Domestic Transport Costs, Inventories, and Shipment Dynamics

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Abstract

We document that a large expansion of domestic transportation infrastructure in China shifts firms from sending infrequent and large shipments to sending frequent and small shipments. To replicate the data patterns, we propose a model of firm-level shipment dynamics that features fixed shipping costs, costly stockout adjustment, and costly inventory holdings. We show that the fixed shipping cost is key to explaining firms' adjustment between the shipment frequency and the shipment size, while the conventional iceberg-type variable shipping cost is not. Our model also predicts that large stockout costs and large inventory holding costs weaken the effects of fixed shipping costs by making it expensive to adjust the shipment size.

1 Introduction

Domestic transportation infrastructure is crucial to the foreign market access of firms in developing countries. While the total exports and the regional development have been of central interest (Limão and Venables, 2001; Coşar and Demir, 2016; Volpe Martincus et al., 2017; Fan et al., 2021), scarce is known about how domestic transportation conditions affect other export margins. This paper fills the gap by studying how the expansion of a domestic transportation network influences exporters' shipment patterns. Our main finding is that the shortened driving distance from a firm to a port shifts exporters from sending large and infrequent shipments to small and frequent shipments.

Conditional on total exports, why does shipment frequency matter? Recent studies have shown that frequent shipments have important implications on consumer welfare gains and resource allocation efficiency along the global value chain. By featuring the time value consumers attach to products, Hummels and Schaur (2013) estimate that each day in transit is

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equivalent to an ad-valorem tariff of 0.6 to 2.1 percent. Carreras-Valle (2021) shows that the reliance on inputs from China, which faces longer and more volatile delivery times, explains 34 percent of the increase in the U.S. manufacturing inventories from 2005 to 2018. For the sake of exporters, frequent shipments are shown to reflect the establishment and continuation of buyer-seller relationships, and thus crucial for relearning the appeal of products and updating knowledge of foreign markets (Eaton et al., 2021). Being able to send frequent and small shipments is also linked with higher product quality (Heise et al., 2021) and critical to the industrial upgrading of a country (Blum et al., 2019).

This paper asks how domestic transport costs shape exporters' shipment frequency. We exploit the Chinese customs monthly records to decompose a firm's annual export value into the number of shipments and the per-shipment size. We find that many firms only export in very few months in a year, which reveals the discreteness of shipments. Furthermore, we construct a panel of driving time between city pairs to proxy the expansion of the transportation network during 1999 and 2005 in China. We find that after controlling for the total export value in a year, the number of shipments decreases in the driving time between a firm and a port. An accompanying action of the shipment frequency adjustment is the inventory holding during the gaps between shipments. Consistent with the discreteness of shipments, we document a positive inventory holding of finished goods for over 75 percent of manufacturing firms in China. We find that firms closer to expressways hold fewer inventories controlling for the total sales in a year. These facts imply that, in response to changes in transport costs, firms are actively substituting between two margins: sending shipments and holding inventories.

We propose a model to replicate the above data patterns. In our single-agent dynamic model, demand is uncertain. In each period the home country and the foreign country each generate an order. The ordered amount is a function of the demand shock component multiplied by a downward sloping demand function of an endogenous price. A firm can choose to accept an order or to decline it. We assume no backlog of orders, hence an order must be fulfilled in the current period upon acceptance. Our model features a fixed shipping cost to generate discrete shipments. In order to generate positive inventories, we impose a one-period production lag and a stockout cost. Due to the production lag, firms cannot sell their current production. The stockout cost is incurred whenever a firm accepts an order with not enough inventories to fulfill it. The cost can be understood as expense either to mobilize emergent production or to obtain similar production from other firms. During a stockout, a firm will charge a price based on its adjustment efficiency and the short amount, and thus the finalized order size will be a compromise between the firm's adjustment limit and consumers' demand. We also introduce costly inventory holdings in the form of a depreciation rate. Therefore, subject to the above frictions, a firm trades off between shipping and holding inventories.

In our model, an order needs to be large enough for a firm to cover the fixed shipping cost; otherwise, the firm can always be better off declining the order. Therefore, higher fixed shipping costs lead to fewer "qualified" orders, less frequent shipments, larger shipment sizes, and larger inventory holdings. We furthermore show that changing the variable shipping cost cannot generate the same pattern. This highlights that changes of the fixed component in the transport cost structure, rather than those of the conventional iceberg-type variable component, lead to the documented changes of shipment patterns.

Going deeper into the industrial level data, however, we find substantial heterogeneity. In particular, industries hold different levels of inventories, and their shipments respond in different magnitudes to the change of transport costs. Moreover, no clear pattern suggests how the first relates to the latter. The office instrument industry responds aggressively to transport costs and holds low inventories. However, this does not necessarily imply that low inventory holdings can predict significant responses to transport costs. The furniture industry, for example, holds few inventories, but its shipments do not respond to transport costs.

To explain the industrial heterogeneity, we turn to our model and let the stockout cost and the inventory holding cost interact with the fixed shipping cost. Our comparative statics demonstrate that, while the stockout cost and the inventory holding cost work oppositely in deciding inventory levels, they can both weaken the effects of fixed shipping costs on shipment frequency. A high stockout cost spells a high price for a unit of shortage per stockout, while a high inventory holding cost pushes firms to hold low inventories and thus induces a large shortage per stockout. Therefore, as long as the stockout adjustment is costly, either a higher stockout cost or a higher inventory holding cost makes it more expensive to accept a large order, and thus pulls down the order-acceptance cutoff.

Our model predictions suggest a direction to identify the frictions facing a certain industry: a mild shipment response to the transport costs suggests either a high inventory holding cost or a high stockout cost; a negative inventory-intensity response suggests a high inventory holding cost relative to the stockout cost, and vice versa for a positive inventory response.

Related Literature

This paper contributes to understanding the role of internal transportation infrastructure in export growth. Limão and Venables (2001) study the road infrastructure on export growth in a cross-sectional setting. Coşar and Demir (2016) finds that high-capacity expressways that were built during the 2000s improved the regional market access of regions remote from the port in Turkey. Fan, Lu, and Luo (2021) estimate that the expressway construction in between 1999 and 2010 increases China's aggregate exports by 10 percent and domestic trade by 14 percent, and it generates 5.1 percent welfare gains. Our paper decomposes the total exports into shipments and the per-shipment size, which enables us to shed light on the impact of internal transport costs on exporters' shipment adjustment margin.

This paper fits into the literature studying shipments. A set of papers highlight the importance of the fixed shipping cost in generating discrete shipments (Alessandria et al., 2010b; Kropf and Sauré, 2014; Hornok and Koren, 2015; Blum et al., 2019). Recently the increasing accessibility to detailed firm-to-firm transaction data allows researchers to identify the buyer-seller relationships and study micro frictions that impede firms' trade flows. Among them, Eaton et al. (2021) discuss how search frictions hurdle exporters' foreign market access, and highlight the important role of customer asset, knowledge about product appeal and reinforcement of the foreign market knowledge in the growth of exporters. Heise et al. (2021) show that the reduced trade policy uncertainty shifts U.S. firms' procurement mode from the "American style" to the "Japanese style", which leads to more frequent, smaller, and more expensive shipments. Our paper complements them by studying the friction on the production side and exploring the source of discrete shipments from the supply side.

This paper relates to the literature studying firms' inventory holding behaviors (Ramey and West, 1999; Guasch and Kogan, 2001; Alessandria et al., 2010a,b, 2013; Carreras-Valle, 2021). Especially since the burst of COVID-19, studies on inventory holding behaviors attract increasing attention and are used to understand pervasive stockout and abnormal pricing (Cavallo and Kryvtsov, 2021). Our paper innovates by incorporating multiple inventory-holding motives and embed them into an exporter dynamics problem.

The rest of this paper proceeds as follows. section 2 describes the motivating evidence. section 3 and section 4 set up and solve the model. section 5 concludes.

2 Evidence

We describe facts from aspects of inventory holdings, shipment patterns, and their industrial heterogeneity. The inventory and shipment information is from firm-level and transaction-level data. The transport costs are proxied with the location-pair driving time along transportation networks.

2.1 Data

The first dataset is the Annual Survey of Industrial Firms (hereafter ASIF) of China, which is collected by the National Bureau of Statistics of China. This dataset covers all non-state-owned manufacturing firms with annual sales revenues greater than 5 million RMB (approximately 600,000 USD) and all state-owned manufacturing firms from 1998 to 2007.

One can observe from the dataset the firm identity information including a firm's name, legal representative, address, ownership type, and phone number, as well as the firm's balance sheet records including its production, sales revenue, material inputs, and export revenue aggregated over a year, and employment, fixed asset, and inventory level at the end of a year (EOY hereafter). Each firm is classified into a unique four-digit industry following the Chinese Industrial Classification Standard (hereafter CIC).

The second data source is the Chinese Customs Transaction Records during the years 2000 to 2006. For each transaction, one can observe the exporting firm, the 8-dight HS commodity, the destination country, the transportation method, the trade mode,[1] the port[2] from which the commodity was exported, as well as the month and year when the transaction took place. Notice that we are not able to observe the exact date or more information at the shipment level. The transaction information here thus should be taken as the shipment information aggregated at the exporter-destination-HS8-transport-mode-port-month level. Since this is the most disaggregated data available, henceforth in the empirical parts of this paper we take the transaction-level records as the shipment-level records. Besides, for each exporting firm, one can observe its name, legal representative, address and phone number. With this information, we are able to link the customs data with the ASIF data.

The driving time data is constructed as follows. We use the digitized maps of Chinese transportation networks in 1999 and 2005 from Baum-Snow, Brandt, Henderson, Turner, and Zhang (2017). For the digitized map of each year, there is geographical information on networks including expressways, local highways, and railways, as well as the junctions between one another. With an embodied routing function in ArcGIS Pro 2.8, one can find the optimal path between locations along a provided network, and report the driving time and effective distance of that path. Using this function, we find the optimal paths and calculate the driving time for city pairs in 1999 and 2005, respectively. For each city pair, the origin city is from the set of cities where firms[3] are located, and the destination city is from the set of cities where ports are located.

Figure 1 displays the distribution of the percentage change of driving time from 1999 to 2005. Most city-pairs have experienced a shortened driving time between each other.

2.2 Road Expansion and Shipment Patterns

Since we cannot observe any shipping details, we cannot identify a real shipment. We therefore collapse the Customs Records to construct the shipment unit in our analysis: a combi-

[1]China Customs classifies each type of trade into different modes by its nature, such as "ordinary trade" and "processing trade".

[2]Here port = customs office.

[3]Here we treat firm locations as the locations of production sites.

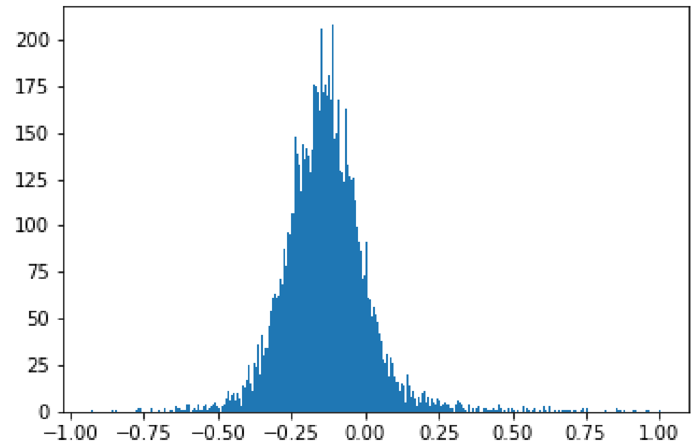


Figure 1: Driving Time Difference between 99 and 05 (City-pair-wise)

Notes: percentage change $= \frac{\text{driving time in 2005}}{\text{driving time in 1999}} - 1$.

nation of the exporting firm, transport mode, destination country, port, and month. Within each shipment, we do not distinguish between commodities.

Figure 2 shows that fixing the transport-port-destination triple, over 55 percent of firms send shipments in less than two months in a year (right panel). Regardless of the shipping month, around 55 percent of firms send only one or two shipments within a year (left panel). This is consistent with the discreteness of shipments documented by Alessandria et al. (2010b) and Hornok and Koren (2015).

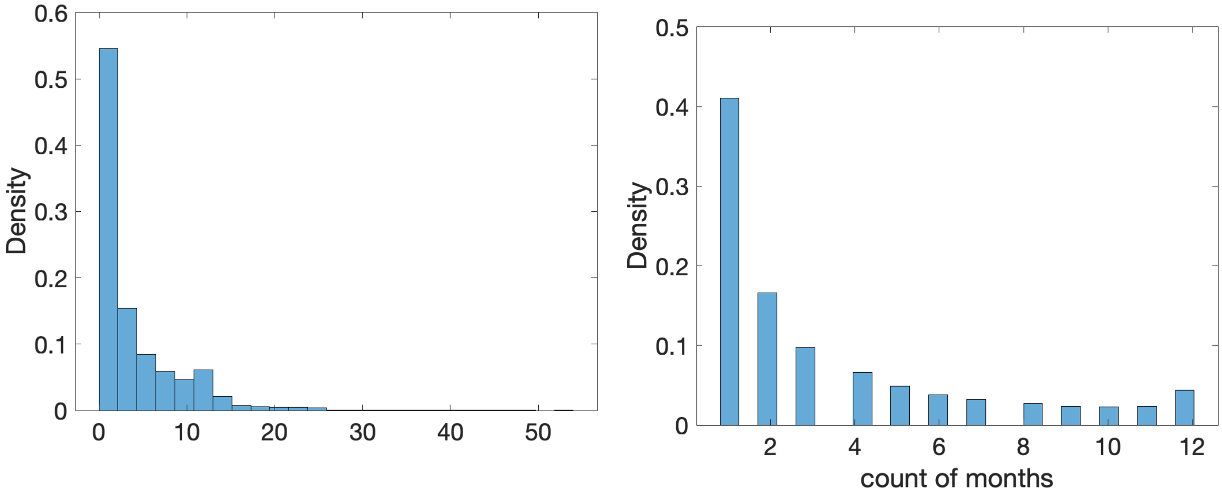
We then investigate the correlation between domestic transport costs and exporters' shipment patterns. We use the driving time from the firm city to the port city to proxy the domestic transportation costs of an exporter. We measure the shipment frequency with the count of shipments within a year. We show in Table 1 that, firms closer to a port send more shipments. A one percent increase in the driving time leads to a 5.3 percent drop in shipments. Table A1 displays the regression results replacing the logarithm of driving hours with the level of driving hours. The relationships in Table 1 still hold. Since we have controlled for the total annual export value, more frequent shipments also mean lower per-shipment value, or smaller per-shipment size in this paper. This result survives robustness checks with different controls for fixed effects. Table 1 also suggests that on average, a one percent increase in total exports contributes to around a 35 percent increase in the number of shipments.

While Fan et al. (2021) and Coşar and Demir (2016) show that domestic road expansions can boost the overall export growth, we provide suggestive evidence that road expansions can also affect shipment patterns.

Figure 2: Distribution of shipments (2006)

(a) Shipments

(b) Shipping months



Notes: The left panel shows the distribution of the count of transactions within the year 2006. A transaction or a shipment here is defined as a unique combination of firm, destination country, transport mode, port, and month. The right panel shows the distribution of the count of months over all transactions.

Table 1: Shipment frequency and driving time to port

	(1)	(2)	(3)	(4)	(5)
	ln_freq	ln_freq	ln_freq	ln_freq	ln_freq
ln(driving hours)	-0.0475***	-0.0450***	-0.0470***	-0.0513***	-0.0538***
	(0.0020)	(0.0021)	(0.0022)	(0.0023)	(0.0033)
ln(annual export value)	0.3257***	0.3223***	0.3260***	0.3263***	0.3532***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0012)
Constant	-2.5059***	-2.4729***	-2.5035***	-2.5011***	-2.7899***
	(0.0060)	(0.0060)	(0.0064)	(0.0065)	(0.0145)
Observations	497888	497877	483862	483079	150507
Adjusted R^2	0.6344	0.6690	0.6769	0.6788	0.6644
Fixed Effects	i,t	i,s,l,p,d,t	i,p,l,sdt	i,pd,lt,sdt	idt,pt,pd,lt,st

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: The shipment frequency, the driving time and the annual export value are all measured in natural logs. Letter i in the row of "Fixed Effects" denotes the control for the firm fixed effect, s for the industry, l for the firm province, p for the port, d for the destination country, and t for the year. Robust standard errors are reported.

Table 2: Inventory holdings of Chinese firms (2006)

	its_ratio	ifs_ratio
Non-exporter		
p25	0.0242	0.0020
p50	0.0761	0.0219
p75	0.1831	0.0755
mean	0.1422	0.0637
sd	0.1853	0.1070
Exporter		
p25	0.0366	0.0027
p50	0.1023	0.0247
p75	0.2106	0.0763
mean	0.1584	0.0610
sd	0.1823	0.0972

Notes: *its_ratio* and *ifs_ratio* are short for the ratio of total inventories to sales and the ratio of finished-good inventories to sales, respectively.

2.3 Road Expansion and Inventory Holdings

The ASIF dataset reports the EOY total inventory and the EOY inventory of finished goods. We obtain the inventory of raw materials by deducting the finished-good inventory from the total inventory. We thereby are able to compute the inventory-sales ratios with two types of inventories and their summation, respectively.

Table 2 presents the inventory-sales ratios of Chinese manufacturing firms in 2006. The existing literature that studies inventory holdings in international trade has focused on inventory management on the demand side Blum et al. (2019); Alessandria et al. (2010b); Kropf and Sauré (2014); Carreras-Valle (2021), and abstracted away from the inventory holdings on the production side. Table 2 shows that over 75 percent of firms hold a positive amount of finished-good inventory (Columns 2), implying that producers are also actively practicing inventory management, and can face the same or different frictions that face importers when trading off between inventory holdings and shipment adjustments. This refreshes the impression delivered by most literature that shipment and inventory holding decisions are mainly decided by the orderer side.

We narrow down our focus to the finished-good inventories from now on, for their direct relevance to firms' supply decisions. For the rest of the paper, without special clarifications, the term inventory exclusively refers to the inventory of finished goods.

We then look at the correlation between transport costs and inventory holdings. Since we cannot observe the destination-market-specific inventories for each firm, we parsimoniously proxy the exposure to a transportation network using the distance between a firm and its

Table 3: Inventories and distance to expressways

	(1)	(2)	(3)	(4)	(5)	(6)
	ln_f_inv	ln_f_inv	ln_f_inv	ln_f_inv	ifs_ratio	ifs_ratio
ln(distance to expressway)	0.0170***	0.0165***	0.0170***	0.0167***	0.0469	0.0488
	(0.0056)	(0.0056)	(0.0057)	(0.0057)	(0.0423)	(0.0435)
ln(sales)	0.4586***	0.4539***	0.4622***	0.4564***		
	(0.0076)	(0.0077)	(0.0079)	(0.0080)		
exporter dummy		0.0803***		0.1093***		-0.7964
		(0.0168)		(0.0173)		(0.6215)
Constant	2.6534***	2.6751***	2.6167***	2.6376***	0.1398	0.4254**
	(0.0806)	(0.0806)	(0.0837)	(0.0837)	(0.1012)	(0.1766)
Observations	98732	98732	98716	98716	121988	121988
Adjusted R^2	0.6452	0.6454	0.6530	0.6533	0.0164	0.0165
Fixed Effects	*i,t*	*i,t*	*i,lt,st*	*i,lt,st*	*i,lt,st*	*i,lt,st*

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: The sample covers the years 2000 and 2006. Inventories, the distance to an expressway, and the sales revenue are all measured in natural logs. The exporter dummy variable is equal to one when the export value of a firm is positive in a year. Letter i in the row of "Fixed Effects" denotes the control for the firm fixed effect and t for the year fixed effect. The robust standard errors are reported.

closest expressway. Both Columns 1 and 2 of Table 3 suggest that a firm tends to hold more inventories when it is far away from an expressway. Fixing the sales and the distance to an expressway, an exporter tends to hold more inventories (Column 2). We then replace the inventory level with the inventory-sales ratio. The positive distance-inventory relationship still holds, but an exporter here tends to have a lower inventory-sales ratio (Column 4). The latter suggests that inventories do not necessarily increase proportionally to the sales revenue.

It is not a new finding that transport costs can affect the overall or the raw-material inventory holdings (Li and Li, 2013; Guasch and Kogan, 2001), however, Table 3 shows that finished-good inventories solely are also related to transport costs. This again suggests that producers do not randomly decide the inventory holdings of their output; they are restricted to at least the domestic transport costs too.

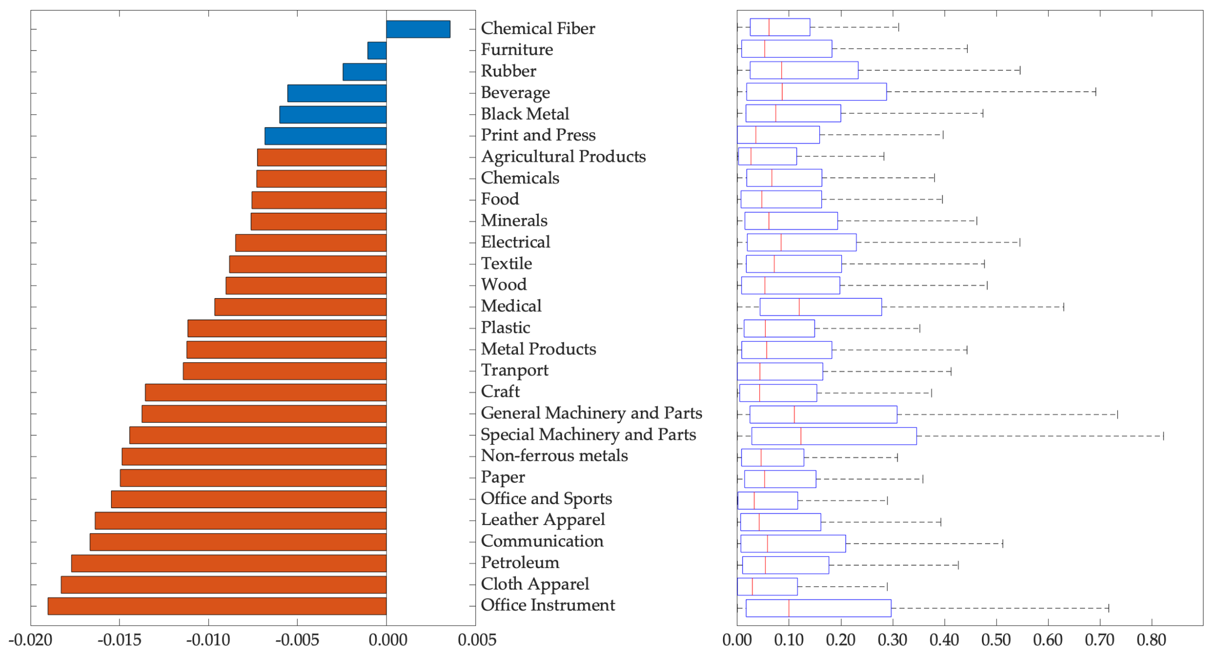
2.4 Industrial Heterogeneity

We further check the shipment and inventory patterns for each industry. We show there is a large difference in the shipment response to the road expansion. We run the same regression in Column 4 of Table 1 for the subsample of each two-digit CIC industry, and the coefficients before the driving time are plotted in Panel (a) of Figure 3. The negative relationship between the shipment frequency and the driving time is robust for most industries (orange bars), but among those industries, there is vast heterogeneity in their inventory holdings (Panel (b)). There is only a vague positive relationship there between the responses of shipments and of the inventory holding (Figure 4). Ideally, since the reductions of transport costs increase a firm's shipping frequency, it should have held fewer inventories, as predicted by Alessandria et al. (2021). But now we can only see a noisy positive relationship. A natural question to ask is what other frictions are needed to rationalize the vast industrial heterogeneity.

Figure 3: Heterogeneity in shipments and inventories

(a) Shipment Response to Road Expansion

(b) Inventory/Sales Ratio

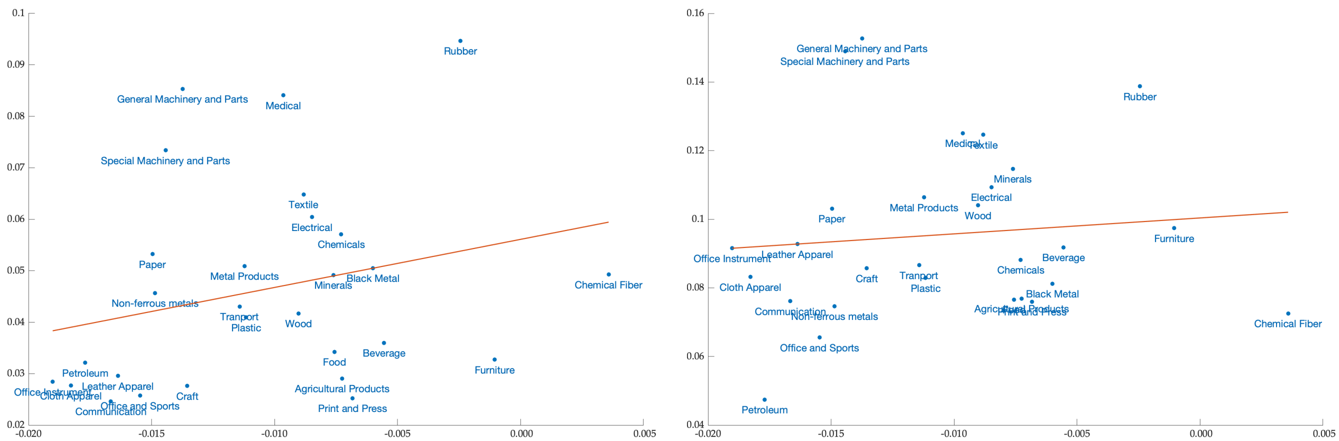


Notes: The left panel plots the coefficients before the driving time obtained by running the regression specified in Column 5 of Table 1 for the subsample of each two-digit-CIC industry separately. The right panel plots the distribution of the inventory-sales ratio for each two-digit CIC industry ordered accordingly to the left panel. The sample used to construct the left panel covers exporting manufacturing firms in the years 2000 and 2006. The right panel pools non-exporters and exporters in manufacturing sectors in the years 1998 and 1999.

Figure 4: Shipments and Inventories

(a) Shipment Response and Median Inventory/Sales

(b) Shipment Response and Mean Inventory/Sales



Notes: The left panel plots the scatter of the medians of inventory-sales ratio (y-axis) over the shipment response coefficients as plotted in Panel (a) of Figure 3 (x-axis). The right panel plots the scatter of the means of inventory-sales ratio (y-axis) over the shipment response coefficients. The medians and the means of the inventory-sales ratio are calculated using the same data sample as in Panel (b) Figure 3.

3 Model

We propose a single-firm dynamic model to explore and clarify the frictions that arise from the production side and are critical to firms' shipment dynamics. We consider a two-market setting, where a firm can sell to either the home market or the foreign market. In the rest of this section, we describe the timing of the dynamic problem and the profit structure of each shipment. Then we set up the optimization problem and derive the conditions that characterize the optimal decision rules.

Figure 5 demonstrates the timing of the firm's problem. At the beginning of each period t, the firm faces its inventory stock of output i_t left over from the last period. It then observes the realizations of the productivity shock, z_t, and the demand shocks in both markets, collected by vector $\nu_t \equiv \left(\nu_t^H, \nu_t^F\right)$. Each of these three shocks follows an AR(1) process. Then the firm jointly makes its decisions on production y_t, shipment d_t, and pricing p_t. These decisions determine its output inventory stock i_{t+1} at the beginning of the next period $t+1$.

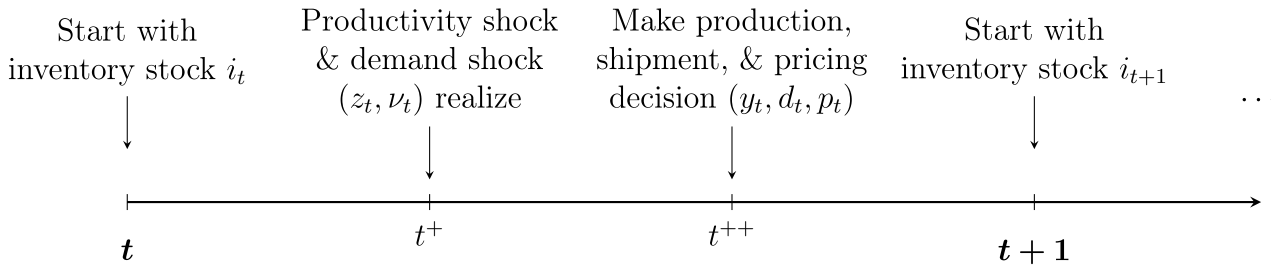


Figure 5: Timing of a Single Firm's Dynamic Problem

3.1 Shipment Profit

In each period, the firm receives an order from each destination market $j \in \{H, F\}$. For each market, the firm can choose to accept the order and send a shipment or decline it and ship nothing. The choice set of the shipment decision d is thus $\{0, h, f, hf\}$, where '0' denotes shipping nowhere, 'h' shipping only to the home market, 'f' shipping only to the foreign market, and 'hf' shipping to both.

Backlogs of orders are not allowed.[4] Upon accepting an order from j, the firm must fulfill it in the current period. The ordered amount is a downward-sloping demand function of price p^j multiplied by a stochastic demand shifter, ν^j. In order to receive q units of goods, the buyer in market j has to order $\tau^j q$ units, where τ^j is an the iceberg cost. Therefore, the shipment sent to j leaves the firm's factory gate with this size:

$$x^j = \tau^j q\left(p^j, \nu^j\right). \tag{1}$$

We assume that the products the firm sells to both markets are perfectly substitutable to each other, and the firm only decides its *ex-factory* price, p. The iceberg cost τ^j is assumed to be completely passed through to buyers. Hence the effective price p^j facing a buyer equals $\tau^j p$.

We assume there is always a one-period production lag, meaning the production plan made today takes one period to complete. The current production is thus disconnected from the current demand, and only enters the inventory stock. The firm can only sell from its inventory stock i_t unless there is a stockout.

Stockout is costly. A stockout cost is incurred whenever the firm accepts an order without enough inventories to fulfill it. The stockout cost is introduced to capture the "stockout avoidance motive" for inventory holdings. In order to accept an order with low inventories, the firm has to meet the short part by either mobilizing emergent production itself or obtaining similar products from other sources. These can both induce considerable expense in hiring

[4]subsection B.1 discusses a way to relax this assumption.

more labor, extending the factory open time, searching for similar products, etc.

Each shipment to market j incurs a fixed cost K^j, independent of the shipment size. Hence the firm's profit generated by each shipment the decision is the sales revenue, net the stockout cost, and the fixed shipping cost:

$$
\begin{aligned}
\pi^h\left(i_t,\nu_t,p_t\right) &= p_t^H x_t^H - C_A\left(x_t^H - i_t\right) - K^H, \\
\pi^f\left(i_t,\nu_t,p_t\right) &= p_t^F x_t^F - C_A\left(x_t^F - i_t\right) - K^F, \\
\pi^{hf}\left(i_t,\nu_t,p_t\right) &= p_t^H x_t^H + p_t^F x_t^F - C_A\left(x_t^H + x_t^F - i_t\right) - K^H - K^F,
\end{aligned}
$$

and $\pi^0\left(i_t,\nu_t,p_t\right)=0$ since the firm ships nowhere. $C_A\left(\cdot,\cdot\right)$ denotes the stockout cost, which is a function of the short amount. Note the outside option of declining orders and shipping nowhere grants the firm the freedom to select into shipping. When an order is not large enough to cover the fixed shipping cost, or too large to induce an unaffordable stockout cost, the firm can always be better off by declining it.[5]

3.2 Bellman Equation

Let $s_t \equiv \left(i_t, z_t, \nu_t\right)$ denote the state vector. The firm's optimization problem can be written as the following Bellman equation,

$$
V\left(s_t\right) = \max_{\substack{y_t,p_t\geq 0;\\ d_t\in\{0,h,f,hf\}}} -C_Y\left(z_t,y_t\right) + \pi^{d_t}(i_t,\nu_t,p_t) + \beta\mathbb{E}_t V\left(s_{t+1}\right) \tag{2}
$$

where $C_Y\left(\cdot,\cdot\right)$ is the production cost, a function of the productivity z_t and production y_t, and β is the discount factor.

The law of motion of inventory stock is,

$$
i_{t+1} = \begin{cases}
\left(1-\delta\right)\left(i_t+y_t\right), & d_t = 0 \\
\left(1-\delta\right)\left(\max\left\{i_t - x_t^H, 0\right\} + y_t\right), & d_t = h \\
\left(1-\delta\right)\left(\max\left\{i_t - x_t^F, 0\right\} + y_t\right), & d_t = f \\
\left(1-\delta\right)\left(\max\left\{i_t - x_t^H - x_t^F, 0\right\} + y_t\right), & d_t = hf
\end{cases}, \tag{3}
$$

where δ denotes the inventory holding cost in the form of a depreciation rate.

[5] In the appendix we show why it is possible for a firm to decline a big order.

3.3 Optimal Decision Rules

We then derive the first-order conditions that characterize the firm's optimal production and pricing.

Optimal Production. Taking derivatives on both sides of Equation (2) with respect to y_t gives the first order condition for the optimal production,

$$\begin{aligned} \frac{dC_Y(y_t)}{dy_t} &= \beta \mathbb{E}_t \frac{\partial V(s_{t+1})}{\partial i_{t+1}} \frac{\partial i_{t+1}}{\partial y_t} \\ &= \beta(1-\delta) E_t \frac{\partial V(s_{t+1})}{\partial i_{t+1}}. \end{aligned} \tag{4}$$

where the second equality follows from the law of motion in Equation (3). Equation (4) takes the standard form of an Euler equation. Production in our model is essentially the source of inventory replenishment, hence the left-hand side is the marginal cost of inventory replenishment today, and the right-hand side is the marginal value of inventory replenishment tomorrow that is discounted to today.

Optimal Pricing. Taking derivatives on both sides of Equation (2) with respect to p_t yields the first order condition for the optimal price. Let q_t denote the total demand in period t. If there is no stockout, the optimal p_t is characterized by

$$\begin{aligned} p_t \frac{\partial q_t}{\partial p_t} + q_t &= -\beta \mathbb{E}_t \frac{\partial V(s_{t+1})}{\partial i_{t+1}} \frac{\partial i_{t+1}}{\partial q_t} \frac{\partial q_t}{\partial p_t} \\ &= \beta(1-\delta) \mathbb{E}_t \frac{\partial V(s_{t+1})}{\partial i_{t+1}} \frac{\partial q_t}{\partial p_t}. \end{aligned} \tag{5}$$

If there is a stockout, the channel via which the current inventory stock affects the marginal value of future inventory stock is shut down while the stockout cost is triggered, yielding

$$p_t \frac{\partial q_t}{\partial p_t} + q_t = \frac{\partial C_A(q_t, i_t)}{\partial q_t} \frac{\partial q_t}{\partial p_t}. \tag{6}$$

Since demand decreases in price, increasing price saves inventories from being sold. The saved inventories can either be carried into tomorrow if there is no stockout today or save the adjustment cost today if there is a stockout. Hence the right-hand sides of both Equations (5) and (6) represent the marginal benefits of raising the price. The left-hand sides of both represent the marginal revenue loss from increasing one unit of price. For this to be legitimate, we need an assumption of elastic demand such that sales revenue decreases in price.

3.4 Fundamental Frictions

We discuss the key frictions featured in the model, shutting down the changes in the production cost since we have not invested much in that direction so far.[6]

Fixed shipping cost. Without this assumption, there will not be economies of scale, and the firm does not need to wait until it can send a bulky shipment. However, zero fixed shipping cost does not necessarily guarantee continuous shipments. The negative shipment profit is only a sufficient condition for a firm to decline an order. Indeed without the fixed shipping cost, the shipments would be more flexible. However, there will be another tradeoff between the profits of selling inventories and the expected returns to replenish the inventories.

Production lag and stockout cost. No stockout cost is equivalent to no production lag in the sense that both allow for immediate production. The firm would then always wait until the realization of demand shocks and produce exactly the demanded amount, hence would have no stockout-avoidance motives to hold inventories. However, the stockout cost is not redundant. It works as a feasible alternative to modeling precisely the length of production lags. The longer the production lag, the more expensive to adjust the inventories, thus the larger the stockout cost. By normalizing the production lag to one period and letting the continuous and contemporary stockout cost reflect the difficulty of adjustment, we circumvent the computational challenge of tracking the state space over multiple periods.

Inventory holding cost. Holding inventory is costly. The cost can reflect the physical perishability, the speed of model upgrading, the fashion trend, and the storage cost.

4 Numerical Analysis

We set up the dynamic problem in the previous section. In this section, we solve it numerically. We will go over the parameterization, the numerical solution, and the comparative statics centering on the frictions of interest.

4.1 Parameterization

Following Alessandria et al. (2010b), we assume the demand function to be

$$q(p, \nu) = \exp(-\nu) p^{-\theta}. \tag{7}$$

[6]Expected production cost changes can incentivize firms to adjust their inventory stock of finished goods. For example, when a firm expects a wage increase in the following period, it may want to take advantage of the current low labor cost, enlarge its production, and carry more inventories to the next period.

The production function is linear $y = zl$, thus the production cost is

$$C_Y(y) = w\frac{y}{z}. \tag{8}$$

We let the stockout cost be analogous to the investment adjustment cost in the macroeconomic literature. The stockout cost is a step function, and takes a quadratic form when the demand exceeds the inventory stock; this is also similar to the adjustment cost in the accelerator model in the inventory literature (Ramey and West, 1999):

$$C_A(x,i) = \begin{cases} 0, & \text{if } x \leq i \\ \phi(x-i)^2, & \text{if } x > i \end{cases}. \tag{9}$$

The relationship between the fixed shipping cost in the home market K^H and the fixed shipping cost in the foreign market K^F are assumed to satisfy

$$K^F = K^H + d_K,$$

where d_K captures the fixed shipping cost generated after the port of the home country.

Similarly the relationship between the iceberg trade cost in home market τ^H and the iceberg trade cost in foreign market τ^F are assumed to satisfy

$$\tau^F = \tau^H + d_\tau,$$

where d_τ captures the iceberg attrition incurred after the the borderline of the home country.

Values of parameters that are used for simulation are given by Table 4. Following Alessandria et al. (2010b), we set $\beta = 0.9949$ and $\theta = 1.5$, which is also close to the average estimates of demand elasticities by Broda, Greenfield, and Weinstein (2017) for China.

Table 4: Parameters for Simulation

Parameters	Value	Description
w_t	1	wage rate
θ	1.5	demand elasticity
ϕ	1	scale parameter of the stockout cost
K^H	0.5	fixed shipping cost before the borderline of Home country
d_K	0.3	fixed cost per shipment after the borderline of Home country
τ^H	1.2	iceberg trade cost in Home country
d_τ	0.2	iceberg cost after the borderline of Home country
σ_{ν^H}	1.1	standard error of demand shock in Home country
ρ_{ν^H}	0.4	persistence parameter of demand shock in Home country
σ_{ν^F}	1.1	standard error of demand shock in Foreign country
ρ_{ν^F}	0.4	persistence parameter of demand shock in Foreign country
σ_z	0.04	standard error of productivity shock
ρ_z	0.8	persistence parameter of productivity shock
β	0.9949	discount factor
δ	0.2	deprecation rate (inventory holding cost)

4.2 Numerical Solution

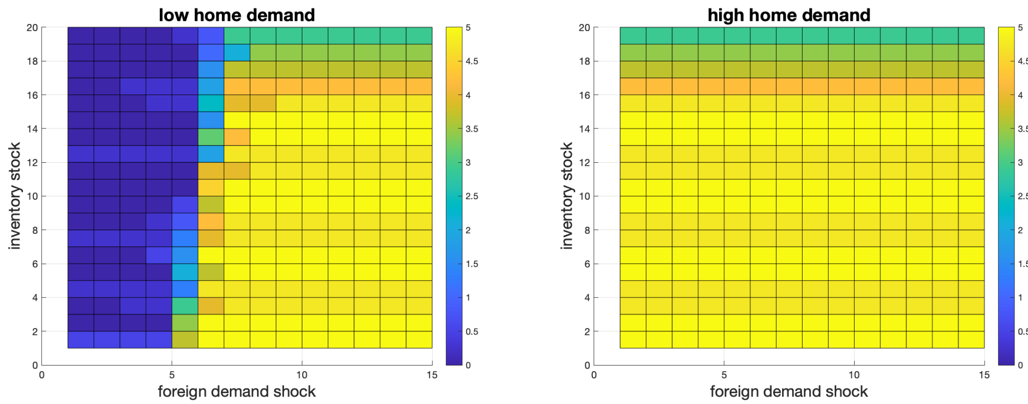
With the specifications we make, we are able to rewrite the optimal decision rules we have derived in the previous section in an explicit way, and to help illustrate our computational exercises.

Optimal production. With a linear production function specified by Equation (8), Equation (4) becomes

$$\frac{w_t}{z_t} = \beta \left(1 - \delta\right) \mathbb{E}_t \frac{\partial V \left(s_{t+1}\right)}{\partial i_{t+1}}. \tag{10}$$

Equation (10) characterizes the optimal inventory level at the beginning of the next period as a function of the realized state in the current state. Therefore the optimal production is simply to refill the inventories to the optimal level. Notice that Equation (10) shares the same expression in Alessandria et al. (2010b), implying a (S, s) rule of inventory replenishment. The the difference lies in that our model uses production while theirs uses outsourcing for

Figure 6: Optimal production



Notes: y-axises are the current inventories; x-axises are the foreign demand. The production level is colorized with the spectrum on the right end of each graph. A lighter color represents a higher production.

inventory replenishment.

Figure 6 depicts the optimal production rule encountering the low home demand (left panel) and the high home demand (right panel), respectively. The numerical illustration is consistent with what is implied by (10): both current demand and inventory level affect the gap to the optimal inventory level, thus affecting the current production. Fix the current inventory stock. With low home demand, sales increase in foreign demand, thus refilling need increases in foreign demand; with high home demand, the firm sells constantly regardless of foreign demand, and accordingly there is a constant refilling need. Fix the current demand, a lower inventory level generates a larger refilling need, therefore production decreases in the inventory level.

Optimal pricing. In the no-stockout case, with the demand function in Equation (7), Equation (5) can be simplified as

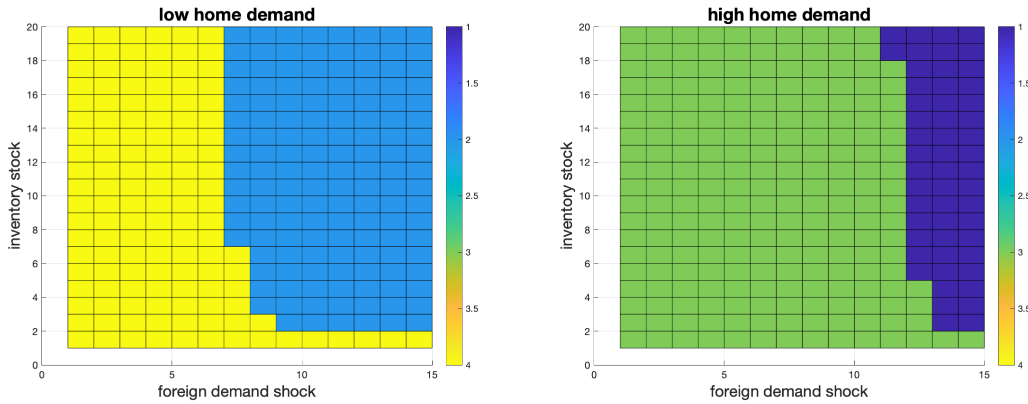
$$p_t = \frac{\theta\beta(1-\delta)}{\theta-1}\mathbb{E}_t\frac{\partial V(s_{t+1})}{\partial i_{t+1}}, \tag{11}$$

which implies that the optimal price the firm charges is proportional to the firm's marginal valuation of an additional unit of inventories. Combining Equations (10) and (11) further yields

$$p_t = \frac{\theta}{\theta-1}\frac{w_t}{z_t}, \tag{12}$$

implying a standard pricing strategy in an environment without inventories (Eaton et al., 2021). The interpretation can be different, though. While Equation (12) arises from an intertemporal tradeoff between foregoing and keeping inventories, the pricing in the literature is all about current production.

Figure 7: Optimal Shipping



Notes: y-axises are the current inventories; x-axises are the foreign demand. The production level is colorized with the spectrum on the right end of each graph. Yellow represents shipping nowhere, green shipping only to the home market, light blue shipping only to the foreign market, and dark blue shipping to both.

Similarly, the pricing rule for stockout can also be simplified. With the demand function in Equation (7) and the stockout function in Equation (9), Equation (6) becomes

$$p_t = \frac{2\theta\phi}{\theta - 1}\left(q_t - i_t\right). \tag{13}$$

Note that Equation (13) does not involve any inter-temporal tradeoff. In this case, no current inventory will be carried into the next period. Besides, the firm needs to adjust to satisfy the excess demand. The larger the excess demand, the harder to adjust, hence a higher price to charge. The finalized price and demand will thus be a compromise between the buyer's willingness to pay and the seller's ability to adjust.

Optimal shipping. The optimal shipping depends on both the demand level and the inventory level.

Figure 7 depicts the optimal shipping rule encountering the low home demand (left panel) and the high home demand (right panel), respectively. Fixing the inventory level, the firm ships to a market when demand from that market increases; fixing the demand, the firm ships as inventories in hand increase.

4.3 Comparative Statics

In this section, we conduct comparative statics to explore the nature of the interested frictions. We compare the model predictions with different domestic fixed shipping costs K^H, and domestic variable shipping cost τ^H, with the intention of understanding which component in the domestic transport cost leads to the documented changes of shipment patterns. We also let the inventory holding cost δ and the stockout cost ϕ interact with the shipping costs, in order to understand how industry-specific frictions affect firms' shipment responses to the changes in transport costs.

Keeping values of other parameters unchanged in Table 4, we set different values for K^H,τ^H,δ, and ϕ. For each combination from $\left\{K^H, \tau^H\right\} \times \{\delta, \phi\}$, we simulate the single firm's decisions for 10000 periods and drop the first 2000 periods to alleviate the initial-state disturbance. We then treat each model period to a month and collapse the simulated observations to a pseudo panel at the annual level. We then compute and record the end-of-year inventory stock, the count of shipments to the foreign country, the annual total sales, and the annual foreign sales, mimicking the structure of the sample data.

Fixed shipping cost and variable shipping cost.

We first check which type of transport costs lead to the documented changes in shipment patterns. We mimic the regressions in Section 2.2 replacing the key regressor, driving time to port, with the fixed shipping cost K^H and the variable shipping cost τ^H, respectively. We expect the key component of transport costs that we are after to generate the same pattern in Table 1.

Figure 8 visualizes our experiment outcomes in binned scatter plots. We show that controlling for the total sales revenue, the number of shipments decreases in the fixed shipping cost but increases in the variable shipping cost.

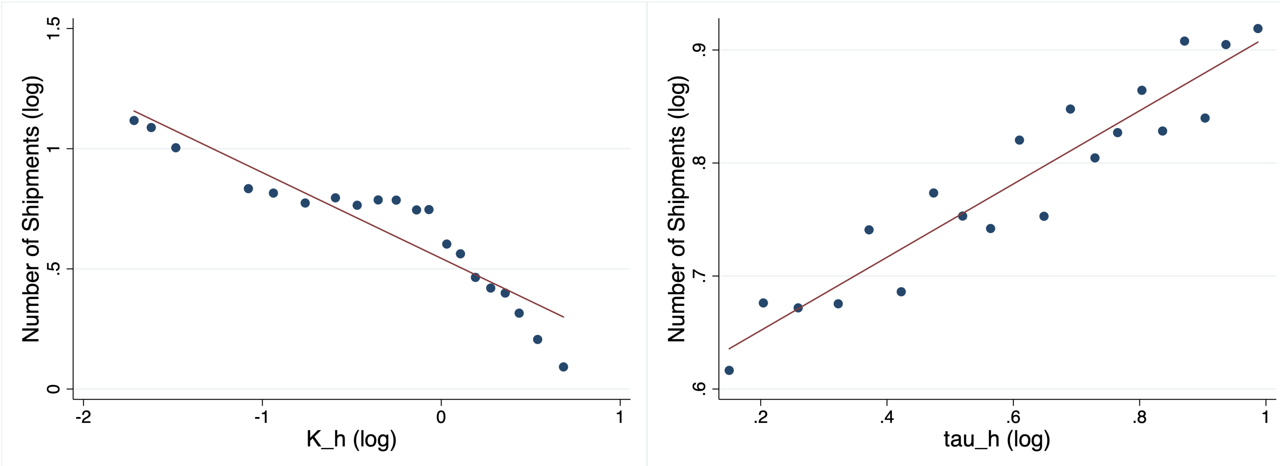
Clearly the fixed shipping cost generates the same shipment patterns that we have documented, suggesting that the fixed component of transport costs is critical to firms' adjustment between shipment frequency and shipment size. The economics behind it is quite straightforward: because of economies of scale, each positive K^H sets a size cutoff for an order to be accepted, keeping other conditions the same. Fixing the distribution of demand, a larger K^H generates a higher cutoff, which leads to larger shipment sizes conditional on acceptance; meanwhile the higher cutoff leads to fewer "qualified" orders and longer intervals between shipments, hence reducing the shipment frequency.

Fixed shipping cost and inventory holding cost.

We then check how inventory holding cost interacts with the fixed shipping cost. Still, we mimic the regressions in Section 2.2 pooling together observations generated by different combinations between K^H and δ. We regress the number of shipments over K^H with controls for the annual foreign sales revenue (left panel of Figure 9) and the annual foreign sales quantity (right panel), respectively.

Clearly there is a pattern that as δ increases, the negative relationship between the shipment frequency and the fixed shipping cost gets dampened. The economics behind can be

Figure 8: Fixed Shipping Cost K^H versus Variable Shipping Cost



Notes: the left (right) panel is the binned scatterplot for the relationship between the number of shipments to the foreign and the domestic fixed (variable) shipping cost, controlling for the total foreign sales revenue.

interpreted in two ways. First, if the firm does not want any stockout, it would prepare sufficient inventories to accept orders. A large K^H sets a higher order-acceptance cutoff, thus asking for more inventories in hand. A larger inventory holding cost in the case makes things worse. Second, if the firm is tolerant of stockout, it will lower its inventory stock when facing a high inventory holding cost. Again a larger K^H sets a higher order-acceptance cutoff, thus generating a larger shortage per stockout and leading to higher stockout expenses. Either interpretation concludes that larger inventory holding costs make it more expensive to adjust shipment size tightly to changes in the fixed shipping cost.

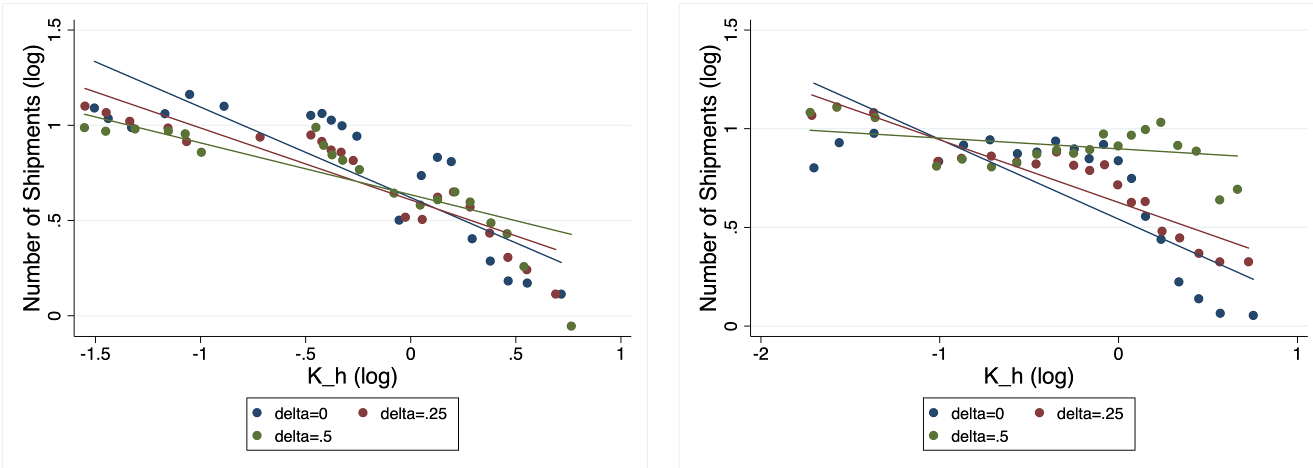
Fixed shipping cost and stockout cost.

We are also interested in the interaction between fixed shipping costs and stockout costs. We redo the same exercises as those for the inventory holding cost but replace it with the stockout cost.

Figure 10 shows that large ϕs also tend to dampen the negative relationship between the shipment frequency and the fixed shipping cost. We interpret this following the similar logic we have used for the inventory holding cost. A larger stockout cost either makes those who do not want to bear stockout hold more inventories, thus increasing the inventory holding expenses, or make makes those tolerant of stockout face a higher price for each unit of shortage per stock, thus increasing the stockout adjustment expenses. Again, either way, a large stockout cost makes it harder to adjust tightly to changes in the fixed shipping cost.

Figure 9: Fixed Shipping Cost K^H and Inventory Holding Cost δ

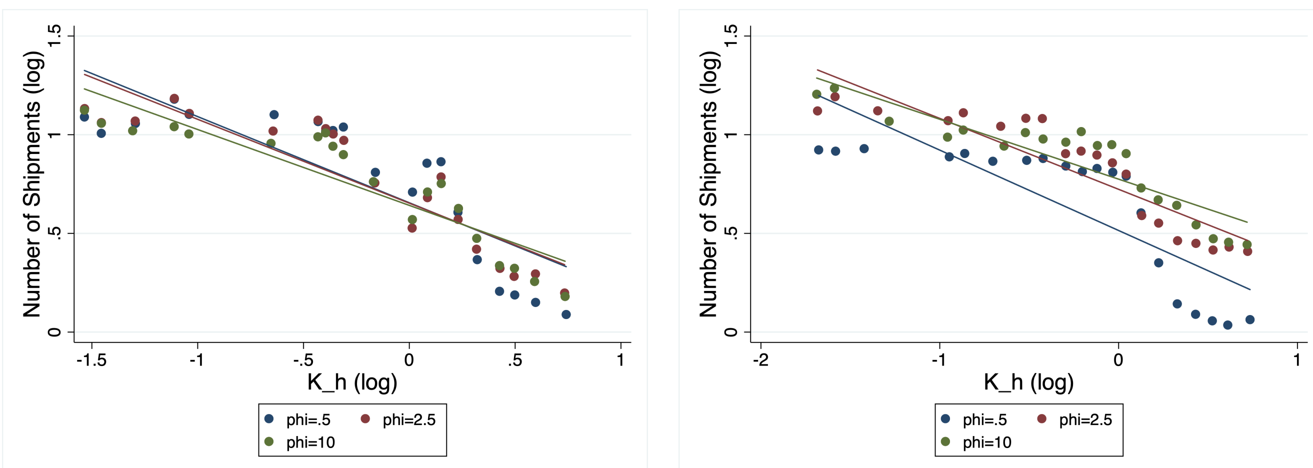
(a) Conditional on the total shipment value (b) Conditional on the total shipment quantity



Notes: the left (right) panel is the binned scatter plot for the relationship between the number of shipments to the foreign and the domestic fixed shipping cost, controlling for the total foreign sales revenue (quantity). For each panel, we run one regression, which is done by pooling observations generated by different δs altogether. The fitted lines are drawn for observations generated by different values of δ, but they share the same coefficients before the total foreign sales revenue (quantity).

Figure 10: Fixed Shipping Cost K^H and Stockout Cost ϕ

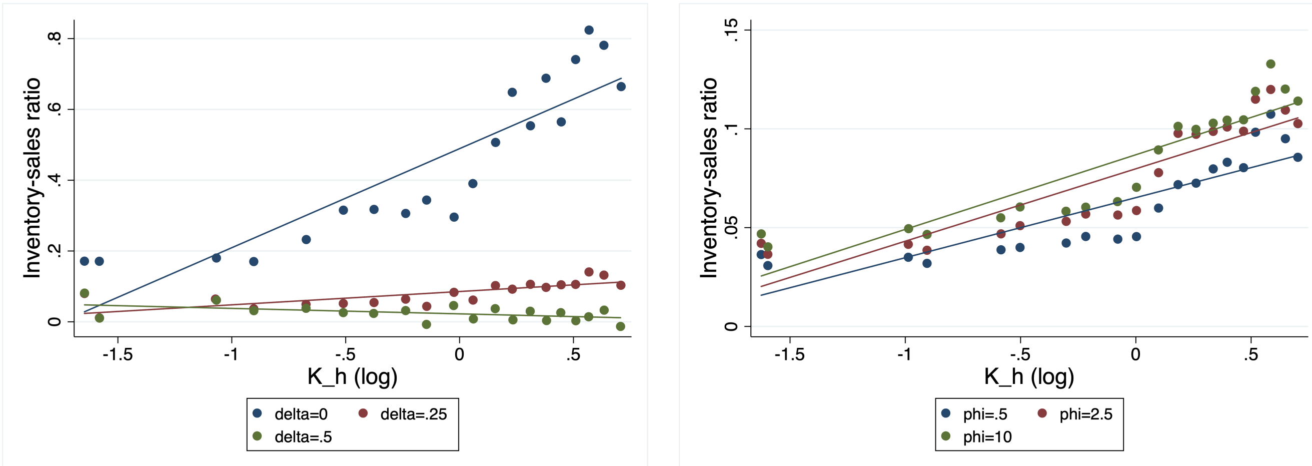
(a) Conditional on the total shipment value (b) Conditional on the total shipment quantity



Notes: the left (right) panel is the binned scatter plot for the relationship between the number of shipments to the foreign and the domestic fixed shipping cost, controlling for the total foreign sales revenue (quantity). For each panel, we run one regression, which is done by pooling observations generated by different ϕs altogether. The fitted lines are drawn for observations generated by different values of ϕ, but they share the same coefficients before the total foreign sales revenue (quantity).

Figure 11: Change of Inventory Stock with K^H

(a) Inventory holding cost δ (b) Stockout cost ϕ



Notes: Each panel is a binned scatterplot for the relationship between the inventory-sales ratio and the domestic fixed shipping cost, controlling for the total foreign sales quantity. The regression in the left (right) panel is done using the pooling observations generated by different δs (ϕs) altogether. The fitted lines in the left (right) panel are drawn for observations generated by different values of δ (ϕ), but they share the same coefficients as the total foreign sales quantity.

Inventory intensity, inventory holding cost, and stockout cost.

Solely based on the shipment response, it is hard to distinguish between the inventory holding cost and the stockout cost. Hence we turn to the responses to the fixed shipping cost in another dimension: the inventory-sales ratio. We repeat the exercises shown in Figure 9 and Figure 10, replacing the dependent variable with the inventory-sales ratio, or inventory-intensity in our context.

The inventory holding cost and the stockout cost are quite differently this time: a larger δ dampens and can even reverse the positive relationship between the inventory-sales ratio and the fixed shipping cost (left panel of Figure 11); a larger ϕ, however, strengthens that positive relationship (right panel). The difference lies in the different implications on inventory holdings of these two frictions: a large inventory holding cost makes it costly to increase inventories in response to increasing fixed shipping costs, while a large stockout cost encourages high inventories to avoid costly penalties for stockout.

We show the full tables of regression outcomes in subsection B.3.

5 Conclusion

This paper studies the impact of domestic transportation improvement on a specific export adjustment margin: the shipment frequency. We document that the massive road expansion during 1999 and 2005 in China has shifted exporters from sending infrequent and large shipments to frequent and small shipments. We replicate the data patterns with a single-firm dynamic model featuring several frictions. Our model implies that changes in the fixed component of the domestic transport costs are key to explaining the shift of shipment patterns. We further show that the stockout cost and the inventory holding cost can weaken firms' responses in shipment size to the change of fixed shipping costs, which can be critical to understanding the heterogenous shipment patterns across industries during the road expansion episode.

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A Data Appendix

Table A1: Shipment Lumpiness and Driving Time before Port

	(1) ln_freq	(2) ln_freq	(3) ln_freq	(4) ln_freq	(5) ln_freq
driving hours	-0.0090***	-0.0116***	-0.0120***	-0.0125***	-0.0129***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0005)
ln(annual export value)	0.3235***	0.3198***	0.3226***	0.3228***	0.3479***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0010)
Constant	-2.4638***	-2.4156***	-2.4384***	-2.4391***	-2.6974***
	(0.0046)	(0.0047)	(0.0049)	(0.0050)	(0.0113)
Observations	687720	687713	672852	671932	207194
Adjusted R^2	0.6451	0.6794	0.6864	0.6881	0.6662
Fixed Effects	*i,t*	*i,s,l,p,d,t*	*i,p,l,sdt*	*i,pd,lt,sdt*	*idt,pt,pd,lt,st*

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.1 Pure exporters hold output inventories in hand

Table A2: Output Inventory Held by Pure Exporters

	All firms		Pure exporters	
Variables	Mean	Std	Mean	Std
Output Inventory/Sales (1998)	0.284	4.708	0.106	0.530
Output Inventory/Sales (2002)	0.338	14.867	0.080	0.286
Output Inventory/Sales (2007)	0.120	13.367	0.054	0.148

A.2 Input inventory and output inventory

In this section, we check if the inventories of input and the inventories of output share the same trend of changing.

Table A3: Summary Statistics of Inventory Change

Year	Inventory/Sales	Output Inventory/Sales	Output Inventory/Total Inventory
1998	0.192	0.062	0.448
1999	0.177	0.059	0.465
2000	0.157	0.051	0.459
2001	0.140	0.045	0.460
2002	0.124	0.040	0.476
2003	0.106	0.032	0.454
2004	0.104	0.025	0.375
2005	0.092	0.025	0.440
2006	0.085	0.023	0.450
2007	0.076	0.021	0.462

Notes: Table A3 reports the median value of variables.

B Model Appendix

B.1 Allowing Backlog of Orders

In this case, the inventory-shipment problem of a seller is:

$$V(I_t, \nu_t, B_t, \bar{p}_t) = \max\left\{V^0(I_t, \nu_t, B_t, \bar{p}_t), V^1(I_t, \nu_t, B_t, \bar{p}_t)\right\} \tag{B.1}$$

Conditioning on a firm chooses not to ship, the value of the firm is:

$$V^0\left(I_t, \nu_t, B_t, \bar{p}_t\right) = \max_{y_t} -C_Y\left(y_t\right) - C_I\left(I_t\right) + p_t X\left(p_t, \nu_t\right) - \lambda B_t \bar{p}_t + \beta \mathbb{E}_t V\left(I_{t+1}, \nu_{t+1}, B_{t+1}, \bar{p}_{t+1}\right) \tag{B.2}$$

Conditioning on a firm chooses to ship, the value of the firm is:

$$\begin{aligned} V^1\left(I_t, \nu_t, B_t, \bar{p}_t\right) = \max_{y_t} & -C_Y\left(y_t\right) - C_I\left(I_t\right) + p_t X\left(p_t, \nu_t\right) - \lambda B_t \bar{p}_t \\ & - \left[\tau\left(\left(1-\lambda\right) B_t + X(p_t, \nu_t)\right) + C_A\left(\left(1-\lambda\right) B_t + X(p_t, \nu_t), I_t\right) + K_t\right] \\ & + \beta \mathbb{E}_t V\left(I_{t+1}, \nu_{t+1}, B_{t+1}, \bar{p}_{t+1}\right) \end{aligned}$$

Then the laws of motion of the inventory stock, the order stock, and the average order value are:

$$I_{t+1} = \begin{cases} \left(1-\delta\right)\left(\max\left\{I_t - \left(1-\lambda\right) B_t - X(p_t, \nu_t), 0\right\} + y_t\right), & \text{ship} \\ \left(1-\delta\right)\left(I_t + y_t\right), & \text{not ship} \end{cases} \tag{B.3}$$

$$B_{t+1} = \begin{cases} 0, & \text{ship} \\ (1-\lambda) B_t + X(p_t, \nu_t), & \text{not ship} \end{cases} \tag{B.4}$$

$$\bar{p}_{t+1} = \begin{cases} 0, & \text{ship} \\ \frac{\bar{p}_t (1-\lambda) B_t + p_t X(p_t, \nu_t)}{(1-\lambda) B_t + X(p_t, \nu_t)}, & \text{not ship} \end{cases} \tag{B.5}$$

where λ is the hazard rate that a buyer would cancel the order, and one can also make it a function of $\bar{p}_t$ and p_t.

B.2 Decline or acceptance

In this part we show that why it is possible for a firm to decline a large order.

Recall we have the Bellman equation

$$V(s_t) = \max_{\substack{y_t, p_t \geq 0; \\ d_t \in \{0, h, f, hf\}}} -C_Y(z_t, y_t) + \pi^{d_t}(i_t, \nu_t, p_t) + \beta \mathbb{E}_t V(s_{t+1}) \tag{B.6}$$

We have derived

$$\frac{w_t}{z_t} = \beta (1-\delta) \mathbb{E}_t \frac{\partial V(s_{t+1})}{\partial i_{t+1}} \tag{B.7}$$

That suggests that the optimal inventories to be held at the beginning of next period is decided by the realization of current shocks and the inventories leftover from this period. When there is a stockout today, all i_{t+1} will come from today's production y_t, because all inventories held at the beginning of today, i_t , is used up. Hence y_t is fixed and the production cost $C_Y(z_t, y_t)$ is fixed.

However, the price and sales revenue are decided independently from this.

$$p_t = \frac{2\theta\phi}{\theta - 1} (q_t - i_t) \tag{B.8}$$

When there is no stockout, today's pricing (demand) and production decisions are decided jointly. Suppose the leftover inventory net today's production is $i_t - q_t > 0$.

In this sense, facing a large order, the firm can always find an optimal price to make the overall value today to be optimal.

B.3 Model Predictions

Table A4: Inventory holding cost and fixed shipping cost

	(1) ln(# trans)	(2) ln(# trans)	(3) inv/sales	(4) inv/sales
ln(sales to Foreign)	0.6747***	0.6246***		
	(0.0015)	(0.0027)		
k^h	-0.5299***	-0.6421***	0.0733***	0.1875***
	(0.0021)	(0.0035)	(0.0013)	(0.0021)
$\delta \times$ ln(sales to Foreign)		0.0971***		
		(0.0053)		
$\delta \times k^h$		0.2658***		-0.2677***
		(0.0068)		(0.0037)
δ		-0.4673***		-0.0890***
		(0.0108)		(0.0043)
Constant	0.0235***	0.2465***	0.0264***	0.0800***
	(0.0032)	(0.0060)	(0.0015)	(0.0025)
Observations	80627	80627	122525	122525

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5: Stockout adjustment cost and fixed shipping cost

	(1)	(2)	(3)	(4)
	ln(# trans)	ln(# trans)	inv/sales	inv/sales
ln(sales to Foreign)	0.6626***	0.6261***		
	(0.0028)	(0.0047)		
k^h	-0.5766***	-0.6321***	0.0473***	0.0437***
	(0.0034)	(0.0061)	(0.0009)	(0.0016)
$\phi \times$ ln(sales to Foreign)		0.0074***		
		(0.0008)		
$\phi \times k^h$		0.0110***		0.0007***
		(0.0010)		(0.0003)
ϕ		-0.0256***		0.0012***
		(0.0018)		(0.0003)
Constant	0.1179***	0.2485***	0.0250***	0.0191***
	(0.0060)	(0.0108)	(0.0011)	(0.0019)
Observations	23376	23376	31798	31798

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A6: Inventory holding cost and variable shipping cost

	(1) ln(# trans)	(2) ln(# trans)	(3) inv/sales	(4) inv/sales
ln(sales to Foreign)	0.7464***	0.6201***		
	(0.0015)	(0.0022)		
τ^h	0.1653***	0.1742***	0.0202***	0.0692***
	(0.0024)	(0.0035)	(0.0010)	(0.0017)
$\delta \times$ ln(sales to Foreign)		0.1678***		
		(0.0049)		
$\delta \times \tau^h$		-0.0690***		-0.0985***
		(0.0069)		(0.0029)
δ		-0.6766***		-0.0658***
		(0.0163)		(0.0056)
Constant	-0.6612***	-0.2462***	0.0304***	0.0632***
	(0.0055)	(0.0083)	(0.0020)	(0.0033)
Observations	81154	81154	110947	110947

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A7: Stockout adjustment cost and variable shipping cost

	(1)	(2)	(3)	(4)
	ln(# trans)	ln(# trans)	inv/sales	inv/sales
ln(sales to Foreign)	0.6594***	0.6332***		
	(0.0024)	(0.0041)		
τ^h	0.1173***	0.0500***	0.0248***	0.0232***
	(0.0039)	(0.0069)	(0.0010)	(0.0017)
$\phi \times$ ln(sales to Foreign)		0.0043***		
		(0.0007)		
$\phi \times \tau^h$		0.0130***		0.0003
		(0.0011)		(0.0003)
ϕ		-0.0387***		0.0012**
		(0.0026)		(0.0006)
Constant	-0.3355***	-0.1278***	0.0122***	0.0063*
	(0.0091)	(0.0162)	(0.0019)	(0.0034)
Observations	24775	24775	26610	26610

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$