** (0.0299)	0.4753	0.4598	2552	-0.036
(9)	Taxes/GDP	+	-0 2197* (0.1188)	0.3104*** (0.0294)	0.4738	0.4574	2387	-0.015
	Infrastructure measures							
(10)	Tel mainlines per person	-	-0.4501*** (0.0754)	0.2695*** (0 0175)	0.47	0.4543	2673	-0.043
(11)	Infrastructure quality	-	-0.0397*** (0.0074)	0.4368*** (0.0480)	0.5172	0 5018	1868	-0.060
(12)	Paved road length/surface area	-	-0 0263** (0.0134)	0.2815*** (0.0188)	0.4824	0.4664	2325	-0.012
(13)	Total road length/surface area	-	-0.0101 (0.0114)	0.2615*** (0.0190)	0.4695	0.4535	2529	-0 005
(14)	Paved roads, % of total	-	-0.2191*** (0.0340)	0.3531*** (0 0276)	0.4718	0 4562	2600	-0 050
(15)	Failed calls	+	0.0444 (0.0617)	0.2353*** (0.0212)	0.4449	0.4275	2008	0.006

* Significant at the 10% level; **Significant at the 5% level, ***Significant at the 1% level

Magnitude is coefficient on independent variable multiplied by the standard deviation of that independent variable

Each row represents a regression of the following form:

Raw materials Inventory = $\alpha + \beta_1$ indep.var·va + β_2 va + γ industry effect + θ country effect + ε

Table 8: Regressions on Finished/Process Country Coefficients

		Exp. sign	Indep. Var	Log GDP/capita	R-Squared	Adj. R-Squared	Obs.	Magnitude
	Log real PPP GDP/capita	-		-0.0069 (0.0045)	0.0451	0.0257	51	
	Free market indices							
(1)	Bureaucratic delay index	-	0.0017 (0.0052)	-0.0002 (0.0104)	0.0077	-0.0632	31	2%
(2)	Corruption	-	0.0047 (0.0032)	-0.0129* (0.0065)	0.0819	0.0401	47	8%
(3)	Business regulation	-	-0.0066 (0.0051)	-0.0003 (0.0060)	0.0575	0.0146	47	-7%
(4)	Gov. cons / GDP	+	0.1756*** (0.0562)	-0.0098** (0.0046)	0.1979	0.163	49	12%
(5)	SOEs in the economy	-	-0.0020 (0.0016)	-0.0031 (0.0050)	0.0477	0.0023	45	-5%
(6)	Transfers & subsidies/GDP	+	0.0013** (0.0006)	-0.0101 (0.0061)	0.1247	0.0809	43	12%
(7)	Public sector emp./pop.	+	0 0045*** (0.0012)	-0 0142** (0.0060)	0.3197	0.2759	34	20%
(8)	Bureaucratic quality	-	0.0031 (0.0029)	-0.0104* (0.0062)	0.0607	0.018	47	6%
(9)	Taxes/GDP	+	0.0121 (0.0394)	-0.0046 (0.0052)	0.0184	-0.0272	46	1%
	Infrastructure measures							
(10)	Tel mainlines per person	-	0.0824** (0.0358)	-0.0195*** (0 0070)	0.1403	0.1044	51	14%
(11)	Infrastructure quality	-	0.0019 (0.0041)	-0.0019 (0.0114)	0.0116	-0.059	31	4%
(12)	Paved road length/surface area	-	-0.0039 (0.0044)	-0.0034 (0.0050)	0.0426	-0.0041	44	-4%
(13)	Total road length/surface area	-	-0.0044 (0.0038)	-0.0045 (0.0047)	0 0611	0.0194	48	-5%
(14)	Paved roads, % of total	-	0 0090 (0.0129)	-0.0090 (0.0055)	0.0552	0.015	50	3%
(15)	Failed calls	+	-0.0245 (0.0224)	-0.0048 (0.0071)	0 0467	-0 0128	35	-6%

* Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level
Magnitude is calculated as coefficient*std.dev of indep variable/United States median inventory ratio
Each row represents a regression of the following form:
Finished/Process country coefficient = $\beta 0 + \beta 1$*Independent variable + $\beta 2$*Log GDP/capita + ε

The results of the regressions on finished/process inventories actually support our primary hypothesis. Certain factors, such as demand uncertainty and accounting system, should affect both raw materials inventory and finished goods inventory. Infrastructure and poor markets, on the other hand, should affect mostly raw materials inventories. If our findings of a significant relationship between raw materials inventories and poor market and infrastructure proxies were a result of omitted variable bias, then we would also obtain the same relationships between finished/process inventories and these proxies. Since we do not see the same relationships, we can be confident that omitted variables are not driving the result.

5. Conclusion

This paper has introduced a new cross-country dataset on inventories at the industry level into the literature, documenting significant holdings of inventory in developing countries. Given the high costs of capital in developing countries, usually in the 15% to 30% rate, plus the other associated costs of inventories, the impact on unit costs and competitiveness are enormous. We have explored some broad causes of high raw materials inventories across countries in the 1970s and 1980s and can confirm the validity of two causes, infrastructure and poor markets, which have been suggested in case studies. Since high inventories are still a problem today in many developing countries, this paper should be useful in understanding the obstacles faced by manufacturing firms in these countries and from a policy standpoint, it indicates the direction to take to address the problem. The policy implications are clear, improvements in infrastructure, roads, ports and telecommunications can have a significant impact in reducing inventories, particularly when accompanied with appropriate and effective regulation. Likewise the development and deregulation of associated markets can also have a significant impact on inventories, reducing the costs of doing business.

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