One State, Many Regions: China’s fragmented Industrial Take-Over

VERY PRELIMINARY, CONTACT AUTHORS FOR MOST RECENT VERSION

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1 Introduction

Industrial policy can be a deciding factor in the allocation of resources across countries and thus welfare. A common rationale for intervention from a government’s perspective involves supporting industries with economies of scale, where policies that subsidize fixed or entry costs may generate domestic consumer surplus. In exporting industries, government intervention could foster a strategic advantage of domestic firms over foreign rivals. On the other hand, when several independent authorities engage in (possibly non-market based) stimulus activities, it could lead to excess capacity and social welfare loss. China’s recent rapid ascension as the world’s largest producer in a number of capital intensive industries is perhaps the most striking example consistent with this narrative. China recently dominated in a short time span a number industries, such as steel, solar panels and shipbuilding. Yet, its decentralized bureaucracy has led to fragmentation and substantial excess capacity, as Chinese provincial governments implement industrial policies outlined by the central government with significant autonomy, often in direct competition with each other.

How has China’s industrial policy shaped its domestic industries? What are the unintended consequences of provincial competition with non-market based policy instruments? How does China’s fast economic development affect the rest of the world? These are just a few examples of questions that naturally surface in media headline discussions in response to China’s unprecedented growth in the past couple of decades. In this paper, we use the world shipbuilding industry as an illustrative example to provide quantitative answers to these questions.

China’s shipbuilding industry was tightly controlled by the central government until the late 1990s when the principal shipbuilding organization CSSC (China State Shipbuilding Corporation) was divided into two separate entities to facilitate competition. In the 2000’s, China designated shipbuilding as a “strategic industry” which led to a sixfold increase in its shipbuilding capacity between 2005 and 2012. At the same time, China’s market share of commercial ships doubled from 25% to 50%, overtaking Japan, South Korea, and Europe to become the world’s largest ship producer.

We build and estimate a production and entry model of the world shipbuilding industry. A set of heterogeneous entities (Chinese SOEs, private companies, as well as companies in Japan, South Korea, and other parts of the world) make capacity and production decisions, each attempting to maximize its own objective function. In particular, consistent with anecdotal
evidence, we allow Chinese public firms to have soft budget constraints. To estimate this model we use a unique combination of datasets that allow for the separate estimation of demand and costs. The first is a dataset of detailed ship production and prices by Clarksons. The second is the annual Survey for all Chinese manufacturing firms. The third is China’s economic census in 1995, 2004, and 2008 that provide a rich set of variables on firm assets, production, and revenue. In counterfactual analysis, we investigate the impact of Chinese industrial policy on the market structure of the shipbuilding industry. We assess the degree and welfare consequences of excess entry and study the implications of consolidation policies promoted by the Chinese central government.

2 Industry Description

Chinese industrial policy has recently been a subject of feverous debate. The central and local governments routinely provide a wide range of support to industries, often in the form of free or low-cost loans, subsidized inputs (energy, raw material, land, etc.), technology transfer, direct investment, and preferential tax rates. Many of these support programs contradict WTO agreements and China has had more trade conflicts than any other country in the world, in more industries and with more countries (Haley and Haley, 2008).

China’s industrial policy is administered through a number of legal instruments, including Central Government Five-Year Plans and provincial Five-Year Plans. These plans identify industries that receive preferential treatment. In the 11th National Five-Year Economic Plan that became effective in 2006, the shipbuilding industry was for the first time identified as a “strategic industry” in need of “special oversight and support”. Consequently, the central government “unveiled an official shipbuilding blueprint to guide the medium and long-term development of the industry”. The plan led to a sixfold increase in the number of world shipyards, as shown in Figure 1. At the same time, China’s market share overtook the competing countries as shown in Figure 2.

![Figure 1: Number of Shipyards.](image)

The implementation of industrial policies is often fragmented. The central government outlines major policy goals and specific targets, while provincial and regional governments have significant autonomy in designing regional development plans. In many industries, such as steel, auto, solar panels, and shipbuilding, this decentralized bureaucracy has led to duplicated investment and substantial excess capacity. For example, China’s surplus steel capacity in 2010 was larger than Japan’s (the world’s second largest producer) total output (Haley and Haley, 2008).
Likewise, the Chinese shipbuilding industry is very fragmented and comprises of a large number of small firms. As shown in Figure 3, Japan and South Korea have more concentrated industries. Prior to 2006, there were on average about 100 firms per year with an annual average market share of 1 percent. By 2013, the average number of shipyards per year jumped to more than 300, thanks to various support programs that led to a massive number of new shipyards. Table 4 reports the evolution of firm entry during the last decade. The majority of Chinese shipyards are located in the delta region (Shanghai, Jiangsu and Zhejiang), followed by the pearl river region (Guangdong province): Jiangsu and Zhejiang have become the leading provinces and account for 50% of domestic production.

Commercial ships are the largest factory produced product. Materials account for about half the cost of the ship (steel is about 13%) and labor (mostly low skill tasks) about 17% of total cost. This paper focuses on cargo transportation and in particular, the following three important ship categories: dry bulk, tankers, containerships. Dry bulk shipping concerns vessels designed to carry a homogeneous unpacked cargo (mostly raw materials such as iron ore, coal, bauxite, grain, sugar), for individual shippers on non-scheduled routes. Tankers operate in the same fashion but carry liquid bulk cargos, mainly crude oil, oil products and chemicals. Finally, containerships carry a wide variety of mostly manufactured products (e.g. toys, electronics)
packed in containers; unlike bulk cargo they operate in specific and regular itineraries. These three ship types account for the vast majority of ships constructed at world shipyards.

3 Model

We consider a model of entry and production of world shipbuilders. Time is discrete, \( t = 1, \ldots, \infty \). Every period firms make static ship production decisions facing world everchanging demand. In China, potential entrants make entry decisions taking into account their expected discounted stream of profits.

There are \( j = 1, \ldots, J^f \) foreign firms, located in Japan and S.Korea. There are \( j = 1, \ldots, J \) firms in China. There are \( r = 1, \ldots, R \) regions in China. Each region has \( J^r \) firms (so that \( \sum_r J^r = J \)).

There are \( M \) types of ships, \( m = 1, \ldots, M \); in our empirical example we consider \( M = \{ \text{bulk, containers, tankers} \} \). Types are segregated markets. Ships within a type are homogeneous.

3.1 Production

**Demand** The demand curve for type \( m \) is

\[
Q_{mt} = Q(d_{mt}, P_{mt})
\]

for \( m = 1, \ldots, M \); where \( d_{mt} \) are demand shifters for type \( m \), \( Q_{mt} \) is the total tonnage produced of type \( m \) and \( P_{mt} \) is the price per DWT of type \( m \) at \( t \). We also define the inverse demand curve\(^2\)

\[
P_{mt} = P(d_{mt}, Q_{mt})
\]

for \( m = 1, \ldots, M \).

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\(^1\)See Kalouptsidi (2014a) and (2014b) for a detailed description of the shipbuilding and bulk shipping industries.

\(^2\)We abstract away from the durability of ships- see Kalouptsidi (2014b).
Production Technology and Cost Function  The production function of firm \( j \) and ship type \( m \) is

\[
q_{mjt} = F_{mj} (x_{mjt}, \omega_{mjt})
\]

where \( x_{mjt} \) are inputs (e.g. capital, labor, materials such as steel) and \( \omega_{mjt} \) are firm \( j \)'s characteristics (e.g. productivity, age, fixed capital such as docks).

Firm \( j \) solves

\[
\min_{x_{ijt}, \ldots, x_{Mjt}} \sum_m p^x_i x_{mjt} \\
\text{s.t. } q_{mjt} \leq F_{mj} (x_{mjt}, \omega_{mjt}), \text{ all } m
\]

where \( p^x_i \) are the input prices, which we assume are not firm specific. Therefore, firm \( j \)'s variable cost function of producing ship type \( m \) is

\[
c_{mjt} (q_{mjt}, \omega_{mjt}, p^x_i) = p^x_i x^*_m (q_{mjt}, \omega_{mjt}, p^x_i)
\]

where \( x^*_m (q_{mjt}, \omega_{mjt}, p^x_i) \) is the optimal input use resulting from the cost minimization above. Note that the cost function \( c_{mjt} (\cdot) \) is firm and time specific (e.g. other shipyard characteristics, such as the number of employees, age, as well as aggregate input prices may be relevant here).

We assume that production is also characterized by a fixed cost of operation; i.e. firm \( j \)'s total cost function is

\[
\sum_m \left[ c_{mjt} (q_{mjt}, \omega_{mjt}, p^x_i) + 1 \{q_{mjt} > 0\} c^0_{mjt} \right]
\]

where \( 1 \{\cdot\} \) is an indicator function and \( c^0_{mjt} \) is a fixed cost that the firm incurs to produce positive tonnage. We assume that \( c^0_{mjt} \) is privately observed by firm \( j \) and drawn iid across \( j, m \) and \( t \) from a distribution \( G^0_{mt} \). We allow for this fixed operating cost because firms very frequently accept zero orders.

Firm Optimal Production Behavior  Let us begin with foreign firms. Foreign firm \( j \) solves

\[
\max_{q_{ijt}, \ldots, q_{Mjt}} \sum_m \left[ P (d_{mt}, Q_{mt}) q_{mjt} - c_{mjt} (q_{mjt}, \omega_{mjt}, p^x_i) - 1 \{q_{mjt} > 0\} c^0_{mjt} \right] \tag{1}
\]

If \( q_{mjt} > 0 \), it satisfies the following FOC:

\[
\frac{\partial P (d_{mt}, Q_{mt})}{\partial Q_{mt}} q^*_{mjt} + P (d_{mt}, Q_{mt}) = \frac{\partial c_{mjt} (q^*_{mjt}, \omega_{mjt}, p^x_i)}{\partial q_{mjt}} \tag{2}
\]

Firm \( j \)'s optimal production is therefore:

\[
q^*_{mjt} = \begin{cases} 
q^*_{mjt}, & \text{if } c^0_{mjt} \leq P (d_{mt}, Q^*_{mt}) q^*_{mjt} - c_{mjt} (q^*_{mjt}, \omega_{mjt}, p^x_i) \\
0, & \text{otherwise}
\end{cases}
\]

We allow Chinese firms to have soft budget constraints, so that they solve

\[
\max_{q_{ijt}, \ldots, q_{Mjt}} \sum_m \left[ P (d_{mt}, Q_{mt}) q_{mjt} - c_{mjt} (q_{mjt}, \omega_{mjt}, p^x_i) + \gamma_{mjt} (q_{mjt}) - 1 \{q_{mjt} > 0\} c^0_{mjt} \right]
\]
where $\gamma_{mjt}(q_{mjt})$ are non-profit incentives. For example, $\gamma(q_{jt}) = \gamma q_{jt}$ would imply that firms care not only about profit but also market share.\(^3\) If they choose to produce a positive amount, the latter satisfies:

$$
\frac{\partial P(d_{mt}, Q_{mt})}{\partial Q_{mt}} q_{mjt}^* + P(d_{mt}, Q_{mt}) - \frac{\partial c_{mjt}(q_{mjt}, \omega_{mjt}, p_t^e)}{\partial q_{mjt}} = \frac{\partial \gamma_{mjt}(q_{mjt})}{\partial q_{mjt}}
$$

### 3.2 Entry

There are $I$ potential entrants; let $I^r$ be the potential entrants in region $r = 1, ..., R$. We assume that potential entrants are ex ante identical. In addition, entrant $j$ is assigned exogenously a vector of characteristics $\omega_{mjt}$ upon entry, drawn from a distribution $G_{mjt}^e$. Let $d_t = [d_1t, ..., d_Mt]$, $c_{mjt}^0 = [c_{1jt}^0, ..., c_{Mjt}^0]$, $\omega_j = [\omega_{1jt}, ..., \omega_{Mjt}]$. Also, let $\omega_t = [\omega_1t, ..., \omega_{jt}]$.

Potential entrant $j$’s expected discounted stream of profits is

$$
V(d_t, \omega_t, p_t^e) = \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \pi(\omega_{jt}, c_{jt}^0, d_r, \omega_r, p_t^e) | d_t, \omega_t, p_t^e \right]
$$

where the expectation is over future $(\omega_{jt}, c_{jt}^0, \omega_r, \omega_r, d_t, p_t^e)$ and $\pi(\cdot)$ are payoffs from ship production.

We assume that potential entrant $j$ draws a private iid entry cost $\kappa_{jt}^e$ from distribution $G_{jt}^e(\cdot | d_t, \omega_t, p_t^e)$ and enters if

$$
V(d_t, \omega_t, p_t^e) \geq \kappa_{jt}^e
$$

Let $p_{rt}^e$ be the entry probability in region $r$ and $\tilde{V}(\cdot; n^1, ..., n^R)$ the expected value for a given set of values for entrants $(n^1, ..., n^R)$. The entry probability satisfies:

$$
p_{rt}^e = \Pr\left[\kappa^e \leq \sum_{n^1}^{I^1} \ldots \sum_{n^R}^{I^R} \left(\frac{I^1}{n^1}\right) \ldots \left(\frac{I^R}{n^R}\right) (p_{1t}^e)^{n^1} \ldots (p_{Rt}^e)^{n^R} \left(1 - p_{1t}^e\right)^{I^1 - n^1} \ldots \left(1 - p_{Rt}^e\right)^{I^R - n^R} \tilde{V}(d_t, \omega_t, p_t^e; n^1, ..., n^R) \right]
$$

We assume that Chinese regions provide entry subsidies in 2006 and estimate entry costs differentially before and after 2006 to obtain the amount of these subsidies for each region.

### 4 Data

Our empirical analysis draws on several unique data sets on the shipbuilding industry. Our first data set comes from Clarksons, a leading ship brokerage firm based in the UK. This dataset reports quarterly orders for all shipyards between 1998 and 2014. For each shipyard and quarter, we observe its production in tons and numbers, its backlog and average time to build, all in a number of different ship types. The dataset also reports shipyard characteristics in 2014 that include first year of delivery, location, number of dry docks and berths, length of the largest dock, number of employees. The number of docks and berths are a measure of capacity, since production bottlenecks occur during the assembly operations done on the docks/berths.

\(^3\)Similar in spirit to Cooper, Gong and Yan (2013).
Our second data source is the annual survey of Chinese Manufacturing firms with annual sales above 5 million RMB (or roughly $600,000). We extract information on Chinese shipyards from 1998 to 2009 that include the number of employees, wages paid, total and fixed assets owned, sales revenue, export, main operating costs, tax paid, ownership type, etc. We follow the procedure of Brandt, Van Biesebroeck, and Zhang (2012) to create a panel on Chinese shipyards.

Our third data source is China’s economic census in 2004 and 2008 that cover all firms and include additional variables on sales, exports, employees by education, revenue, financial information (capital, assets, inventory, revenue, profit, tax, payroll, employment, etc.), total production, total sales, inventory, depreciation, operating cost, etc.4

5 Estimation

We wish to estimate the following primitives: ship demand curves \( P_m(d_{mt}, Q_{mt}) \), ship production cost function \( c_{mjt}(q_{jt}) \), non-profit incentives \( \gamma_{mjt}(q_{jt}) \), and finally shipyard entry costs \( G_r(d_j, \omega_t, p^T_t) \). We estimate the demand curve for ships via IV using ship prices and total quantities. The volatile demand for freight services which dictates demand for ships provides rich variation. In addition, we have plausible instruments related to input costs (e.g. steel). The main primitives of interest, however, are the production and entry costs, as well as the non-profit incentives. To estimate the production costs and the non-profit incentives, we combine the production first order conditions (2), (3), with assumptions on the shipbuilding production function. In particular, we adopt an approach that combines cost estimation from first order conditions as is standard in IO with production function estimation techniques. The latter makes use of our rich Census dataset on Chinese firms. In fact, it is the combination of demand and Census data that makes possible to identify the non-profit incentives \( \gamma(q) \). Finally, we estimate entry costs from the observed entry probabilities.

5.1 Ship Demand Curve

We estimate the demand curve for ships \( P(d_t, Q_t) \) directly from ship prices \( P_t \), total quantity of ships produced \( Q_t \), demand shifters \( X_t \) and instruments. We assume that the demand curve is log-linear so that

\[
P_t = \exp(\alpha_0 X^0_t + \varepsilon^0_t) Q_t^\alpha_1
\]

For now, we focus only on bulk carriers. We estimate equation (6) by 2SLS using quarterly data between 1998 and 2012. The demand shifters we include are the Baltic Exchange Freight Index (BFI), iron ore imports of China, U.S. gulf wheat price, and interest rates (LIBOR). The freight rate (measured by BFI) reflects the operating revenue of a ship, as well as the current information set of potential ship buyers (note that the bulk shipping industry is very unconcentrated so that assuming that firms are price-takers is reasonable- see Kalouptsidi (2014a)). Iron ore and grains are main products carried by bulk ships (and China is a major importer), while the interest rate reflects the price of borrowing for ship buyers. We use world steel production as an instrument, which plausibly is an exogenous supply shifter.5

Table 1 presents the results. Our demand elasticity estimate of \( \alpha_1 = -0.19 \) indicates that 1% increase in price would lead to about 5% decrease in world demand of bulk carriers rendering the

\[\text{We have also tried to include U.S. steel import price as an additional instrument and the estimates are very similar.}\]

\[\text{In the Appendix (work in progress) we describe the procedure followed to merge these datasets.}\]
The demand curve is rather inelastic. Note that quantity is measured by deadweight ton (DWT) and the average DWT for a bulk carrier is about 62,000; therefore 5% is actually a small number. As expected, the freight rate and the Chinese iron ore imports positively affect ship prices, since both increase current and future (due to their persistence) expected payoffs from shipowning. It is unclear how commodity prices and interest rates should affect ship prices; yet here we will lump all shifters in a single demand indicator, \( d_t \). Indeed, let

\[
d_t = \exp(\alpha_0 X^d_t + \varepsilon^d_t)
\]

Table 1: Demand Estimation, 2SLS

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity demand (( \alpha_1 ))</td>
<td>-0.209 (0.101)</td>
</tr>
<tr>
<td>Freight rate (BFI)</td>
<td>0.342 (0.081)</td>
</tr>
<tr>
<td>China iron import</td>
<td>0.198 (0.054)</td>
</tr>
<tr>
<td>U.S. wheat price</td>
<td>0.323 (0.105)</td>
</tr>
<tr>
<td>Interest rate (LIBOR)</td>
<td>0.054 (0.012)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.874 (0.628)</td>
</tr>
</tbody>
</table>

1st Stage F-stat (excl. \( X_t \)) 56.50
\( R^2 \) 0.75
\( N \) 60

Note: The table reports the 2SLS estimates of the log-linear demand function, instrumenting quantity demand by world steel production. We use quarterly data between 1998 and 2012 and focus on bulk carries for now. The average price for bulk carries is used. BFI abbreviates for the Baltic Exchange Freight Index. Data are obtained or computed from Clarkson.

5.2 Production Cost Function

In this section we provide preliminary cost function estimates ignoring the non-profit incentives.

**Foreign Firms** Let us begin with foreign firms (i.e. Japan and South Korea). We use the method of moments to estimate costs via (2). We assume that costs are quadratic so that

\[
c_{jt}(q_{jt}, \varepsilon_{jt}; \theta^c) = [c_{1j}(\theta^{c1}) + \sigma \varepsilon_{jt}] q_{jt} + c_{2j}(\theta^{c2}) q_{jt}^2
\]

(7)

where \( \varepsilon_{jt} \) represents an unobserved cost component. We use the following shipyard characteristics: age, backlog, linear time trend, U.S. steel import price, the number of docks, and the largest dock length. The instruments we use include the number of shipyards in other regions.
and the average age of other shipyards in other regions. For now, we assume \( c_1 \) is linear in all the characteristics and \( c_2 \) is a constant.

Using annual shipyard level data between 1998 and 2012, we estimate \((\theta^{c_1}, \theta^{c_2})\) via GMM using the FOC:

\[
\hat{\alpha}_1 \tilde{Q}_t \hat{\alpha}_1^{-1} \tilde{d}_{ijt} + \tilde{P}_t - c_{1j} (\theta^{c_1}) - \sigma \xi_{jt} - 2c_{2j} (\theta^{c_2}) \tilde{q}_{ijt} = 0
\]  

(8)

where \( \hat{\alpha}_1 \) is our estimate from the demand curve, \( \tilde{Q}_t, \tilde{d}, \) and \( \tilde{P}_t \) are annual transformation from quarterly data.

We focus our sample on shipyards with 20 percent or more of their lifetime contracts consisting of bulks and observations with positive quantities. Table 5 presents the estimates from GMM. As expected, backlog, docks and dock length affect decrease costs, while steel prices increase costs.

![Figure 5: Cost Function of Foreign Firms.](image)

### Chinese Firms

Unlike foreign firms, Chinese firms have non-profit incentives. Using the Chinese Census and Manufacturing Survey, we are able to estimate their cost function independently of their marginal revenue. We proceed in two ways: (i) estimate the production function; (ii) use directly observed operating cost data. Once the cost function is known, we employ (3) to obtain the non-profit incentives \( \gamma(\cdot) \).

### References


