Roads to Inventory:
Market Expansion and Input Sourcing Cost Reduction

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Abstract

This paper studies the effect of transport infrastructure on inventory using firm level data combined with road information. Different from previous studies, we measure a firm's accessible transport infrastructure using road area of both local and neighboring cities and focus on the transmission channels through which transport infrastructure affects inventory. Our theoretical framework highlights that under demand uncertainty, roads affect inventory through market expansion and reduction in sourcing cost of input. The two transmission channels are also confirmed in our empirical evidence. This paper enhances the literature by providing a comprehensive framework for analyzing the relationship between transport infrastructure and inventory and more importantly, on estimating the causal effect of infrastructure on economic scale and efficiency.

Keywords: *Infrastructure; Inventory; Market Expansion; Sourcing Cost of Input*

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1. Introduction

Infrastructure investment has been playing an important role in global economic growth, especially in developing economies. Take China as an example: At the beginning of the reforms and opening in 1978, infrastructure investment accounted for only 5.44 percent of GDP. In 2010, this percentage more than tripled, reaching 18.19 percent. This growth is even more impressive considering an annual economic growth rate of 10 percent.

The literature has established that infrastructure is an important and essential force driving productivity improvement and economic growth (see Romp and De Haan (2007) for relevant reviews). According to The World Bank (1994), infrastructure provides access to basic services, facilitates human/physical capital accumulation, promotes trade via linkage to markets, lowers production/transaction costs, and helps improve the environment. Meanwhile, infrastructure investment is known to directly generate jobs and may lead to inflows of investment to lagging areas, potentially producing beneficial distributive effects. However, most existing research focuses on only one aspect of the growth effect provided by infrastructure. There is no comprehensive framework to analyze the main growth impact of infrastructure. It is therefore important to identify what main role infrastructure plays in sustaining economic growth.[1]

In this paper, we examine the impact of roads on firm's inventory decision. We build a theoretical model to understand firm's incentive to invest in inventory, and generate several testable hypotheses. We then test these hypotheses regarding roads' effect on inventory using a comprehensive firm-level dataset. Moreover, by using inventory as dependent variable, we are able to quantify the different aspects of infrastructure's growth impacts in a uniform and comprehensive framework, given that inventory is an important sign of a firm's business scale and operational efficiency. On one hand, inventory is closely related to business scale. The larger a firm's market size, the more inventory it needs, as inventory serves as the basis for production (Rumyantsev and Netessine, 2007). On the other hand, firms bear warehousing and logistics costs for inventory. Thus, if a firm reduces its inventory storage without reducing its business scale, its operating efficiency or productivity must have improved (Capkun et al, 2009; Lieberman and Demeester, 1999).

We mainly rely on data from the National Bureau of Statistics of China (NBS) for empirical research. In particular, inventory and other firm attributes are taken from a firm-level data set, the Annual Survey of Industrial Firms (ASIF). We use a new dataset for transport infrastructure--the city-level road area database. Compared with existing studies, the use of road area alleviates measurement error as it takes into

[1] This is important for China, especially in the context of the expansive blueprint issued by China's government, often called "One Belt, One Road," and the setup of the Asian Infrastructure Investment Bank (AIIB), as we can quantify how much and which aspects of China's economy could benefit from infrastructure.

account the quality of infrastructure. By combining macro-infrastructure data with micro-inventory data, this paper also mitigates the reverse causality problem, as the improvement of infrastructure may affect firms' inventory, but firms' inventory is not capable of influencing infrastructure investment.

We propose two testable transmission channels (hereinafter "channels") through which roads can affect firms' inventory, which are strongly supported by our empirical evidence: market expansion and reduction in sourcing cost of inputs. Under demand uncertainty, firm invests in inventory to obtain intermediate inputs for next period's production in advance, while instant sourcing of intermediate inputs (rather than relying on inventory of inputs) is costly due to imperfect transportation infrastructure. Road infrastructure could integrate the markets, leading to a larger market size and therefore higher demand for inventory. In contrast, road infrastructure reduces the transportation cost of instant sourcing and therefore lowering the marginal benefit to invest in inventory, decreasing the demand for inventory. Among the two channels, we find that local infrastructure mainly helps reduce sourcing cost of inputs, while neighboring infrastructure mainly helps market expansion. Consistent with the empirical result of Li and Li (2013), our findings also indicate that transport infrastructure has significant network externalities or spillover effects. The spillover effect provides additional strong evidence that infrastructure helps market integration.

The rest of the paper proceeds as follows. The next section provides a detailed literature review. Then in Section 3, a theoretical framework is proposed to gauge infrastructure's effects on inventory. Section 4 introduces the empirical specification and data. Section 5 presents empirical results and quasi-natural experimental analysis. Section 6 provides further discussion and conducts endogeneity check. Finally, Section 7 concludes.

2. Literature Review

This paper relates closely to two strands of literature. The first addresses infrastructure's impact on growth. The literature on infrastructure began with research efforts to explain the positive correlation between development of infrastructure, such as railroads, and the rapid economic growth in the early days of industrial economies, including those of Western Europe, Japan, and the United States (Easterly and Rebelo, 1993; Gramlich, 1994; Donaldson, 2010). Until recently, literature has focused on micro-evidence to explore the channels through which infrastructure promotes economic growth.

There is literature that considers infrastructure's effect on market integration and competition aggravation. Michaels (2008) studies the impact of interstate highways on rural counties. He finds that highways generate an increase in trade-related activities. Donaldson (2010) considers the effect of railroads on a sample of 235 districts covering the majority of India during the period 1870 to 1930. He finds that railroads could increase interregional and international trade. Faber (2014) focuses on China's National Highway Trunk System and finds that the highway network promotes the integration of markets and improves the degree of industrialization in targeted cities. Moreover, as a firm's market size expands with infrastructure improvement, it faces fiercer market competition (Du et al., 2013).

Infrastructure improvement helps reduce transportation costs. Using data from 29 sectors in the U.S., Fernald (1999) finds that road growth is associated with larger productivity growth in industries that are more vehicle intensive. Bougheas et al. (1999) and Jacoby and Minten (2009) find that infrastructure lowers transportation costs and trade costs, thereby promoting trade and economic growth. Similarly, Donaldson (2010) finds that construction of the Indian railways reduces transportation costs.

The second strand of literature relates to the possible channels through which infrastructure could affect inventory. In fact, according to the Economic Order Quantity (EOQ) model, firms hold inventory for at least one of the following reasons: there are procurement lead times, production capacity might be rigid but demand is typically variable, there are economies of scale in handling inventories, or there is non-stationarity in demand and supply. Rumyantsev and Netessine (2007) comprehensively consider the determinants of inventory. They find that the demand for product, demand uncertainty, lead time, and holding costs of inventory are among the most important factors that affect inventory. Therefore, there are several inferences regarding possible channels that infrastructure can use to affect inventory.

First, since inventory is positively correlated with product demand, the improvement of infrastructure could raise inventory levels by expanding market size for firms. Second, firms would have to hold more inventory to deal with a vacancy period when the lead time is long (Shirley and Winston, 2004; Cachon and Terwiesch, 2008; Zipkin, 2000). Thus, when roads improve, lead time is significantly shortened.

In fact, previous studies have discussed the relationship between infrastructure and inventory. Shirley and Winston (2004) and Lai (2006) find that infrastructure would reduce inventory. Li and Li (2013) verify the results. Further, they find that transport infrastructure reduces inventory by reducing transportation costs. However, as we have discussed above, infrastructure can affect inventory through more than one channel. In this paper, we study infrastructure's growth impacts in a uniform and comprehensive perspective and discover the main channel through which roads affects inventory. Below we provide a framework to rationalize channels that might have impacts on firm's inventory, and set forth several testable hypotheses that describe the channels through which roads affect inventory.

3. Inventory Decision: Conceptual Framework and Hypothesis

In this section, we set up a partial equilibrium model featuring demand uncertainty and firm's investment in inventory of intermediate inputs to characterize how the improvement of road infrastructure shapes firm's inventory behavior. In this model, under demand uncertainty, firm invests in inventory in intermediate inputs according to its forecast to next period's demand. Once the demand is pinned down, firm will need to decide whether to source additional intermediate inputs in the current period, which, however, is subject to higher transportation cost.

Therefore a firm is faced with a trade-off between possible excess inventory and higher variable cost when making inventory decision. Higher inventory lowers the risk that a firm might have to source additional intermediate inputs, which is subject to higher variable transportation costs due to imperfect transportation infrastructure, if the actual demand is revealed to be higher than expected. However, higher inventory might exceed the realized demand and incurs losses if the actual demand turns out to be lower than expected. Improvement of roads infrastructure lowers the transportation cost of delivering final output, as well as the transportation cost of sourcing inputs in the current period (or instant sourcing cost of inputs). These two sources of transportation cost reductions deliver distinct effect on firm's inventory investment.

We summarize the intuitions of how improvement of road infrastructure impact firm's inventory here: On one hand, lower transportation cost for final output expands firm's access to external market and therefore will increase firm's ex ante demand for inventory as firm is now serving larger market. On the other hand, if instant sourcing cost of inputs is low, the marginal benefit to invest in inventory is also minor, lowering firm's inventory as well. Our model delivers these intuitions, which will be further tested empirically in the later sections.

3.1 Setup and Firm's Problem

The market structure is assumed to be monopolistic competition. Consumer's preference is subject to a CES-form utility function of (3.1), with i denoting a differentiated variety produced by firm *i* in the sector:

$$q_{it} = D_t \cdot p_{it}{}^{-\sigma} \tag{3.1}$$

Here, D_t is the aggregate demand parameter and is drawn from a distribution with CDF $G(\cdot)$ and PDF $g(\cdot)$. D_t is unknown to firm i in period $t-1$ and is revealed until period t. p_{it} is the consumer price of the variety (firm), and σ is the elasticity of substitution between varieties and assumed to be identical across all varieties for simplicity.

Prior to the realization of the stochastic demand D_t, firm i decides its purchase in intermediate inputs L_{it} in period $t-1$ to serve for the production need in period t. We define L_{it} as firm's "inventory". For firm i with unit production cost c_i, the production capacity with inventory L_{it} in period t is L_{it}/c_i. By investing in inventory L_{it}, firm also incurs a fixed warehousing cost F.

Firm is faced with *ad valorem* transportation cost τ_o when it sells its output to consumer, and τ_o is assumed to be decreasing with the stock of road infrastructure. The producer price p_{it}^* and consumer price p_{it} therefore satisfy (3.2):

$$p_{it} = \tau_o \cdot p_{it}^* \quad (3.2)$$

Once D_t is revealed (and L_{it} is given by firm's decision in period *t-1*), firm *i* can use its inventory L_{it} to produce up to its capacity L_{it}/c_i, with the objective function being (3.3):

$$\max_{p_{it}^*} p_{it}^* \cdot D_t \cdot {p_{it}}^{-\sigma} - L_{it} - F \quad (3.3)$$

Alternatively, firm *i* can instantly source additional intermediate inputs to expand production beyond its production capacity. However, instant sourcing of additional inputs is assumed to be costly due to imperfect transportation infrastructure. We assume that the unit production cost using additionally sourced inputs is raised to $\tau_I \cdot c_i$, where $\tau_I > 1$ measures the *ad valorem* cost of instant sourcing and is also decreasing with the stock of road infrastructure. τ_I can be thought of as variable costs associated with instant delivery of intermediate inputs in the current period, for example, delivery fees, probability of delayed delivery, unsatisfactory logistic services, etc. In this case firm's objective function follows (3.4):

$$\max_{p_{it}^*} (p_{it}^* - c_i)\frac{L_{it}}{c_i} + (p_{it}^* - \tau_I c_i)\left(D_t \cdot {p_{it}}^{-\sigma} - \frac{L_{it}}{c_i}\right) - F \quad (3.4)$$

Therefore, at period *t-1*, firm *i* chooses inventory L_{it} to maximize the expected profit, given the stochastic distribution of demand parameter D_t. As D_t is revealed at period *t*, firm chooses objective function (3.3) or (3.4). Therefore, the expected profit for firm is in fact the probability-weighted average of (3.3) and (3.4). For objective function (3.3), since $q_{it} = D_t \cdot {p_{it}}^{-\sigma}$, it is easily observed that the problem is equivalent to (3.5):

$$\max_{q_{it}} \left(\frac{D_t}{q_{it}}\right)^{\frac{1}{\sigma}} \cdot \frac{q_{it}}{\tau_o} - L_{it}\,, s.t.\, q_{it} \le \frac{L_{it}}{c_i} \quad (3.5)$$

It is easy to observe that, (3.5) is a monotonic increasing function of output q_{it}. Therefore, if a firm chooses to produce only using its inventory L_{it} purchased in period *t-1*, its optimal strategy is to produce at its capacity and generate the maximum output. In other words, solving the problem of (3.5) would yield a corner solution $q_{it}^* = \frac{L_{it}}{c_i}$ and a profit function of (3.6):

$$\pi_{1it} = \frac{D_t^{\frac{1}{\sigma}}}{\tau_o}\left(\frac{L_{it}}{c_i}\right)^{1-\frac{1}{\sigma}} - L_{it} - F$$

(3.6)

For objective function (3.4), we take the first-order condition with respect to p_{it}^* and obtain the profit function of (3.7):

$$\pi_{2it} = D_t \frac{(\sigma-1)^{\sigma-1}}{\sigma^\sigma} \tau_o^{-\sigma}(\tau_I c_i)^{1-\sigma} + (\tau_I - 1)L_{it}$$

(3.7)

For objective function (3.4) to be valid, $D_t \cdot p_{it}^{-\sigma} - \frac{L_{it}}{c_i} > 0$ is required. Therefore, firm can only choose to pursue (3.4) when the following condition (3.8) holds:

$$q_{it} = D_t \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} (\tau_o \tau_I c_i)^{-\sigma} > \frac{L_{it}}{c_i} \to D_t > \frac{L_{it}}{c_i}\left(\frac{\sigma}{\sigma-1}\tau_o \tau_I c_i\right)^\sigma$$

(3.8)

For $D_t > \frac{L_{it}}{c_i}\left(\frac{\sigma}{\sigma-1}\tau_o \tau_I c_i\right)^\sigma$, it is easy to show that $\pi_{2it} > \pi_{1it}$ since objective function (3.3) is nested in (3.4) and the optimal decision under (3.3) is in fact feasible under (3.4). On the other hand, when $D_t \le \frac{L_{it}}{c_i}\left(\frac{\sigma}{\sigma-1}\tau_o \tau_I c_i\right)^\sigma$, solution to objective function (3.3) is feasible while solution to (3.4) is not allowed. We therefore have the following general profit function (3.9) for firm *i*:

$$\pi_{it} = \begin{cases} \frac{D_t^{\frac{1}{\sigma}}}{\tau_o}\left(\frac{L_{it}}{c_i}\right)^{1-\frac{1}{\sigma}} - L_{it}, D_t \in (0, \frac{L_{it}}{c_i}\left(\frac{\sigma}{\sigma-1}\tau_o \tau_I c_i\right)^\sigma] \\ D_t \frac{(\sigma-1)^{\sigma-1}}{(\sigma\tau_o)^\sigma}(\tau_I c_i)^{1-\sigma} + (\tau_I - 1)L_{it}, D_t \in (\frac{L_{it}}{c_i}\left(\frac{\sigma}{\sigma-1}\tau_o \tau_I c_i\right)^\sigma, \infty) \end{cases}$$

(3.9)

3.2 Optimal Inventory

The profit function of (3.9) is conditioned on inventory L_{it}. To obtain optimal inventory, firm would maximize the expected profit as in (3.10), which is the probability-weighted average profit function of (3.9):

$$\max_{L_{it}} \int_0^{\infty} \pi_{it} dG(D_t) = \int_0^{A} \pi_{1it} dG(D_t) + \int_A^{\infty} \pi_{2it} dG(D_t)$$
$$= \int_0^{A} \left[\frac{D_t^{\frac{1}{\sigma}}}{\tau_o} \left(\frac{L_{it}}{c_i} \right)^{1-\frac{1}{\sigma}} - L_{it} \right] dG(D_t)$$
$$+ \int_A^{\infty} \left[D_t \frac{(\sigma-1)^{\sigma-1}}{(\sigma\tau_o)^{\sigma}} (\tau_I c_i)^{1-\sigma} + (\tau_I - 1) L_{it} \right] dG(D_t)$$

(3.10)

Here, $A = \frac{L_{it}}{c_i}\left(\frac{\sigma}{\sigma-1}\tau_o\tau_I c_i\right)^{\sigma}$ is threshold of demand parameter which determines whether firm would source additional intermediate inputs. Leibniz's rule gives the following first-order condition:

$$\frac{\sigma-1}{\sigma}\left(\frac{L_{it}}{c_i}\right)^{-\frac{1}{\sigma}} \frac{1}{c_i} \int_0^{A} \frac{D_t^{\frac{1}{\sigma}}}{\tau_o} dG(D_t) = \tau_I G(A) + 1 - \tau_I$$

(3.11)

Assume that D_t follows a uniform distribution with boundary $[0, M]$, then we have the close-form solution for optimal inventory L_{it}:

$$L_{it} = (\sigma+1)\left(\frac{\sigma-1}{\sigma}\right)^{\sigma} M \cdot \frac{\tau_I - 1}{\tau_I^{\sigma+1}} \cdot \frac{c_i^{1-\sigma}}{\tau_o^{\sigma}}$$

(3.12)

Taking log yields:

$$\ln(L_{it}) = \ln[(\sigma+1)Mc_i] + \sigma \ln\left(\frac{\sigma-1}{\sigma c_i}\right) + \ln(\tau_I - 1) - (\sigma+1)\ln(\tau_I) - \sigma\ln(\tau_o)$$

(3.13)

Since better road infrastructure unambiguously gives rise to lower transportation cost for final output and lower instant sourcing cost of inputs, we now assume τ_o and τ_I are inverse to the stock of road infrastructure R_t:

$$\tau_o = \frac{1}{R_t};\ \tau_I = \frac{1}{R_t}$$

(3.14)

We therefore have the following two propositions characterizing the impacts of road infrastructure on firm's inventory decision.

Proposition 1 (Market Expansion)

Improvement of road infrastructure leads to decrease in transportation costs of output, which helps firm's market expansion and thus expands firm's inventory, namely:

$$\frac{\partial \ln(L_{it})}{\partial \ln(\tau_o)} \cdot \frac{d \ln(\tau_o)}{d \ln(R_t)} = \sigma > 0$$

The intuition of Proposition 1 is that once the transportation cost to delivery final output decreases, firm's *ex ante* potential market size expands and therefore increasing its own demand for inventory.

Proposition 2 (Input Sourcing Cost Reduction)

Improvement of road infrastructure leads to decrease in instant sourcing cost of inputs, which either shrinks or expands firm's inventory, namely

$$\frac{\partial\, ln(L_{it})}{\partial\, ln(\tau_I)} \cdot \frac{d\, ln(\tau_I)}{d\, ln(R_t)} = \sigma - \frac{1}{\tau_I - 1}$$

Therefore, if $\tau_I < 1 + \frac{1}{\sigma}$, *we have* $\frac{\partial\, ln(L_{it})}{\partial\, ln(\tau_I)} \cdot \frac{d\, ln(\tau_I)}{d\, ln(R_t)} < 0$, *otherwise* $\frac{\partial\, ln(L_{it})}{\partial\, ln(\tau_I)} \cdot \frac{d\, ln(\tau_I)}{d\, ln(R_t)} \geq 0$.

Thus, the relationship between input sourcing cost and inventory is non-linear and depicts an inverse-U shape. When input sourcing cost τ_I is relatively low, further decrease in τ_I reduces the marginal benefit to invest in inventory and saves inventory investment for firm. Note that when input sourcing cost τ_I is high, a decrease in τ_I induces firm to invest in inventory in turn. Intuitively, this is also due to the market expansion effect of transport infrastructure on inventory, as decrease in τ_I lowers firm's cost and thus output price, helping firm's market expansion and expanding firm's inventory. Therefore, empirically, once we control for the effect of market expansion, input sourcing cost would be negatively correlated with inventory, and improvement in transport infrastructure could serve to reduce inventory through the reduction of input sourcing cost.

The following two hypotheses are used for empirical test, based on the above two propositions:

Hypothesis 1 (Market Expansion)

Improvement in road infrastructure leads to an increase in inventory demand through market expansion.

Hypothesis 2 (Input Sourcing Cost Reduction)

When market expansion effect is controlled, improvement in road infrastructure leads to a decrease in inventory demand through instant sourcing cost of inputs reduction.

4. Empirical Specifications and Data

4.1 Specification

We design specifications to test our hypotheses. The baseline model is motivated by a determinant function of inventory (Rumyantsev and Netessine, 2007). We augment the inventory function with road infrastructure:

$$Ln(Inventory_{it}) = \beta_0 + \beta_1 Infra_{it} + X_{it}'\beta + \eta_i + \phi_t + \varepsilon_{it} \qquad (4.1)$$

$Ln(Inventory_{it})$ is the log form of firm *i*'s inventory at year *t*, $Infra_{it}$ is the level infrastructure that firm *i* could have access to, and X_{it} includes other determinants of inventory. We control for the firm fixed effect η_i and year fixed effect ϕ_t. The coefficient of $Infra_{it}$ measures the general impact of transport infrastructure on inventory, which could be thought of as causal if our baseline controls were exhaustive.

Model (4.1) is used to assess the impact of roads on inventory in general. To explore the topical question of how roads affect inventory, following Cutler and Lleras-Muney (2010), we use the model of mediation. First, the mediating variables F_{it}, which characterize the channels through which road infrastructure can impact on inventory, are regressed on road infrastructure:

$$F_{it} = \alpha_0 + \alpha_1 Infra_{it} + X_{it}'\alpha + \eta_i + \phi_t + \varepsilon_{it} \qquad (4.2)$$

According to our hypotheses, the mediating variables include market size (stands for market expansion) and sourcing cost of inputs. Further, the coefficient of road infrastructure is expected to be positive in the regression of market size and negative in the regression of sourcing cost of inputs, as infrastructure can help firm's market expansion, while it can also serve to reduce input sourcing cost.

Second, after confirming the impact of infrastructure on the mediating variables, we add the corresponding mediating variables into model (4.1):

$$Ln(Inventory_{it}) = \beta_0 + \beta_1 Infra_{it} + \beta_2 F_{it} + X_{it}'\beta + \eta_i + \phi_t + \varepsilon_{it} \qquad (4.3)$$

We focus on the coefficient difference of road infrastructure between (4.1) and (4.3). According to Hypothesis 1, the improvement of road infrastructure helps firm's market expansion and thus expands firm's inventory. Therefore, when the variable of market size is added into (4.3), the coefficient of market size is expected to be positive, and the coefficient of road infrastructure drops.

Further, according to Hypothesis 2, when market expansion effect is controlled, improvement in road infrastructure leads to a decrease in inventory demand through instant sourcing cost of inputs reduction. Therefore, when the variable of input sourcing cost is added after market expansion, the coefficient of input sourcing cost is expected to be positive, and the coefficient of road infrastructure rises.

4.2 Data

To empirically estimate models (4.1)-(4.3), data are compiled from the Annual Survey of Industrial Firms (ASIF) and the National Bureau of Statistics of China (NBS). Firm-level data are all from the ASIF, while the data of infrastructure are city-level data from the NBS. The ASIF database is constructed by the National Bureau of Statistics of China. It covers all state-owned manufacturing firms and those non-state manufacturing enterprises “above designated size” (with annual sales over 5 million Yuan, or about 0.6 million U.S. dollars at the 2005 exchange rate) for the 1998-2007 period. They account for more than 85 percent of China’s industrial output (Jefferson et al., 2008).

Inventory

For the dependent variable, following Shirley and Winston (2004) and Li and Li (2013), we use non-finished goods as inventory. In fact, most classical inventory models focus on non-finished goods inventory, as finished goods are more subject to increasing costs of production and production smoothing and are thus not related to infrastructure. In addition, non-finished goods inventory accounts for more than two-thirds of the total inventory in China, which is similar to the U.S. (Blinder and Maccini, 1991; Shirley and Winston, 2004). Therefore, we focus on the impact of infrastructure on non-finished goods inventory, which is also consistent with our theoretical model that reflects firm’s sourcing decision.

Road Infrastructure

For the variable of road infrastructure, we use a new measure, the ratio of road area to land area, to better characterize the quality of infrastructure. Previous studies use the ratio of road length to land area (or road length directly) to approximate the level of infrastructure, while road length only captures part of infrastructure quality. In addition to road length, another important aspect of infrastructure quality is road width: The wider is a road, the less congested the road, the shorter the lead time, and the less the input sourcing costs will be, which will certainly have an impact on inventory. Therefore, using only road length as measure of infrastructure will result in omitted variable bias, while considering road area can mitigate such bias to a great extent.

We also take into account the spatial spillover effect of infrastructure and measure a firm's accessible transport infrastructure using the total road area of both local and the neighboring cities which border on the local city. In fact, road infrastructure from neighboring areas would also have influence on inventory in local areas, as suggested by Li and Li (2013). Considering neighboring road infrastructure would, again, help mitigate omitted variable bias.

Mediating Variables

The mediating variables include market size and input sourcing cost, as we have mentioned in section 4.1. For market size, following conventional wisdom, we directly use the log of sales as a proxy. For input sourcing cost, we use the log of lead time, a common accounting measure of transportation time, to approximate transportation sourcing cost of inputs.[2]

Controlled Variables

The main controlled variables include product margin, road congestion, inflation rate, and market competition. These variables all prove to affect inventory. The higher a firm's product margin, the higher the opportunity cost of a deficiency in inventory. The improvement of highways is often accompanied by more traffic congestion. We use the number of vehicles per kilometer of road to measure traffic congestion (Sherley and Winston, 2004; Li and Li, 2010). A higher inflation rate will result in lower real interest rates and will therefore lower the opportunity costs of inventory. Market competition is measured by the city-industry-year Herfindahl index, which is conjectured to be negatively correlated with inventory. Finally, following conventional wisdom, we also control for the fixed effect of firm's age.

Since the city-level infrastructure data starts in 2001, the sample period is from 2001 to 2007. We drop those observations with non-positive inventory, net fixed assets, or lead time. We also drop markets (defined as an industry-city-year combination) with less than 5 observations, since these markets are better characterized as monopoly or oligopoly, whereas our theoretical analysis is based on monopolistic competition or perfect competition. In the end, our final sample consists of 863,463 observations (firm-year). Table 1 tabulates the summary statistics.

[Insert Table 1 approximately here]

5. Empirical Results

5.1 Baseline Results

The baseline results, estimated using OLS with time and firm fixed effects, are

[2] Lead time is measured by 365/ (Cost of goods sold/Accounts payable).

reported in Table 2 and 3, using model (4.1)-(4.3). We cluster the standard error by city level, where the variable of infrastructure varies. In Table 2, we only control for time and firm fixed effects, while the results do not alter significantly after we add the controlled variables of product margin, congestion, and inflation rate in Table 3, suggesting that the empirical results are robust to different empirical specifications.

Surprisingly, different from previous studies, especially Li and Li (2013), we find an insignificant, though negative, coefficient of infrastructure on inventory from column (3) in both Table 2 and 3, seemingly indicating that in general, infrastructure does not have a significant impact on inventory. This is probably due to two reasons. Firstly, we cluster the standard error by city level, rather than firm level, where the variable of infrastructure varies, resulting in a significant enlargement of the value of standard error.[3] Secondly, we do not control the variable of market size in column (1), which, based on infrastructure's market size effect as indicated by Hypothesis 1, may incorporate a positive impact from infrastructure on inventory. This in turn suggests that the market expansion effect cannot be ignored when considering the effect of infrastructure on inventory.

[Insert Table 2 approximately here]

The market expansion effect is confirmed as we find a positive impact of road infrastructure on sales in column (1) of both tables and a significant drop in the coefficient of road infrastructure in column (4) once market size is added into model (4.1). The market expansion effect of road infrastructure on inventory is also economically significant, as doubling infrastructure will bring in an increase in inventory by 6.0-6.4 percent through the market expansion channel. Thus, based on the results of column (4), our findings do not contradict to the previous studies regarding the negative correlation between infrastructure and inventory, e.g., Li and Li (2013), as most studies have controlled for market size when testing this negative correlation, while we contribute to the literature by providing a more comprehensive analysis of infrastructure and inventory, and thus the causal effect of infrastructure on economic scale and efficiency.

Next, we test the hypothesis that once market expansion effect is controlled, improvement in road infrastructure leads to a decrease in inventory demand through instant sourcing cost of inputs reduction. In fact, most studies investigating the relationship between road infrastructure and inventory focus on this effect (e.g., Li and Li, 2013). The results in the last columns of both tables confirm Hypothesis 2. First, we find a positive effect of input sourcing cost (measured by lead time) on the value of inventory. Thus, the more time it takes to transport inputs, the more inventory firms need to store in order to meet market demand. Second, there is a significant rise in the coefficient of road infrastructure once the input sourcing cost is added into model (4.1). As for economic significance, doubling infrastructure will save inventory investment by 2.7-3.3 percent through the reduction of input sourcing cost.

[3] Li and Li (2013) clustered the standard error by firm level, resulting in an over-estimation of coefficient significance.

[Insert Table 3 approximately here]

It is even interesting to note that, once we control for the two channels, namely, market expansion and sourcing cost of inputs, the coefficient of infrastructure, again, becomes insignificant in both tables, indicating that we have probably exhausted the channels through which infrastructure can impact on inventory. Thus, consistent with the theoretical interpretation, the empirical framework we propose here provides a complete analysis of infrastructure's effect on economic scale and efficiency.

One may have a concern that road infrastructure may not be enjoyed thoroughly by firms if the city area is too large. To alleviate this concern, we drop those samples located in the five cities with the largest geographic areas, namely, Erdos, Chifeng, Jiuquan, Hulunbeier, and Chongqing and replicate the regressions in Table 3. The empirical results remain robust, as can be seen in Table 4.

[Insert Table 4 approximately here]

Taken together, the baseline empirical results confirm that roads affects inventory through market expansion and reduction in sourcing cost of inputs. After controlling for the channels, the coefficient of infrastructure becomes insignificant, indicating that the channel analysis of infrastructure's impact on inventory is relatively exhausted and therefore, we have achieved a consistent estimation of each channel's economic significance. In the next section, by conducting subsample analysis (quasi-natural experiment), we further check the causality of each channel, to have a better understanding of infrastructure's effect on economic scale and efficiency.

5.2 Quasi-Natural Experiment Based on Firm/Industry Heterogeneity

The argument that road infrastructure can affect firm's inventory decision through market expansion and instant sourcing cost reduction can be extended to generate heterogeneous patterns across different firms/industries. These heterogeneous patterns provide theoretical predictions that can be further tested in the empirical section.

For the market expansion, it is straightforward to see that different firms/industries exhibit different dependences on transportation infrastructure when delivering final output to consumers. For example, Duranton et al. (2014) find little effect of highways on export, indicating that firms with high export intensity depend less on local transport infrastructure than firms with low export intensity. Another example is that industry with higher weight-to-value ratio in its output is also more dependent on transport infrastructure.

To see this, we extend the model and further specify that the output *ad valorem* transportation cost τ_o is a function of road infrastructure R_t with intensity of infrastructure dependence:

$$\tau_o(R_t) = {R_t}^{-\delta} \tag{5.1}$$

Here, $\delta > 0$ is a parameter characterizing transportation cost's reliance on road, varying by firm/industry. Higher dependence on road corresponds to higher δ since transportation cost of final output decreases more quickly as road infrastructure improves.

Similarly we can specify that *ad valorem* cost of instant sourcing cost τ_I is a function of road infrastructure R_t with intensity of infrastructure dependence:

$$\tau_I(R_t) = R_t^{-\rho} \tag{5.2}$$

Here, $\rho > 0$ again is a parameter characterizing instant sourcing cost's reliance on road, varying by firm/industry. For example, industry with higher input use of transportation service corresponds to higher ρ since instant sourcing cost decreases more quickly as road infrastructure improves.

Therefore the effects of road infrastructure on firm's inventory can exhibit firm/industry heterogeneity, as Proposition 3 argues:

Proposition 3

Improvement of road infrastructure affects firm's inventory through two channels. The market expansion channel is stronger for industry with higher δ, whose output transportation cost rely on road infrastructure more heavily:

$$\frac{\partial \ln(L_{it})}{\partial \ln(\tau_o)} \cdot \frac{d \ln(\tau_o)}{d \ln(R_t)} = \sigma\delta \tag{5.3}$$

The instant sourcing cost reduction channel is stronger for industry with higher ρ, whose instant sourcing cost rely on road infrastructure more heavily:

$$\frac{\partial\, ln(L_{it})}{\partial\, ln(\tau_I)} \cdot \frac{d\, ln(\tau_I)}{d\, ln(R_t)} = \left(\sigma - \frac{1}{\tau_I - 1}\right) \rho \tag{5.4}$$

Therefore, based on Proposition 3, we can conduct sub-sample analysis, which can also be seen as quasi-natural experiment analysis, if firm can hardly switch from one subsample to another subsample, to provide further evidence on the causality of infrastructure on inventory.

5.2.1 Market Expansion

First, we analyze different performance of infrastructure's market expansion effect based on firm's export pattern. As we have mentioned, firms with high export intensity may depend less on local transport infrastructure than firms with low export intensity. Therefore, the market expansion effect is expected to be more significant in the subsample with low export intensity.

We classify firms by export intensity, based on the ratio of export sales over total sales. The control group is defined as those firms with the ratio less than 0.2, and the treatment group is defined with the ratio larger than 0.8.[4] In each group, we conduct two-step empirical analysis using model (4.1)-(4.3) to check: 1) whether the coefficient of road infrastructure on sales is significant; 2) whether the coefficient of road infrastructure drops significantly once market size is added into model (4.1). Column (1)-(3) of Table 5 reports the results of control group, and column (4)-(6) reports the results of treatment group.

[Insert Table 5 approximately here]

We find that, firstly, road infrastructure significantly helps firm's market expansion only in the treatment group in which firms are with low export intensity and thus rely more on local market and local road infrastructure (column 1). Secondly, the coefficient of road infrastructure on inventory drops significantly once the variable of market size is added into model (4.1) (column 2-3) in the treatment group. Thirdly, for firms in the control group with high export intensity, neither is the coefficient of infrastructure on market size significant, nor does that on inventory drops significantly once market size is added. The three findings are in line with Proposition 3 and provide further support for Hypothesis 1 arguing that improvement of road infrastructure expands firm's inventory by helping firm's market expansion.

It's worthy to note that, our results are not contradicted to classical inventory theory arguing that inventory is positively correlated with firm's market size, as we observe that the coefficients of market size are positive and significant in every regression of both control group and treatment group in Table 5. The intuition is that a firm, no matter whether it is with high or low export intensity, needs inventory to support its output sales. Therefore, the larger is the firm's market size, the more inventories it needs.

5.2.2 Sourcing Costs of Inputs

Next, we verify the channel of input sourcing cost. As we have mentioned, the input sourcing cost decreases more as road infrastructure improves in industry with higher input use of transportation service. Therefore, the channel of input sourcing cost is expected to be more significant in industry with higher input use of transportation service.

Following Fernald (1999), we classify industries transportation input intensity, based on China's 42-sector Input-Output table. We calculate the total consumption coefficient using Input-Output table, and use each sector's total consumption

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[4] The empirical results remain robust when altering the sample division method and are available upon request.

coefficient from Transportation Service sector to measure transportation intensity.[5] This index reflects a sector's reliance on transportation in terms of inputs. The higher the index, the more the sector utilizes transportation inputs in the production process through overall input-output linkages. We then concord this sector-level index into CIC 2-digit industry level, and divide the sample into industries with more (less) transportation inputs using the median value of this index in the particular year. The control group is defined as industries with less transportation inputs, and the treatment group is defined as industries with more transportation inputs. Similar to section 5.2.1, in each group, we conduct two-step empirical analysis using model (4.1)-(4.3) to check: 1) whether the coefficient of road infrastructure on lead time is significant; 2) market size controlled, whether the coefficient of road infrastructure rises significantly once lead time is added. Column (1)-(3) of Table 6 reports the results of control group, and column (4)-(6) reports the results of treatment group.

[Insert Table 6 approximately here]

We find that, firstly, road infrastructure significantly reduces firm's lead time and thus input sourcing cost in both groups (column 1 and 4), while the effect is more significant in the treatment group, as confirmed by both the magnitude of the coefficients and the whole sample analysis incorporating the interaction term of transport intensity and infrastructure in column (7) and (8). Secondly, market size controlled, the coefficient of road infrastructure on inventory rises significantly once the variable of input sourcing cost is added in the treatment group (column 2-3), while we do not observe the same coefficient pattern in the control group. The findings support for Hypothesis 2 arguing that improvement of road infrastructure leads to a decrease in inventory demand through instant sourcing cost of inputs reduction.

6. Further Discussion

The above quasi-experiment analysis confirms the causal effect of infrastructure on economic scale and efficiency. In this section, we provide further evidence to further support our arguments. We then conclude by conducting endogeneity check using reduced form regression.

6.1 Weight to Value of Output

To start with, we follow Duranton et al. (2014) and use weight to value of output to measure the degree of dependence on transportation. On the one hand, industry with higher weight to value of output will benefit more from improved infrastructure as firms can be more convenient to expand their markets. Therefore, road infrastructure's

[5] Since the 42-sector Input-Output table is available for year 2002, 2005 and 2007, we use the 2002 table for sample from 2001 to 2002, the 2005 table for sample from 2003 to 2005, and the 2007 table for sample from 2006 to 2007.

market expansion effect on inventory is expected to be more significant in industry with higher weight to value of output. On the other hand, industry with higher weight to value of output is often with higher weight to value of input. Thus, road infrastructure's instant sourcing input cost effect is also expected to be more significant in industry with higher weight to value of output.

The results of Table 7 are in line with our expectation. We find that the market expansion and instant sourcing input cost effect exist only in the treatment group that is with higher weight to value of output. For the control group, neither does the coefficient of infrastructure on inventory drop significantly once market size is added, nor does that rises significantly after lead time is incorporated.[6] The finding, again, confirms the causal effect of infrastructure on economic scale and efficiency.

[Insert Table 7 approximately here]

6.2 Market Development

Next, we discuss the potential effect of market development across regions. Market development differs across regions, which may impact on the relationship between road infrastructure and inventory. In a more market-oriented environment, firms are subject to less distortion and can react more promptly towards price and cost shocks. To illustrate, we introduce in cost τ_o and τ_I a wedge τ_D invariant to road infrastructure to reflect the effect of distortion, namely:

$$\tau_o = \frac{1}{R_t} + \tau_D;\ \tau_I = \frac{1}{R_t} + \tau_D \tag{6.1}$$

In fact, the magnitude of τ_D measures the degree of distortion in cost signal. The higher the τ_D, the lower the degree of marketization since improvement in road infrastructure does not significantly reduce cost to deliver final output to consumers and cost to instantly source inputs. τ_D needs not to be related to transportation costs, but can rather be interpreted as regulations resulting in market barriers, taxes that distort costs, financial repression associated with logistic activities, and so on. All in all, distortions induce firms to be less reactive in terms of inventory decision to shocks in transportation costs.

Under the setup of (6.1), different patterns of road infrastructure and inventory under different stages of market development can be generated:

Proposition 4 (Marketization)

In a market-oriented environment with lower distortion τ_D, *firm's inventory decision*

[6] For simplicity, the empirical results of infrastructure on market size and lead time are available upon request.

is more reactive towards improvement of road infrastructure, namely

$$\frac{\partial\, ln(L_{it})}{\partial\, ln(\tau_o)} \cdot \frac{d\, ln(\tau_o)}{d\, ln(R_t)} = \frac{\sigma}{1 + R_t \tau_D}$$

$$\frac{\partial\, ln(L_{it})}{\partial\, ln(\tau_I)} \cdot \frac{d\, ln(\tau_I)}{d\, ln(R_t)} = \left(\sigma - \frac{1}{\tau_I - 1}\right) \frac{1}{1 + R_t \tau_D}$$

In Table 8, we divide the sample based on the provincial marketization index (NERI index) constructed by Fan and Wang (2011). The index is widely used in many distinguished papers, e.g., Firth et al. (2009) and Qian et al. (2014). Firth et al. (2009) use the NERI index as an indicator of market development conditions.

In Table 8, we confirm that, market expansion and instant sourcing input cost effect exist only in regions with developed market. For the control group with less developed market, neither does the coefficient of infrastructure on inventory drop significantly once market size is added, nor does that rises significantly after lead time is incorporated.

[Insert Table 8 approximately here]

6.3 SOE vs non-SOE

Further, we compare the performance between state-owned enterprises (SOEs) and non-SOEs. China's SOEs suffer from agency problems and insider control (Lin and Tan, 1999; Kornai et al., 2003), and may be deviated from profit-maximizing behaviors. Thus, it is expected that our models only fit for non-SOEs that are more profit-oriented.

In Table 9, the subsample analysis based on SOE and non-SOE is conducted, in which SOE is defined as firm with state-owned capital proportion larger than 50%. Again, we confirm that market expansion and instant sourcing input cost effect exist only in non-SOEs. For SOEs, neither does the coefficient of infrastructure on inventory drop significantly once market size is added, nor does that rises significantly after lead time is incorporated.

[Insert Table 9 approximately here]

6.4 Endogeneity

Finally, we make endogeneity check, though it may not be a key issue in the relationship between infrastructure and inventory. In fact, one minor concern is that infrastructure and inventory may be affected by common but unobservable variables, resulting in possible biased estimated results.

There are two potential instrumental variables (IVs) for road infrastructure to cope with endogeneity problems. The first one is the average slope in the corresponding area, and the other is the weighted average price of the exported equipment[7]. The greater the slope, the more difficult it is to construct transport infrastructure. The higher the weighted average price, the more expensive it is to construct transport infrastructure. Therefore, both the average slope and the equipment price are negatively correlated to road infrastructure. However, slope is time invariant while equipment price is area invariant. Therefore, we instrument road infrastructure using the interaction of average slope and equipment price. In the column (1) of Table 10, as expected, the constructed IV is negatively correlated with road infrastructure.

Usually we conduct 2SLS for IV estimation, while this is not applicable in the mediating model, as 2SLS will provide consistent estimators for road infrastructure in every regression in Table 3, resulting in improper comparison of coefficients among regressions (Cutler and Lleras-Muney, 2010). Therefore, we directly use reduced form regression and replace the variable of road infrastructure with the IV. Since road infrastructure is negatively correlated with the IV, we expect that the coefficients of the IV change in the opposite direction compared with those of road infrastructure as we add the variable of market size and lead time. Table 10 confirms our expectations, indicating the robustness of our results.

[Insert Table 10 approximately here]

7. Conclusion

The importance of infrastructure in economic development has been recognized increasingly by governments and research institutes. The goal of this study is to enrich the literature by investigating the causal effect of transport infrastructure on economic scale and efficiency. In particular, we estimate the extent to which infrastructure has affected firms' inventory and identify the transmission channels. We verify the robustness of either channel by using subsample empirics, which can also be seen as quasi-natural experiments. A new dataset of infrastructure, which takes road width into consideration and therefore incorporates the quality of infrastructure, is introduced to mitigate measurement error. To address potential omitted variable biases, we incorporate the neighboring infrastructure.

This paper contributes to the literature by identifying infrastructure's growth channels in a uniform and comprehensive framework. We formalize two channels through which transport infrastructure may impact firm's inventory in a simple model. Based on the hypotheses generated by the model, our estimates suggest that roads affect inventory mainly through market expansion and reduction in sourcing cost of

[7] The price data are calculated using the Chinese Longitudinal Firm Trade Transaction Database (CLFTTD). We calculated the export price for road-building machinery (with customs number 8429), including motorized bulldozers, side shovel bulldozers, road graders, graders, scrapers, mechanical shovels, excavators, shovel loaders, tamping machines, and road rollers.

inputs. This paper enhances the literature by providing a comprehensive framework for analyzing the relationship between transport infrastructure and inventory and, more important, on estimating the causal effect of infrastructure on economic scale and efficiency.

Our results also indicate that SOEs respond little to the road improvement, while non-SOEs benefit much more. This implies that, in order to improve benefits from roads, SOE reform should be conducted by allocating more resources to the private sectors. Additionally, this study shows the existence of a significant spillover effect of road on firms. We believe this benefit could be even larger if China can further remove its hukou system and domestic trade barriers to allow for further mobility of both capital and labor.

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Table 1 Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Ln (inventory)	863,463	6.902	1.998	0.000	16.870
Ln (infra)	856,870	-6.355	1.093	-10.969	-4.186
Ln (sales)	863,463	10.089	1.270	0.000	19.047
Ln (lead time)	853,500	4.893	1.256	-8.275	17.408
Product margin	863,463	0.139	0.117	-1.000	1.000
Congestion	823,194	3.650	1.065	-0.701	6.344
Inflation	863,463	0.022	0.018	-0.018	0.066
Competition	863,463	4.800	1.019	0.314	6.580

Table 2 Baseline Estimation Results

	(1)	(2)	(3)	(4)	(5)
	Ln (sales)	Ln (lead time)	Ln (inventory)	Ln (inventory)	Ln (inventory)
Ln (infra)	0.184**	-0.199***	-0.121	-0.185*	-0.158
	(0.076)	(0.072)	(0.109)	(0.110)	(0.107)
Ln (sales)				0.346***	0.566***
				(0.020)	(0.016)
Ln (lead time)					0.341***
					(0.009)
Age FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	856,870	847,014	856,870	856,870	847,014
R-squared	0.905	0.810	0.806	0.811	0.819

Note: 1) Robust cluster standard errors are in parentheses (cluster by city level).

2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3 Baseline Estimation Results with Controlled Variables

	(1)	(2)	(3)	(4)	(5)
	Ln (sales)	Ln (lead time)	Ln (inventory)	Ln (inventory)	Ln (inventory)
Ln (infra)	0.172**	-0.209***	-0.156	-0.216*	-0.183
	(0.075)	(0.071)	(0.119)	(0.119)	(0.117)
Ln (sales)				0.347***	0.574***
				(0.021)	(0.016)
Ln (lead time)					0.351***
					(0.010)
Product margin	0.014	1.326***	0.161**	0.156**	-0.309***
	(0.106)	(0.117)	(0.069)	(0.072)	(0.067)
Congestion	-0.031*	0.062**	0.022	0.033	0.015
	(0.018)	(0.026)	(0.030)	(0.029)	(0.031)
Inflation	-0.134	0.416	2.415*	2.462*	2.306
	(0.848)	(0.702)	(1.380)	(1.418)	(1.408)
Competition	0.056***	-0.043***	0.007	-0.012	-0.010
	(0.009)	(0.010)	(0.012)	(0.011)	(0.011)
Age FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	816,941	807,626	816,941	816,941	807,626
R-squared	0.907	0.817	0.808	0.813	0.821

Note: 1) Robust cluster standard errors are in parentheses (cluster by city level).

2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4 Robustness Check: Drop Five Cities with Largest Geographic Areas

	(1) Ln (sales)	(2) Ln (lead time)	(3) Ln (inventory)	(4) Ln (inventory)	(5) Ln (inventory)
Ln (infra)	0.173**	-0.210***	-0.159	-0.218*	-0.185
	(0.076)	(0.072)	(0.119)	(0.120)	(0.117)
Ln (sales)				0.346***	0.574***
				(0.022)	(0.017)
Ln (lead time)					0.352***
					(0.010)
Controls	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	805,077	795,805	805,077	805,077	795,805
R-squared	0.907	0.817	0.808	0.812	0.821

Note: 1) Robust cluster standard errors are in parentheses (cluster by city level).

2) Samples from Erdos, Chifeng, Jiuquan, Hulunbeier, and Chongqing are dropped.

3) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5 Quasi-Natural Experiment: Market Expansion

	Export/Sales>0.8			Export/Sales<0.2		
	(1)	(2)	(3)	(4)	(5)	(6)
	Ln (sales)	Ln (inventory)		Ln (sales)	Ln (inventory)	
Ln (infra)	-0.003	-0.043	-0.042	0.218**	-0.195	-0.265*
	(0.055)	(0.097)	(0.097)	(0.088)	(0.154)	(0.154)
Ln (sales)	-0.018		0.367***	-0.030		0.323***
	(0.239)		(0.041)	(0.087)		(0.021)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	98,642	98,642	98,642	637,478	637,478	637,478
R-squared	0.940	0.857	0.860	0.907	0.809	0.813

Note: 1) Robust cluster standard errors are in parentheses (cluster by city level).

2) *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 6 Quasi-Natural Experiment: Input Sourcing Cost Reduction

	Less Transportation Inputs			More Transportation Inputs			Whole Sample	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ln (lead time)	Ln (inventory)		Ln (lead time)	Ln (inventory)		Ln (lead time)	
Ln (infra)	-0.173**	-0.222	-0.197	-0.238***	-0.211*	-0.176	-0.201***	-0.158**
	(0.071)	(0.157)	(0.155)	(0.082)	(0.116)	(0.112)	(0.072)	(0.076)
Ln (sales)		0.337***	0.568***		0.339***	0.567***		
		(0.021)	(0.018)		(0.026)	(0.021)		
Ln (lead time)			0.348***			0.352***		
			(0.012)			(0.013)		
D (Intensity)*Ln (infra)							-0.017*	
							(0.009)	
Transport inputs ratio*Ln (infra)								-0.089**
								(0.034)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	400,838	405,884	400,838	406,788	411,057	406,788	807,626	807,626
R-squared	0.841	0.834	0.842	0.839	0.835	0.843	0.817	0.817

Note: 1) Robust cluster standard errors are in parentheses (cluster by city level).

2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7 Weight to Value of Output

	Low Weight to Value of Output			High Weight to Value of Output		
	(1)	(2)	(3)	(4)	(5)	(6)
	Ln (inventory)			Ln (inventory)		
Ln (infra)	-0.170	-0.231	-0.204	-0.137	-0.191*	-0.170
	(0.146)	(0.146)	(0.141)	(0.108)	(0.110)	(0.106)
Ln (sales)		0.339***	0.565***		0.345***	0.575***
		(0.024)	(0.018)		(0.021)	(0.017)
Ln (lead time)			0.366***			0.337***
			(0.013)			(0.011)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	399,265	399,265	395,774	392,101	392,101	386,540
R-squared	0.823	0.827	0.835	0.810	0.815	0.823

Note: 1) Robust cluster standard errors are in parentheses (cluster by city level).

2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8 Market Development

	Regions with Less Developed Market			Regions with Developed Market		
	(1)	(2)	(3)	(4)	(5)	(6)
	Ln (inventory)			Ln (inventory)		
Ln (infra)	-0.161	-0.231	-0.201	-0.162	-0.192**	-0.165
	(0.248)	(0.250)	(0.241)	(0.101)	(0.095)	(0.102)
Ln (sales)		0.289***	0.554***		0.439***	0.605***
		(0.022)	(0.022)		(0.018)	(0.019)
Ln (lead time)			0.369***			0.318***
			(0.011)			(0.012)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	419,265	419,265	412,797	397,676	397,676	394,829
R-squared	0.814	0.817	0.827	0.819	0.825	0.831

Note: 1) Robust cluster standard errors are in parentheses (cluster by city level).

2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9 SOE vs Non-SOE

	SOE			Non-SOE		
	(1)	(2)	(3)	(4)	(5)	(6)
	Ln (inventory)			Ln (inventory)		
Ln (infra)	-0.156	-0.228	-0.213	-0.160	-0.216*	-0.182
	(0.403)	(0.391)	(0.381)	(0.111)	(0.113)	(0.111)
Ln (sales)		0.274***	0.557***		0.345***	0.569***
		(0.039)	(0.037)		(0.022)	(0.017)
Ln (lead time)			0.335***			0.351***
			(0.028)			(0.010)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	33,959	33,959	33,613	782,982	782,982	774,013
R-squared	0.912	0.915	0.918	0.804	0.808	0.817

Note: 1) Robust cluster standard errors are in parentheses (cluster by city level).

3) SOE is defined as firm with state-owned capital proportion larger than 50%

3) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 10 Endogeneity: Reduced Form Regression

	(1)	(2)	(3)	(4)
	Ln (infra)	Ln (inventory)	Ln (inventory)	Ln (inventory)
Slope_price	-0.000195***	-0.0968	-0.0747	-0.127***
	(1.16e-05)	(0.0792)	(0.0796)	(0.0178)
Ln (sales)	0.00413***		0.346***	0.573***
	(0.000469)		(0.0208)	(0.00582)
Ln (lead time)	-0.00227***			0.351***
	(0.000317)			(0.00441)
Controls	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	754,843	763,522	763,522	755,148
R-squared	0.996	0.803	0.808	0.816

Note: 1) Robust cluster standard errors are in parentheses (cluster by city level).

2) The instrumental variable (Slope_price) is the interaction between average slope in the corresponding area and the weighted average price of the exported equipment.

3) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.