Does Public Infrastructure Reduce Private Inventory?

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The discipline of operations management is rarely studied with an eye on public policies. Yet, it is glaring to even the casual observer that public infrastructure is very different in different countries. How does public infrastructure affect private sector inventory levels? I develop as a baseline a "substitution hypothesis," which predicts that infrastructure reduces inventory. I also consider competing hypotheses that can explain negative correlation between infrastructure and inventory. To empirically distinguish these hypotheses, I use data on public firms from 60 countries. The econometric challenge is in identifying the exogenous component of infrastructure changes. I address that using instrumental variables consisting of physical attributes of countries—such as their elevation, whether they are land-locked, their mean distance to a coast or river. I find evidence consistent with the substitution hypothesis. This finding is robust to many tests.

Keywords:

Inventory, public infrastructure, international comparison, instrumental variables

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The discipline of operations management is rarely studied with an eye on public policies. Yet, it is glaring to even the casual observer that public infrastructure is very different in different countries. How does public infrastructure affect private sector inventory levels?

Informal figures indicate the importance of this question. Guasch and Kogan (2004), in a paper for the World Bank, estimate that the additional inventory burden in "many [unspecified] developing countries," over the U.S. level, costs these countries 2% of their GDP (pg. 2). To put this in perspective, more than half the countries in the world have defense expenditures at 2% of their GDP, or less[1]. Using estimates at the industry level, they attribute an important cause of the inventory burden to underdeveloped infrastructure in developing countries. Yet, Figure 1 shows only very *weak* correlation (0.09) between median firm-level inventory (scaled by cost of goods sold) versus infrastructure, measured with the ratio of road length to total area. Anecdotal evidence supports this. For example, Singapore and Malaysia is separated by a ¾ mile causeway. A walk over the causeway often sends the observer from a gleaming Singapore with wide expressways and the world's second largest port to Johor Bahru (the border city in Malaysia), where pot-holed roads support traffic gridlocks. Yet, the backroom of the Carrefour store in Singapore does not seem to be any smaller than that of the Carrefour in Johor Bahru. Would a rigorous analysis support the Guasch and Kogan proposition, or Figure 1 and the

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[1] http://www.cia.gov/cia/publications/factbook/rankorder/2034rank.html, accessed January 29, 2006. Specifically, 93 – or 56% of the 166 countries listed – have "military expenditures" at 2% of GDP or less.

Singapore/Malaysia anecdote that infrastructure does not really reduce firm-level inventory?

I begin in section 1, in which I define what I mean by public infrastructure. I also outline the hypothesis of interest, that private firm-level inventory substitutes for public infrastructure. I shall call this the "substitution hypothesis." I further consider alternative hypotheses about the relationship between infrastructure and inventory, which I summarize in Table 1. One competing view is that we might observe low inventory with better infrastructure, not because of substitution, but because of reverse causality. In this interpretation, low inventory levels could be an indication of firm quality (*e.g.*, Lai (2005)). Countries with low firm-level inventories have better, more profitable firms that pay more taxes. Better public finances translate to better infrastructure, holding factors like government and institutions constant. Thus, any purported evidence for the substitution hypothesis must rule out this alternative "public finance hypothesis."

Another competing view is concerned not with reverse causality, but with the possibility that the relationship between infrastructure and inventory is spurious altogether. Specifically, infrastructure and inventory can both increase with anticipated GDP growth. If one rises faster than the other, we might observe a (spurious) substitution between them. I shall call this the "co-determination hypothesis."

In section 2, I describe a dataset to test the substitution hypothesis and these competing hypotheses. The dataset contains information for 4,268 unique retail firms in 60 countries, for the period 1983 through 2004. I study retail firms because these hold large inventories as part of their regular course of business. Even in the U.S., where infrastructure is developed and inventory levels are presumably lower, the median retailer holds as much as 20% of their cost of goods sold as inventory (see analysis later). At the country level, retailers also hold much inventory. For example, U.S. retailers hold $467 billion in inventories in November 2005, a shade higher than the $466 billion held by manufacturers (Commerce (2006)).

In section 3, I describe the empirical strategy. The centerpiece of the empirics is in identifying the exogenous component of infrastructure. To do that, I use several instrumental variables—such as the elevation of a country, and information on whether a country is landlocked or is an island—which I argue serve the identification purpose. I also control for GDP growth, which the co-determination hypothesis argues is the underlying driver of both infrastructure and inventory. If, after controlling for GDP growth (and other relevant factors), exogenous infrastructure is still not negatively correlated with inventory, then I can reject the substitution hypothesis. This baseline strategy is bolstered with many robustness analyses.

In section 4, I report the key result that there is evidence consistent with the substitution hypothesis. That is, after proper accounting for endogeneity (aka the public finance or co-determination hypotheses), there is evidence that more infrastructure means less inventory. A doubling of the length of roads (scaled by total area)—roughly as in Malaysia's 0.20 km/sq km to Turkey's 0.45—reduces firm-level inventory by about 6%.

In section 5, I find that the baseline result is robust to many sensitivity analyses. These include analyses that expand the measures of infrastructure (from just roads in the baseline to airports and container ports), vary the dataset (from focusing on small countries with homogenous infrastructure to larger ones), focus on sub-samples with different accounting standards and treatments of inventory valuations, and many others.

In section 6, I report the cross-section contingencies—*i.e.,* are there meaningful sub-samples in which substitution does not occur? One contingency is at the country level. Some countries might find that utilization increases “too much” with improved infrastructure, so that at the firm level, the net result is that improved infrastructure does not improve operating conditions (even though at the country level, welfare might be improved with more firms and more activity). I do not find this to be the case empirically. Another contingency is at the firm level. I find that firms with greater agency problems—measured using the proportion of minority interest—exhibit less reduction in inventory with improved infrastructure.

Finally, in section 7, I conclude with some implications. I also interpret what this finding really means. For example, it hardly implies that investing in infrastructure leads *only* to reduction in private firm inventory, since such investments often produce positive externalities (*e.g.*, jobs in a logistics hub). This paper also does not answer many questions. For example, the Guasch and Kogan (2004) World Bank paper really argue that infrastructure reduces inventory for *all* industries, not just retailing. It could be that manufacturing or wholesaling firms involve a different set of considerations. I also describe some interesting avenues for further research.

To sum up this introduction, this paper makes two contributions to the literature. First, it addresses a vital question at the interface of operations management and public policy. Given the astonishing magnitude of public infrastructure investments, it is important to clarify their benefits, one of which is purported to be improved inventory management at the firm level. Second, the paper also makes a modest empirical contribution, using large-scale econometrics in a multi-country setting with physical country characteristics as instrumental variables.

1. DEFINITIONS, HYPOTHESES, ANTECEDENTS

The American Heritage Dictionary defines “infrastructure” as “the basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices, and prisons." Because my scope of interest is public policy and inventory, I use a narrower definition in this paper: infrastructure includes the basic facilities, services, and installations typically *built and operated by governments* that could reduce logistics costs, supply lead times, or demand volatilities. Under this definition, I am primarily referring to roads, railways, ports, and airports. I exclude utilities like water and power. Importantly, I exclude communications infrastructure like phone networks, because these are mostly built and operated by the private sector during the period covered by my dataset (mostly in the late 1980's through 2004, depending on model specification).

Does public infrastructure reduce private-sector firm-level inventory? Table 1 summarizes various hypotheses.

The baseline I investigate is the "substitution hypothesis" described in the introduction. Guasch and Kogan (2004) use a standard news-vendor formulation to argue that more and better infrastructure decreases transit time, which in turn reduces inventory requirement. Another possibility is that consumers can reduce the need to bulk-purchase. Furthermore, infrastructure can enlarge market catchment and therefore volume, allowing retailers to produce more accurate forecasts and again decrease inventory needs. Larger catchment may also introduce more competition, forcing firms to become more efficient at inventory management. There is some empirical evidence to support these arguments. Chikan and Whybark (1990) survey firms in South Korea, China, Western Europe and Hungary and conclude that more industrialized countries with better infrastructure have lower inventory.

Goonatilake (1990) argues that firms in developing countries are more likely to operate in less competitive environments and therefore have less incentive to manage inventory tightly. However, most of these papers use surveys or cases (surveys are in Prasad and Babbar (2000) and Prasad, et al. (2001), rather than the large-scale econometric approach in this paper. One paper that does take an econometric approach is Guasch and Kogan (2004). However, their result is mixed: they find that infrastructure reduces inventory only for raw materials, not aggregate inventory, work-in-progress, or finished goods. Also, they address inventory at the industry level, rather than the firm-level that is the focus of this paper. Furthermore, they compare mostly the U.S. and only Latin American countries. Because many of these are geographically expansive countries with uneven infrastructure development in say, urban versus rural areas (*e.g.*, Brazil), it is hard to see that infrastructure can be properly measured. Most importantly, their estimation, using ordinary least squares, is open the challenge of many competing hypotheses, which I describe next.

One competing view is the "public finance hypothesis," which argues that inventory could indirectly be driving infrastructure. This endogeneity argument is very similar to a very extensive parallel literature in industrial organization, where the question is whether industry structure determines firm performance (*e.g.*, Porter (1980)) or firm performance determines industry structure (*e.g.*, Demsetz (1973)). The latter's story is that high-performing firms grows to dominate their industries, so it would be wrong to attribute firm performance to "favorable" industry structures (fewer competitors). The analogous argument here is that lean inventory could be a manifestation of firm performance (*e.g.*, Chen, et al. (2005), Gaur, et al. (1999), Lai (2005)). Better, more profitable firms contribute more to taxes and therefore better infrastructure, holding other factors like the quality of government and budget allocations constant.

Apart from "public finance," there is another potential source of endogeneity in the substitution hypothesis. Here, a competing "co-determination hypothesis" is that the relationship between inventory and infrastructure could be spurious, if both are determined by other factors. A candidate for this third factor is expected GDP growth. When growth is anticipated, both private firms stock up inventory and public policy makers invest in infrastructure (*e.g.*, Glaeser, et al. (2004)). GDP growth may not be the only third factor. For example, Chikan and Whybark (1990) suggest that indigenous and cultural factors in South Korea, China, Hungary, and Western Europe lead to different inventory practices in these places. Such factors could also determine investments in infrastructure, perhaps through channels such as the quality of government (*e.g.*, La Porta, et al. (1999b)). I emphasize that the co-determination hypothesis is agnostic about the specific relationship between inventory and infrastructure. However, if GDP growth spurs inventory and infrastructure unevenly, then co-determination is an alternative explanation for observed negative correlation between inventory and infrastructure.

Even if I find substitution for the average country and average firm, a further question is whether substitution might still not hold for some countries or firms in a cross-section. There are at least two theoretical reasons for this, summarized in Table 1, panel (b). I call these cross-sectional contingencies.

One country-level contingency is utilization: in a cross-section of countries, do some countries experience no substitution because more roads leads to so much utilization that firms do not benefit from more infrastructure? The idea is that the new roads first increase the value of the road system disproportionately, in a network effect, but further increase in utilization causes traffic jams – *e.g.*, the new Ring Expressway in Bangkok, and empirical evidence for induced traffic in Boarnet and Chalermpong (2000) and the survey in there.[2]

Another contingency is at the firm level. In a firm where management is divorced from ownership, such as the classic Berle and Means (1932) corporation (see also La Porta, et al. (1999a)), there could be agency problems. In such firms, shareholders cannot evaluate management's hidden and costly (to management) action to keep inventory lean, given that inventory has only a noisy correlation with observable measures of management quality such as financial performance (*e.g.*, Chen, et al. (2005), Lai (2005), Netessine and Roumiantsev (2005)). Therefore, management consistently under-invests in keeping inventory lean even when inventory *could* be reduced with more and better infrastructure. This idea is also called "shirking" in "team production" in the literature on the economics of organization (*e.g.*, Alchian and Demsetz (1972)) and the "dissipation hypothesis" in Lai (2006). The prediction is that we may not observe substitution in firms where agency issues are strident.

2. DATA

There does not appear to be a sufficiently deep single source of data for the purpose of my analysis, so I assemble my dataset from a number of sources. The main one is Osiris, an

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[2] A sophisticated version of this view requires understanding the simultaneity involved in the supply of and demand for infrastructure. For example, it could be that the counter-factual is: without the investment in more roads, the increase in traffic will be even worse.

integrated dataset that is in turn assembled from Dow Jones, Edgar, Bureau van Dijk (Europe), World'Vest Base, Multex, KIS (Korea Information Service), Teikoku of Japan, and Huaxia of China. It covers 38,000 listed and major unlisted and delisted companies worldwide, 30,000 of which are non-US companies. A particularly important feature of the dataset is that there is standardization across countries. Standardization is done on one of three formats: Anglo, Continental, and Hybrid. I choose Anglo, since the majority of the countries fit into this without standardization). It also includes standardizing values in U.S. currency (but as I argue below, this is not important anyway because I mostly use ratios). I supplement this with COMPUSTAT's Global Vantage, both to check that the comprehensiveness of the Osiris integrated dataset (COMPUSTAT turns out to be largely a subset of Osiris) and to obtain important information on accounting conventions each firm adopts. From the combined dataset, I extract only those in retail (NAICS 2000 code 44 through 45). For a sense of the coverage of the dataset, COMPUSTAT claims that it covers "over 90% of the world's market capitalization, including coverage of over 96% of European market capitalization and 88% of Asian market capitalization."

The dataset is summarized in Table 2. Panel (a) shows the firm-year observations. Given that the firms are retailers, it is not surprising that most of the inventories are "finished goods" rather than raw materials or work-in-progress (WIP). Therefore, in the rest of this paper, I focus on aggregate inventory (separate estimations using only finished goods inventory produce qualitatively the same results and are not reported). Panel (b) shows the distribution by country. Many countries have very few observations per year. In the analyses, I therefore conduct analyses with and without these (usually small) countries. I report results including these countries, since the results are qualitatively the same. In the unreported sub-samples, I use thresholds of 50 and 100 minimum number of observations. To guard against potential sample selection bias arising from these culls, I further correct them using a Heckman procedure. The independent variables in the selection model include year, assets, ROA, and listing status.

A key concern is whether comparisons across countries are meaningful, given the differing accounting conventions. I address this in two ways. First, many of the key variables are ratios, For example, following the literature, I measure *INVENTORY* by dividing firm-level inventory by cost of goods sold (*e.g.*, Chen, et al. (2005), Gaur, et al. (2005)). This removes some variation that affects numerator and denominator in the same way. This is the approach I take in our baseline analyses. Second, in robustness checks, I marshal detailed information about various conventions our firms take and conduct analyses for sub-samples in which firm-years have the same conventions. Panels (c), (d), (e), and (f) show the listing status (important since many firms in emerging markets are private), cost accounting methods, inventory accounting treatment, and standards adopted in the firm-years. These are used to construct sub-samples for robustness tests, described later.

The rest of the panels show country characteristics. In panel (g), I summarize country-year observations in a dataset that is joined with the firm-year dataset for analysis. This country-year information is from the World Bank, who in turn obtained the information from national statistical agencies around the world. Consistency is ensured to a reasonable extent. For example, all agencies compile data according to at least the 1968 SNA (System of National Accounts), and more are adopting the 1993 SNA. Furthermore, "data are shown for economies as they were constituted in 2003, and historical data are revised to reflect current political arrangements." Some data is time-invariant, and these are reported in panel (h). I obtain these from CIESIN (Center for International Earth Science Information Network) at Columbia.

3. METHOD

To discriminate the three hypotheses, the key is to partial out the exogenous component of *INFRASTRUCTURE*. The baseline model is:

$$LOGINVENTORY_{cif,t+1} = LOGINFRASTRUCTURE_{ct} + LOGGDPGROWTH_{ct} + \mathbf{F}_{\mathbf{cift}} + \mathbf{C}_{\mathbf{ct}} + FIRM_f + \varepsilon_{cift}\ ,$$

where $LOGINVENTORY_{cif,t+1}$ is the aggregate inventory for firm *f* in country *c* in year *t*+1, scaled by contemporaneous cost of goods sold, $LOGINFRASTRUCTURE_{cift}$ is a measure of some element of country *c*'s infrastructure in year *t* scaled by the country's area, and $LOGGDPGROWTH_{ct}$ a measure of country *c*'s GDP growth in year *t*.. $\mathbf{F}_{\mathbf{cift}}$ and $\mathbf{C}_{\mathbf{ct}}$ are vectors of firm and country control variables, $FIRM_f$ are firm effects, and ε_{ft} is assumed to be white noise. The idea is that, after all the controls, what is left in $LOGINFRASTRUCTURE_{ct}$ affects next-period $LOGINVENTORY_{cif,t+1}$. Under the substitution hypothesis, $LOGINFRASTRUCTURE_{ct}$ is negatively signed, while under the public finance hypothesis, it is not, since next-period inventory should not affect previous-period infrastructure. Importantly, the substitution hypothesis predicts that $LOGINFRASTRUCTURE_{ct}$ is negatively signed even with $LOGGDPGROWTH_{ct}$ on the right hand side, while the co-determination hypothesis says that including $LOGGDPGROWTH_{ct}$ will render $LOGINFRASTRUCTURE_{ct}$ statistically insignificant. Furthermore, under co-determination, $LOGGDPGROWTH_{ct}$ is predicted to have a significant coefficient, since it is supposed to correlate with inventory.

I measure *LOGINFRASTRUCTURE*$_{ct}$ on several dimensions: road length, portion of roads paved, railway length, container port and airport facilities. However, I am able to obtain *installed* capacity data only for roads infrastructure. I do have *utilized* capacity for railway, container ports, and airports (see Table 2, panel (h)). Utilized capacity has the advantage that it correlates with infrastructure "usability" or quality—*e.g.*, many roads might be poorly paved or located. However, it also has the disadvantage of being simultaneously determined not only by the supply of infrastructure, but also its demand, which is correlated with *LOGINVENTORY*. Therefore, I consider these measured with error so I also estimate the baseline model with instrumental variables (see later).

The *LOGINFRASTRUCTURE*$_{ct}$ measures are scaled in two alternate ways: GDP and geographic area of the country. Both approaches give similar results and I report only those scaled with area. Another reason for choosing area over GDP is that GDP could be endogenous with infrastructure investment.

Another concern is that for many big countries, infrastructure development is uneven. For example, for a Chinese firm in Shanghai, the average infrastructure for China is not relevant unless the firm operates in all parts of China. Therefore, my baseline dataset will focus on geographically small countries (total area less than 400,000 square km) or countries with well-developed infrastructure (GDP per capita at US$20,000 or above, at purchasing power parity PPP, in the firm-year). The idea for the latter is that, unlike say China, more developed countries like the U.S. facilitate their firms taking advantage of its average infrastructure across wide swaths of area. I report robustness checks for this restriction later. These sub-samples are summarized in Table 1, panel (i).

The firm controls $\mathbf{F}_{cft}$ include gross margin, capital intensity, and a measure of "sales surprise." Gaur, et al. (2005) show that these explain 97.2% of the inventory variance among retail firms in the U.S. One difference is that I have only a very short time period to measure sales surprise (which they measure using Holt's exponential smoothing method), so I use sales growth as a proxy. Perhaps the important argument for why this is less relevant here is that it is hard to imagine that sales surprise could be correlated with $LOGINFRASTRUCTURE_{ct}$. Indeed, the correlation between my proxy (sales growth) and *LOGROADS* is 0.01., close to zero.

For the country controls $\mathbf{C}_{ct}$, I include inflation and interest rates, following Chen, et al. (2005). They also have GDP growth, which is a variable of interest here under the "co-determination hypothesis." Therefore, this is also included as a regressor, as we will see. I also add *LOGPHONE* (log of the number of fixed line and mobile phone subscribers per 1,000 people), which measures usually private-owned infrastructure that might correlate with the publicly-owned infrastructure of interest to me.

As mentioned earlier, one of the issues with fixed effects estimation is that it might still not control for unobserved time-varying heterogeneity. I use an alternative instrumental variables approach. Specifically, I instrument $LOGINFRASTRUCTURE_{ct}$ using the exogenous variables: (1) the country's total area, (2) whether the country is landlocked, (3) whether it is an island, (4) its mean elevation, (5) the shortest air distance from its capital to New York, Tokyo, or Rotterdam, and (6) the mean distance from coast or river (details are in n Table 2, panel (h)). The economic argument for these is that they determine the cost of infrastructure construction. For example, the U.S. Forest Service, which constructs roads on terrain at different elevations, documents that the cost loading on road construction at high elevation can be up to 7.9 times of that at coastal elevation (the supporting literature is extensive; see, for example, U.S. Forest Service, (2003)). I also confirm the intuition with an expert in civil engineering familiar with geographic conditions in a variety of developed and emerging nations in Asia[3].

Because the instruments are time-invariant country characteristics, the model is as before, but without the firm fixed effects:

$$LOGINVENTORY_{cif,t+1} = LOGINFRASTRUCTURE_{ct} + LOGGDPGROWTH_{ct} + \mathbf{F_{cift}} + \mathbf{C_{ct}} + \varepsilon_{cift} \text{ ,}$$

Econometrically, the instrumental variables are satisfactory in their correlation with the potentially endogenous variables. Table 3 shows that each endogenous variable is highly correlated with at least one instrumental variable. I cannot reject the null of substitution if $LOGINFRASTRUCTURE_{ct}$ still has a negative coefficient after partialing out potential endogeneity with the instrumental variables. I also formally test the model for over-identification in the reported results below.

All estimation for these as well as subsequent models (unless otherwise stated) is done with robust Huber-White standard errors, and clustered around industry to minimize serial correlation.

BASELINE RESULTS

In Table 4, I first report in model (1) a fixed effects regression of $LOGINVENTORY_{cfi,t+1}$ on $LOGINFRASTRUCTURE_{ct}$, as measured using $LOGAIR_{ct}$. As expected, this model shows a strong substitution effect: doubling the tonnage flown (in million tons per km flown within and

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[3] Dr. XXXX, professor and former chair Department of Civil and Structural Engineering, XXX University (masked for review).

into/out of a country)—roughly Saudi Arabia's 852 vs. Thailand's 1764 for year 2003—reduces inventory in the average firm by 9%. The corresponding reduction in the balance sheet translates to 10% improvement in ROA.[4] Since the median ROA for firms in my dataset is 8% (Table 2, panel (a)), this is a respectable improvement Given the much wider disparity in infrastructure—considering say, the UK's 1.52 km/sq km in roads—it does seem like firms in countries with poor infrastructure do suffer by holding considerably more inventory. The co-determination hypothesis meets a double blow: $LOGGDPGROWTH_{ct}$ is not significant while $LOGINFRASTRUCTURE_{ct}$ continues to be so.

The control variables are signed as predicted. For example, Gaur, et al. (2005) report that the signs for $LOGGM_{cift}$, $LOGCAPINTENSITY_{cift}$, and $LOGREVGROWTH_{cift}$ are positive, negative, and negative respectively. Chen, et al. (2005) report mixed signs for country effects. This is what I find here, too. The over-identification test has a zero *p*-value.

In model (2), I report the results with the alternative instrumental variables approach. The coefficient on $LOGINFRASTRUCTURE_{ct}$ is unchanged, at 0.07, and turns more significant.

In model (3), I use $LOGROADS_{ct}$ as a measure of $LOGINFRASTRUCTURE_{ct}$, with qualitatively the same result. The interpretation is that a doubling of $LOGROADS_{ct}$—roughly as in Malaysia's 0.20 km/sq km to Turkey's 0.45—reduces firm-level inventory by about 9%. Recall that $LOGROADS_{ct}$ is scaled by total area, and it measures installed capacity, getting at $LOGINFRASTRUCTURE_{ct}$ differently than $LOGAIR_{ct}$, which measures used capacity.

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[4] If earnings are E and assets A, the improvement in ROA is from E/A to E/[A*(100%-9%)].

4. ROBUSTNESS CHECKS

In Table 5, I report a sample of the robustness checks I conduct. Other tests not reported here provide qualitatively similar results. In all cases here, the model is:

$$LOGINVENTORY_{cif,t+1} = LOGINFRASTRUCTURE_{ct} + \mathbf{F_{cift}} + \mathbf{C_{ct}} + INDUSTRY_i + YEAR_t + \varepsilon_{cift} .$$

This then, is the first variation: I add $INDUSTRY_i$ and $YEAR_t$ to the model.

In model (1), I expand the measure of $LOGINFRASTRUCTURE_{ct}$ beyond roads to the portion of roads paved and airports. Only $LOGROADS_{ct}$ in the baseline model appears significant. This is consistent with a story in which airports and air freight have diminishing impact on lead time. After the first airport and the first use of air freight, more airports and air freight do not help much. Otherwise, the substitution hypothesis continues to hold.

In model (2), I use 4-digit NAICS industry codes rather than the 2 digits used in the baseline. Once again, $LOGROADS_{ct}$ is signed negative, so substitution holds. I also use secondary industry codes, beyond the primary industries in the baseline. The result is unchanged.

In model (3), I restrict the dataset to smaller countries. Recall that the baseline dataset includes countries with geographic area 400,000 square km or smaller and with GDP per capita at US$20,000 (at PPP) or higher. Here, I restrict the former to just 100,000 square km. Again, substitution holds. Other restrictions, using bigger geographies or without the GDP per capita restriction, produce the same qualitative results.

An example of this last is in model (4), in which I remove the U.S. This is because the U.S. provides many observations—as shown in the reduction in *N* between models (3) and (4)—and it would be prudent to check that the results are not skewed by one country. As model (4) shows, substitution holds again.

In model (5), I show an example of the sub-samples on which I do robustness checks. In this case, I add to the baseline restriction a further restriction that firms must be listed. As the results show, the substitution theory holds again. Other sub-samples include MNCs, stand-alone business units (those without recorded subsidiaries), and focused firms (those without secondary NAICS codes, or whose secondary codes are the same as the primary ones).

Other robustness tests include using lagged dependent variables on the right-hand side, to further minimize endogeneity problems. Another test uses rolling 3-year periods rather than 1-year periods in the baseline. This accounts for the possibility that changes in infrastructure exhibit long lags. Yet another test interacts *LOGGDPGROWTH* with *LOGROADS*, to address the possibility that GDP growth affects the impact of infrastructure differently depending on the level of infrastructure. Finally, I also include the numerous controls in Table 2, panel (g), under the categories "Macroeconomics," "Financial Constraints," "Openness," "Rule of Law and Governance," and "Technology." All these produce qualitatively the same result, supporting the substitution hypothesis and are not reported (but are available from the author).

5. CROSS-SECTIONAL CONTINGENCIES

In the section on "Hypotheses," I describe predictions about substitution in a cross-section of firms. These can be viewed as still more robustness checks and as a way to produce a more nuanced notion of how substitution works or does not work.

The "utilization contingency" asks thus: in a cross-section of countries, do some countries experience no substitution because more roads leads to so much utilization that firms do not benefit from more infrastructure? First, I confirm that new roads generally do increase utilization, measured with *LOGVEHICLES*, log of the number of vehicles per km of roads. The correlation between *LOGROADS* and *LOGVEHICLES* is 0.55. In Table 6, models (1), I see the *LOGVEHICLES* does not influence the inventory, whether on its own or in its interaction with *LOGROADS*. One interpretation is that utilization does not have a contingent effect on our substitution hypothesis. But an *F*-test of *LOGROADS* and *LOGVEHICLES* confirms that they are jointly significant at the 1% level. So perhaps it is the specification that is inadequate. We address this in model (2) by including a quadratic term for *LOGVEHICLES* and its interaction with *LOGROADS*. The partial on *LOGROADS* is as follows: it is negative (substitution), and more so at higher utilization levels (*LOGVEHICLES* ranges from 0.71 to 5.67). In other words, utilization is never so high as to clog up the roads to diminish substitution.[5]

The "agency contingency" asks: in a cross-section of firms, do firms with agency issues not exhibit substitution? I measure the severity of agency problems with the proportion of shares held by minority interests. The idea is that, with concentrated owners, the majority shareholders have more incentive to monitor management, and in many cases, they are management themselves (*e.g.*, La Porta, et al. (1999a), Morck, et al. (1988)). In Table 6, model (3), I report estimations including a *MINORITY* variable (reported earlier in Table 2, panel (a)) and its interaction with *LOGROADS*. As predicted, both are positively signed, and *LOGROADS* continues to be negative and (now modestly) statistically significant. I interpret this as agency

[5] The partial on *LOGVEHICLES* is not pertinent to our substitution story, but may be interpreted as follows: it is positive when infrastructure is low and negative when it is high (LOGROADS ranges from -4.33 to 1.72). In other words, with very poor infrastructure, utilization does clog up and inventory rises. It is only with better infrastructure that utilization reduces inventory.

both increasing inventory levels as well as reducing substitution when infrastructure improves.

6. DISCUSSION AND CONCLUSION

I begin by asking whether public infrastructure reduces private inventory. Using a novel dataset and a range of techniques, I present evidence consistent with a substitution hypothesis. I enrich the hypothesis with investigations into cross-sectional implications.

I acknowledge that an important qualifier for this paper's finding is *ceteris paribus*: holding all others constant. Since "all others" are rarely constant, observed differences in firm-level inventory may not be attributable to differences in infrastructure in the magnitude described here. Another qualifier is that I have not investigated the cost of infrastructure, but only the (partial) benefit. Nevertheless, it is still quite astonishing that the partial differential in the substitution theory is as high as it is.

In this paper, I focus on infrastructure that is mostly government led. One interesting empirical push beyond this paper is to investigate interesting *private*-led infrastructure developments, such as phone networks, freight hubs, and industrial warehouse facilities. Indeed, the benefit is probably so large that one often reads about private firms in infrastructure-poor countries building or contributing to building infrastructure. For example, Infosys and Wipro have contributed Rs 1 billion toward the Rs 4.5 billion needed to build a four-lane flyover from Hosur Road to Electronic City (Rediff (2005)).

On a theoretical front, it would be interesting to investigate the interface between other aspects of operations management beyond inventory management—such as facility locations and supply chain contracting—that might also be affected by public infrastructure and institutions. Practically, this paper does not immediately suggest that governments start investing in infrastructure, but it does provide a clear-cut case that there are benefits that can accrue to firms.

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7. APPENDIX

Table 1 – Hypotheses

(a) – Competing Hypotheses to Explain Negative Relationship between Infrastructure and Inventory

All hypotheses hold as constant both relevant time-invariant and time-varying firm characteristics, industry characteristics, and country characteristics like inflation and interest rates, quality of institutions, etc. Importantly, the hypotheses hold each other constant. For example, "substitution" says we should observe "more infrastructure, less inventory" even after we factor out endogeneity from "public finance."

Competing hypothesis	Predicted relationship between inventory and infrastructure	"Story"	Theoretical antecedents (examples)
Substitution (baseline)	More infrastructure, less inventory	Infrastructure reduces supply chain lead time and demand volatility – *e.g.*, less need for customers to bulk-purchase	Chikan and Whybark (1990), Guasch and Kogan (2004)
Public finance	Less inventory, more infrastructure	Low-inventory firms are better performing, and pay more taxes, that provide for more infrastructure	Chen, et al. (2005), Demsetz (1973), Gaur, et al. (1999), Lai (2005)
Co-determination	Ambiguous , spurious relationship	Both are co-determined by GDP growth	Chikan and Whybark (1990), Glaeser, et al. (2004)

(b) – Cross-sectional Contingencies

These ask: even if there is substitution for the average country or average firm, wouldn't some countries or some firms still experience no substitution because of particular country or firm effects?

Contingency	Predicted relationship between inventory and infrastructure	"Story"	Theoretical antecedents (examples)
Utilization in a country	Substitution only if utilization does not increase "too much"	Greater utilization is evidence of "increasing returns" to infrastructure, and reduces need for inventory. But too high utilization is evidence of traffic jams, which increases need for inventory	Boarnet and Chalermpong (2000)
Agency in a firm	Substitution only if agency issues are not too serious	Firms with agency issues (*e.g.*, diversified ownership) have managers who spend less effort on minimizing inventory, especially if the effort is only noisily revealed through financial performance	Berle and Means (1932), Lai (2006), La Porta, et al. (1999a)

Table 2 – Summary Statistics

(a) – Firm-year Observations

The data is for all retail (NAICS 2000 code 44 through 45) firms from Osiris and COMPUSTAT Global Vantage tapes. Each observation is a firm-year. There are 4,268 unique firms from 60 countries. The period covered is 1983 through 2004. All values are in millions of nominal U.S. dollars, at current exchange rates for non-US firms. Inventory values are scaled by cost of goods sold. Variables are winsorized at 1% and 99%.

	N	Median	Std. dev.
Year	28,229	1,999	4.64
Inventory – total	28,229	0.15	0.26
Inventory – raw materials	8,328	0.01	0.11
Inventory – WIP (work in progress)	6,782	0.001	0.09
Inventory – finished goods	10,857	0.13	0.25
Levered free cash flow margin	24,914	0.04	0.45
COGS (cost of goods sold)	28,229	360.06	50,694.93
Market capitalization	9,647	161.19	4,062.53
Assets	19,228	169.47	3,459.51
Gross margin	28,226	0.17	0.27
ROE	25,985	0.50	658.57
ROA	26,601	0.08	0.19
Revenue growth	21,630	0.08	5,544.62
Common stock	18,725	7.25	131.91
Tobin's *q*	3,798	1.66	1.56
Minority interest (ratio of shares)	6,477	0.04	0.31
Number of subsidiaries	19,228	2.00	45.12

(b) Observations by Country and Year

		N			*N*			*N*			*N*
1	Argentina	8	16	Germany	114	31	Mauritius	1	46	Singapore	318
2	Australia	194	17	Greece	168	32	Mexico	270	47	Slovenia	19
3	Austria	3	18	Hong Kong	1,000	33	Namibia	2	48	South Africa	198
4	Bahrain	16	19	Hungary	10	34	Netherlands	308	49	Sri Lanka	65
5	Belgium	33	20	Iceland	4	35	Norway	3	50	Sweden	218
6	Brazil	44	21	Indonesia	184	36	Occ Palestine	1	51	Switzerland	52
7	Canada	544	22	Ireland	153	37	Oman	34	52	Taiwan	220
8	Chile	42	23	Israel	55	38	Pakistan	6	53	Thailand	189
9	China	717	24	Japan	8,456	39	Peru	33	54	Turkey	101
10	Colombia	25	25	Jordan	17	40	Philippines	54	55	UAE	9
11	Denmark	182	26	Korea, Rep.	496	41	Poland	7	56	UK	3,755
12	Egypt	180	27	Kuwait	5	42	Portugal	7	57	USA	9,130
13	Estonia	5	28	Latvia	24	43	Qatar	3	58	Venezuela	2
14	Finland	20	29	Lithuania	7	44	Russia	7	59	Vietnam	19
15	France	76	30	Malaysia	393	45	Saudi Arabia	19	60	Zimbabwe	4

(c) – Firm-years by Listing Status

	N	%
Listed	20,891	74.0
Delisted	3,315	11.7
Unlisted	4,023	14.3
Total	28,229	100.0

(d) – Cost Accounting Treatment

	N	%
Current Cost	11	0.10
Historic Cost(company does not revalue fixed assets)	8,444	78.77
Modified Historic Cost(company states assets at cost in its statements but assumes replacement cost for depreciation)	2,265	21.13
	10,720	100.0

(e) – Distribution by Inventory Accounting Method

	N.	%
First In, First Out (FIFO)	2320	38.27
Last In, First Out (LIFO)	811	13.39
Specific Identification	287	4.73
Average Cost	1460	24.09
Retail Method (See note below)	124	2.03
Standard Cost	989	16.32
Current or Replacement Cost	59	0.97
No Inventory or information	14	0.23
Total	6064	100.00

(f) – Accounting Standards

	N	%
Domestic standards generally in accordance with IASC guidelines	151	1.41
Domestic standards generally in accordance with OECD guidelines	1	0.01
Domestic standards	10,485	97.76
Domestic standards in accordance with principles generally accepted in the United States and generally in accordance with IASC and OECD guidelines	6	0.06
Domestic standards in accordance with principles generally accepted in the United States	23	0.21
Modified US standards (Japanese companies' financial statements translated into English)	42	0.39
United States' standards	17	0.16
Total	10,725	100.0

(g) – Country-year Information: Time-Varying

The data is from WDI. To keep this paper of reasonable length, I refer readers to the World Bank's "Country Data Technical Notes" for details of these measures.
http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20461806~menuPK:64133163~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html

	Variable	*N*	*Med*	*SD*
Macroeconomics				
GDP, PPP (constant 2000 international bil $)	*GDP*	4856	27.6	3830
GDP per capita, PPP (constant 2000 international $)	*GDPCAPITA*	4856	4620.5	8203.4
GDP growth (annual %)	*GDPGROWTH*	5279	3.53	6.30
Inflation, GDP deflator (annual %)	*INTEREST*	4745	7.1	588.2
Real interest rate (%)	*TAX*	3334	6.2	20.6
Highest marginal tax rate, corporate rate (%)	*SERVICES*	658	30.0	9.5
Services, etc., value added (% of GDP)		4661	51.4	13.0
Financial constraints				
Domestic credit provided by banking sector (% of GDP)	*CREDIT*	4794	45.3	55.7
Finance (% of mgrs ranking this as major constraint)	*FINANCE*	49	27.9	17.3
Market capitalization of listed companies (% of GDP)	*MKTCAP*	1658	27.0	53.4
Business disclosure index (0=less to 7=more)	*DISCLOSURE*	153	3.0	1.9
Legal rights of borrowers & lenders index (0=least to 10=most)	*RIGHTS*	142	5.0	2.0
Openness				
Trade in goods (% of GDP)	*TRADEGDP*	4799	51.5	52.4
Foreign direct invest., net inflows (% of gross capital formation)	*FDI*	4412	4.3	50.1
Customs and other import duties (% of tax revenue)	*CUSTOMS*	970	16.2	16.9
Rule of Law and Governance				
Corruption (% of mgrs ranking this as major constraint)	*CORRUPTION*	49	31.4	19.2
Courts (% of mgrs not confidence courts uphold property rights)	*COURTSCONFI*	47	47.1	14.8
Courts (% of mgrs ranking this as a major constraint)	*COURTSCONSTR*	37	15.7	10.5
Time to enforce a contract (days)	*CONTRACTTIME*	160	360.0	215.3
Procedures to enforce a contract	*CONTRACTPROC*	160	29.0	10.6
Management time dealing with officials (% of management time)	*MGT_TIME*	47	11.0	3.8
Policy uncertainty (% of mgrs ranking this as major constraint)	*UNCERTAINTY*	48	39.7	16.0
Technology				
Internet users (per 1,000 people)	*INTERNET*	2311	3.9	102.7
Fixed line and mobile phone subscribers (per 1,000 people)	*PHONE*	5648	62.5	278.8
Information and comm.. tech expenditure per capita (US$)	*TECHPERCAP*	276	261.0	832.8
Computer, comm. and other services (% of commercial service imports)	*TECHIMPORTS*	4460	25.8	15.4
Infrastructure				
Air transport, freight (million tons per km)	*AIR*	4402	31.5	8,691.8
Container port traffic (mil TEU: 20 foot equivalent units)	*PORT*	280	2.0	41.3
Roads, total network (thousand km)	*ROADS*	2108	42.2	2,564.7
Roads, paved (% of total roads)	*ROADSPAVED*	1959	48.3	33.2
Roads, goods transported (million ton-km)	*ROADSGOODS*	626	10,525.5	167,658.6
Vehicles (per km of road)	*VEHICLES*	1337	16.0	45.9
Railways, good hauled (bil ton-km)	*RAILWAYS*	102	3.77	303

(h) – Country Information: Time-Constant

The data is as of year 2000. The data is courtesy of CIESIN (Center for International Earth Science Information Network) at Columbia. "Total area" is area in square kilometers from World Bank (1997), except for Taiwan and Mexico from CIA (1997), with submerged land subtracted out. "Landlocked indicator" is 1 for landlocked country, excluding countries in Western and Central Europe (Austria, the Czech Republic, Hungary, the former Yugoslav Republic of Macedonia, Slovakia, and Switzerland), and includes Eastern European countries of Belarus and Moldova. "Island indicator" is 1 if the country is linked to another country only via a man-made connection. "Air distance from New York/Tokyo/Rotterdam" is the log of the minimum Great-Circle (air) distance in kilometers to one of the three capital-goods-supplying regions: the U.S., Western Europe, and Japan, specifically measured as distance from the country's capital city to New York, Rotterdam, or Tokyo. "Mean elevation" is calculated in geographic projection. "Mean distance from coast or river (km)" is distance from the nearest sea-navigable rivers and ice-free coastline calculated in Plate Caree projection.

	Variable	*N*	Med	Std dev.
Total area (sq. km)	*TOTALAREA*	208	109,875	1,861,384
Landlocked indicator	*LANDLOCKED*	208	0.20 (mean)	0.40
Island indicator	*ISLAND*	208	0.25 (mean)	0.43
Mean elevation (m)	*ELEVATION*	159	442	565
Air distance from New York/Tokyo/Rotterdam (km)	*DISTANCE_AIR*	149	4,160	2,430
Mean distance from coast or river (km)	*DISTANCE_COAST*	159	141	472

(i) – Sub-samples

The baseline dataset focuses on geographically small countries (total area less than 400,000 square km) or countries with well-developed infrastructure (GDP per capita at US$20,000 or above, at purchasing power parity PPP, in the firm-year). The idea for the latter is that, unlike say China, more developed countries like the U.S. allow American firms in any part of the country to take advantage of its average infrastructure. The other sub-samples are used for robustness tests.

Area<400,000 sq km or GDP/capita > $20,000/year	Area<100,000 sq km or GDP/capita > $20,000/year	Area<100,000 sq km
Australia, Austria, Bahrain, Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Japan, Jordan, Korea, Rep., Kuwait, Latvia, Lithuania, Malaysia, Mauritius, Netherlands, Norway, Oman, Philippines, Poland, Portugal, Qatar, Singapore, Slovenia, Sri Lanka, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States, Vietnam, Zimbabwe	Australia, Austria, Bahrain, Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Japan, Jordan, Korea, Rep., Kuwait, Latvia, Lithuania, Mauritius, Netherlands, Norway, Portugal, Qatar, Singapore, Slovenia, Sri Lanka, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States	Austria, Bahrain, Belgium, Denmark, Estonia, Hong Kong, Hungary, Ireland, Israel, Jordan, Korea, Rep., Kuwait, Latvia, Lithuania, Mauritius, Netherlands, Portugal, Qatar, Singapore, Slovenia, Sri Lanka, Switzerland, United Arab Emirates

Table 3 – Correlation between Instrumental and Endogenous Variables

This is for the sub-sample "Area<400,000 sq km or GDP/capita > $20,000/year" used in the rest of the paper.

	LOGROADS	*LOGROADS_ PAVED*	*LOGRAILWAY*	*LOGPORT*	*LOGAIR*	*LOGVEHICLES*
LOGTOTAREA	**0.54**	**-0.93**	**0.53**	**-0.57**	**-0.72**	**-0.80**
ISLAND	-0.09	**0.51**	-0.28	**0.71**	0.09	0.25
LANDLOCKED	-0.11	.	0.06	0.01	-0.04	-0.02
LOGELEV	**0.59**	-0.46	0.28	-0.30	**-0.64**	-0.32
LOGAIRDIST	**-0.61**	0.22	**-0.64**	-0.25	0.20	0.32
LOGDISTCR	0.46	**-0.93**	0.43	**-0.79**	**-0.78**	**-0.73**

Table 4 – Discriminating the Hypotheses

Models (1) and (2) are use firm fixed effects:

$$LOGINVENTORY_{cif,t+1} = LOGINFRASTRUCTURE_{ct} + LOGGDPGROWTH_{ct} + \mathbf{F_{cift}} + \mathbf{C_{ct}} + FIRM_f + \varepsilon_{cift}\ ,$$

where $LOGINVENTORY_{cif,t+1}$ is the aggregate inventory for firm *f* in country *c* in year *t*+1, scaled by contemporaneous cost of goods sold, $LOGINFRASTRUCTURE_{cift}$ is a measure of some element of country *c*'s infrastructure in year *t* scaled by the country's area, and $LOGGDPGROWTH_{ct}$ a measure of country *c*'s GDP growth in year *t*.. $\mathbf{F_{cift}}$ and $\mathbf{C_{ct}}$ are vectors of firm and country control variables, $FIRM_f$ are firm effects, and ε_{ft} is assumed to be white. In the other models, $LOGINFRASTRUCTURE_{ct}$ is estimated with country time-invariant instruments, and uses 2-stage least squares, naturally without the firm fixed effects. The dataset includes only firm-years from geographically small countries (total area less than 400,000 square km) or countries with well-developed infrastructure (PPP GDP per capita at US$20,000 or above, in the firm-year). Estimation is done with robust Huber-White standard errors, and clustered around industry to minimize serial correlation. *** = 1% significance, ** = 5%, *=10%. OLS = fixed effects, IV = instrumental variables.

	(1) FE	(2) IV	(3) IV
LOGINFRASTRUCTURE			
LOGAIR	-.07 (.04)*	-.07 (.03)***	
LOGROADS			-.09 (.04)**
LOGGDPGROWTH	.01 (.01)	-.02 (.01)	-.02 (.01)**
$\mathbf{F_{cft}}$			
LOGGM	.35 (.04)***	.82 (.04)***	.79 (.03)***
LOGCAPINTENSITY	-.18 (.04)***	-.56 (.03)***	-.61 (.04)***
LOGREVGROWTH	-.01 (.01)	.00 (.00)***	.00 (.00)***
$\mathbf{C_{ct}}$			
LOGINFLATION	-.01 (.01)	.04 (.02)	.01 (.03)
LOGINTEREST	.02 (.01)	.03 (.02)	-.03 (.04)
LOGGDPCAPITA	.38 (.19)**	.17 (.11)	-.22 (.10)**
LOGPHONE	-.21 (.07)***	-.20 (.05)***	-.03 (.11)
Intercept	-3.24 (1.49)**	-.87 (.80)	1.59 (.73)**
Over-identification test (*p*-value)	-	.00	.00
N	7727	7698	9979
Adj *R*-squared	.88	.45	.44
F on ***LOGINFRASTRUCTURE***	2.9	9.8	6.7
p-value	.09	.00	.01

Table 5 - Robustness Analyses

The model, estimated using instrumental variables, is:

$$LOGINVENTORY_{cif,t+1} = LOGINFRASTRUCTURE_{ct} + \mathbf{F}_{cift} + \mathbf{C}_{ct} + INDUSTRY_i + YEAR_t + \varepsilon_{cift} \ ,$$

where $INVENTORY_{cif,t+1}$ is the aggregate inventory for firm *f* in country *c* in year *t*+1, scaled by contemporaneous cost of goods sold, $INFRASTRUCTURE_{cift}$ is a measure of some element of country *c*'s infrastructure in year *t*, $\mathbf{F}_{cift}$ and $\mathbf{C}_{ct}$ are matrices of firm and country control variables, $INDUSTRY_i$ and $YEAR_t$ are (2-digit NAICS, except in model 2) industry and year effects, and ε_{ft} is assumed to be white.. Models (1) and (2) include only firm-years from geographically small countries (total area less than 400,000 square km) or countries with well-developed infrastructure (PPP GDP per capita at US$20,000 or above, in the firm-year). Model (3) changes the 400,000 square km restriction to 100,000 square km. Model (4) excludes firm-years for the USA. Model (5) restricts the baseline dataset further, to include only listed firms.
Estimation is done with robust Huber-White standard errors, and clustered around industry to minimize serial correlation. *** = 1% significance, ** = 5%, *=10%.

	(1) Broad infrastructure	(2) 4 digit NAICS	(3) Tiny countries	(4) No USA	(5) Listed firms
Variables of interest					
LOGINFRASTRUCTURE					
LOGROADS	-.24 (.09)***	-.11 (.03)***	-.12 (.03)***	-.07 (.04)*	-.12 (.05)***
LOGROADSPAVED	.38 (.24)				
LOGAIR	-.03 (.04)				
LOGGDPGROWTH	-.01 (.01)	.00 (.00)	.00 (.00)	-.02 (.01)*	-.02 (.01)*
$\mathbf{F}_{cft}$					
LOGGM	.79 (.04)***	.64 (.04)***	.66 (.04)***	.68 (.05)***	.82 (.04)***
LOGCAPINTENSITY	-.61 (.04)***	-.44 (.04)***	-.44 (.04)***	-.79 (.07)***	-.58 (.05)***
LOGREVGROWTH	.00 (.00)***	.00 (.00)***	.00 (.00)***	-.03 (.02)	-.0003 (.00)***
$\mathbf{C}_{ct}$					
LOGINFLATION	-.05 (.04)	.03 (.02)	.02 (.02)	.05 (.03)	-.02 (.03)
LOGINTEREST	-.07 (.04)*	.00 (.02)	.00 (.02)	.04 (.05)	-.06 (.05)
LOGGDPCAPITA	.16 (.17)	-.02 (.08)	-.03 (.12)	.04 (.17)	-.21 (.11)**
LOGPHONE	-.34 (.16)**	-.20 (.05)***	-.23 (.05)***	-.20 (.15)	-.02 (.12)
Intercept	-1.60 (2.08)	.72 (.68)	.16 (1.01)	-.41 (1.02)	1.29 (.78)*
Over-identification test (*p*-value)	.00	.00	.00	.00	.00
N	9667	9979	9771	3257	7490
Adj *R*-squared	.44	.59	.60	.43	.44
F on country-infrastructure	6.62	15.1	15.23	3.38	6.39
p-value	.0002	.000	.0001	.067	.01

Table 6 – Cross-Sectional Contingencies

The model, estimated using instrumental variables, is:

$$LOGINVENTORY_{cif,t+1} = LOGINFRASTRUCTURE_{ct} + \mathbf{Contingencies_{cift}} + \mathbf{F_{cift}} + \mathbf{C_{ct}} + INDUSTRY_i + YEAR_t + \varepsilon_{cift}\ ,$$

where **Contingencies**$_{\mathbf{cift}}$ are the contingency variables below. Road utilization is measured with *LOGVEHICLES* is the log of the number of vehicles per km of roads. Agency is measured with *MINORITY*, the ratio of shares owned by minority shareholders. Estimation is done with robust Huber-White standard errors, and clustered around industry to minimize serial correlation. *** = 1% significance, ** = 5%, *=10%.

	(1)	(2)	(3)
Variables of interest			
LOGROADS	-.25 (.20)	.02 (1.27)	-.08 (.05)*
LOGGDPGROWTH	-.02 (.01)*	-.01 (.01)	-.01 (.01)
Contingencies$_{\mathbf{cift}}$			
LOGVEHICLES	-.05 (.06)	1.46 (.57)**	
LOGVEHICLES x *LOGROADS*	.05 (.06)	-.21 (.08)**	
LOGVEHICLESSQ		-.15 (.79)	
LOGVEHICLESSQ x *LOGROADS*		.04 (.12)	
MINORITY			.01 (.00)***
MINORITY x *LOGROADS*			.02 (.00)***
F$_{\mathbf{cft}}$			
LOGGM	.79 (.04)***	.78 (.04)***	.71 (.06)***
LOGCAPINTENSITY	-.61 (.04)***	-.60 (.04)***	-.58 (.07)***
LOGREVGROWTH	.00 (.00)***	.00 (.00)***	-.01 (.00)**
C$_{\mathbf{ct}}$			
LOGINFLATION	.02 (.03)	.04 (.03)	.05 (.03)
LOGINTEREST	-.02 (.04)	.00 (.04)	.07 (.06)
LOGGDPCAPITA	-.26 (.11)**	-.48 (.13)***	.16 (.15)
LOGPHONE	.00 (.12)	.04 (.12)	-.24 (.16)
Intercept	1.98 (.87)**	1.22 (.97)	-1.34 (.89)
N	9972	9972	1996
Adj *R*-squared	.44	.44	.59

Figure 1 – Inventory versus Infrastructure for Retailers, Year 2004

The data is for all retail (NAICS 2000 code 44 through 45) firms from Osiris and COMPUSTAT Global Vantage tapes. Each observation is a firm-year. There are 4,268 unique firms from 60 countries. The period covered is 1983 through 2004. All values are in millions of nominal U.S. dollars, at current exchange rates for non-US firms. Inventory values are scaled by cost of goods sold. Roads/area for each country is road length divided by area. It is obtained from WDI.