Detection and Impact of Industrial Subsidies: The Case of World Shipbuilding
Online Appendix

Myrto Kalouptsidi*

Department of Economics, Princeton University and NBER

October 2014

1 Proof of Lemma 1

The shipyard's optimal production policy is as follows: shipyard j chooses $q_{jt} = 0$ if

$$-c\left(0, s_{jt}^{y}, s_t\right) + \beta CV^{y}\left(s_{jt}^{y}, s_t, 0\right) \geq VE_j^{o}\left(s_t\right) q' - c\left(q', s_{jt}^{y}, s_t\right) - q'\varepsilon_{jt} + \beta CV^{y}\left(s_{jt}^{y}, s_t, q'\right)$$

all $q' \in \{1, ..., \overline{q}\}$, or

$$\varepsilon_{jt} \geq VE_j^{o}\left(s_t\right) + \max_{0<q'\leq\overline{q}}\left\{\frac{c\left(0, s_{jt}^{y}, s_t\right) - c\left(q', s_{jt}^{y}, s_t\right) + \beta\left(CV^{y}\left(s_{jt}^{y}, s_t, q'\right) - CV^{y}\left(s_{jt}^{y}, s_t, 0\right)\right)}{q'}\right\}$$

Similarly, shipyard j chooses $q_{jt} = q \neq 0, \overline{q}$ if:

$$VE_j^{o}\left(s_t\right) q - c\left(q, s_{jt}^{y}, s_t\right) - q\varepsilon_{jt} + \beta CV^{y}\left(s_{jt}^{y}, s_t, q\right) \geq VE_j^{o}\left(s_t\right) q' - c\left(q', s_{jt}^{y}, s_t\right) - q'\varepsilon_{jt} + \beta CV^{y}\left(s_{jt}^{y}, s_t, q'\right)$$

all $q' \neq q$, or

$$\varepsilon_{jt} \geq VE_j^{o}\left(s_t\right) + \max_{q<q'\leq\overline{q}}\left\{\frac{c\left(q, s_{jt}^{y}, s_t\right) - c\left(q', s_{jt}^{y}, s_t\right) + \beta\left(CV^{y}\left(s_{jt}^{y}, s_t, q'\right) - CV^{y}\left(s_{jt}^{y}, s_t, q\right)\right)}{q' - q}\right\}$$

*Princeton University, Department of Economics, 315 Fisher Hall, Princeton, NJ 08544-1021. email: myrto@princeton.edu

$$\varepsilon_{jt} \leq VE_j^o(s_t) + \min_{0<q'\leq\overline{q}} \left\{ \frac{c\left(q, s_{jt}^y, s_t\right) - c\left(q', s_{jt}^y, s_t\right) + \beta\left(CV^y\left(s_{jt}^y, s_t, q'\right) - CV^y\left(s_{jt}^y, s_t, q\right)\right)}{q' - q} \right\}$$

Finally, shipyard j chooses $q_{jt} = \overline{q}$, if

$$\varepsilon_{jt} \leq VE_j^o(s_t) + \min_{0\leq q'<\overline{q}} \left\{ \frac{c\left(\overline{q}, s_{jt}^y, s_t\right) - c\left(q', s_{jt}^y, s_t\right) + \beta\left(CV^y\left(s_{jt}^y, s_t, q'\right) - CV^y\left(s_{jt}^y, s_t, \overline{q}\right)\right)}{q' - \overline{q}} \right\}$$

Proving Lemma 1 amounts to proving that if the shipbuilding cost function $C(q, \cdot) : [0, \overline{q}] \to \mathbb{R}$, is convex in q, then:

$$\begin{aligned}
\max_{q<q'\leq\overline{q}} \left\{ \frac{c(q,\cdot) - c(q',\cdot) + \beta\left(CV^y(\cdot,q') - CV^y(\cdot,q)\right)}{q'-q} \right\} &= c(q,\cdot) - c(q+1,\cdot) + \\
&\quad +\beta\left(CV^y(\cdot,q+1) - CV^y(\cdot,q)\right) \\
\min_{0\leq q'<\overline{q}} \left\{ \frac{c(q,\cdot) - c(q',\cdot) + \beta\left(CV^y(\cdot,q') - CV^y(\cdot,q)\right)}{q'-q} \right\} &= c(q-1,\cdot) - c(q,\cdot) + \\
&\quad +\beta\left(CV^y(\cdot,q) - CV^y(\cdot,q-1)\right)
\end{aligned}$$

I first show the following lemma:

Lemma 1 *If $f(x) : [a, b] \to \mathbb{R}$ is convex in x, then*

$$\min_{\kappa=1,2,\dots} \left\{ \frac{f(x+\kappa) - f(x)}{\kappa} \right\} \leq f(x+1) - f(x)$$

Proof. *It suffices to show that the sequence $\frac{f(x+\kappa)-f(x)}{\kappa}$ is decreasing in $\kappa = 1, 2, \dots$. Indeed, the inequality*

$$\frac{f(x+\kappa+1) - f(x)}{\kappa+1} \geq \frac{f(x+\kappa) - f(x)}{\kappa}$$

holds if and only if

$$\kappa f(x+\kappa+1) + f(x) \geq (\kappa+1) f(x+\kappa) \Leftrightarrow \frac{\kappa}{\kappa+1} f(x+\kappa+1) + \frac{1}{\kappa+1} f(x) \geq f(x+\kappa)$$

which holds because of Jensen's inequality, since

$$\frac{\kappa}{\kappa+1} f(x+\kappa+1) + \frac{1}{\kappa+1} f(x) \geq f\left(\frac{\kappa}{\kappa+1}(x+\kappa+1) + \frac{1}{\kappa+1} x\right) = f(x+\kappa)$$

■

Therefore, it suffices to show that the function $c(q,\cdot) - \beta CV^y(\cdot, q)$ is convex in q. By assumption, $c(q,\cdot)$ is convex. It then follows that $CV^y(\cdot, q)$ is concave. Indeed, standard dynamic programming arguments yield concavity of the value function if: the per period payoff is continuous, bounded and concave in both the state and the control (which holds in this case by convexity of the cost function), the transition function is continuous, bounded and concave in the control and state (which holds under the backlog transition chosen in the empirical exercise), $\beta \in (0,1)$, and the state space is convex.

2 Summary Statistics

Table 1 reports statistics on new ship prices, showing that Chinese ships are somewhat cheaper than Japanese both before and after 2006, while all ship prices increased significantly in the post period.

New Ship price (million $)	pre- 2006	post- 2006
All	19.21	30.67
	(6.35)	(6.68)
Chinese	18.43	27.67
	(6.8)	(5.51)
European	n.a.	24
	n.a.	(0)
Japanese	20.7	29.8
	(5.26)	(7.9)
South Korean	19.8	34.85
	(6.2)	(5.77)

Table 1: New-building price summary statistics.

Table 2 reports some summary statistics of shipbuilding capital infrastructure and exhibits China's post-2006 rise in both the number of docks, as well as the length of each dock. This Table shows that the average shipyard in China grew significantly.

	Average Docks/Berths		Average Length of Largest Dock	
	pre-2006	post-2006	pre-2006	post-2006
All	1.065 (0.183)	3.01 (0.3)	92.9 (11.41)	295.6 (25.51)
Chinese	0.451 (0.166)	3.901 (0.49)	60.47 (15.56)	439.8 (39.49)
European	2.375 (1.224)	1.75 (0.88)	91.25 (31.66)	9126 (77.5)
Japanese	1.606 (0.337)	2.45 (0.45)	159.5 (20.42)	203.94 (25.68)
Korean	1.25 (0.536)	1.938 (0.61)	59.6 (26.81)	109.9 (40.52)

Table 2: Shipbuilding capital summary statistics.

3 Additional cost function results

I report several additional specifications that are omitted from the main text due to space limitations.

Table 3 reports results when China-year dummies are added in the cost function.

Table 4 presents a specification where the convexity parameter c_2 is country-specific. It seems that there is indeed variation across countries, yet the main findings remain unchanged. Interestingly, despite differences in c_2 across countries, all coefficients in the linear term are very close to our baseline estimates (e.g. specification II of Table 2 of the main text).

As regional governments in China can play an important role, I consider the possibility that they implement the national subsidization plan at different dates and magnitudes. As no official documentation was found on implementation dates, I consider the first quarter that new shipbuilding docks/berths come online. I divide regions into three groups: Region A (Jiangsu region) initiated in Q3-2005; Region B (Fujian, Hainan, Hebei, Hubei, Shandong, Tianjin regions) initiated in Q4-2006; Region C (Anhui, Guangdong, Guizhou, Liaoning, Shanghai, Zhejiang regions) initiated in Q3-2007. Table 5 presents the results which are similar to prior specifications. It seems that the last region to implement, also has the lowest subsidy level.

China 2001	26.95 (4.23)**
China 2002	28.74 (4.4)**
China 2003	27.79 (4.17)**
China 2004	28.05 (4.02)**
China 2005	27.54 (3.72)**
China 2006	22.55 (2.75)**
China 2007	20.94 (2.55)**
China 2008	21.72 (3.37)**
China 2009	24.82 (3.44)**
China 2010	20.4 (2.85)**
China 2011	25.26 (4.05)**
China 2012	24.16 (4.3)**
Europe	28.7 (3.88)**
Japan	23.06 (2.48)**
S. Korea	28.04 (3.39)**
Backlog	-0.57 (0.11)**
Steel price	0.39 (0.19)**
t	0.29 (0.05)**
c_2	1.104 (0.22)**
σ	11.27 (2.1)**

Table 3: Static cost function estimates with China-year dummies. Time t measured in quarters. Countries refer to country dummy variables. Stars indicate significance at the 0.05 level. Standard errors computed from 500 bootstrap samples.

China	33.39 (6.08)**
China,POST	-7.13 (2.34)**
Europe	30.59 (5.85)**
Japan	24.85 (3.57)**
S. Korea	34.00 (5.7)**
Backlog	-0.72 (0.18)**
Docks/Berths	-0.13 (0.15)
Max Length	-0.0009 (0.001)
Steel price	0.36 (0.22)
t	0.33 (0.06)**
c_2,China	1.03 (0.28)**
c_2,Europe	3.71 (1.21)**
c_2,Japan	1.65 (0.46)**
c_2,S. Korea	0.86 (0.33)**
σ	13.9 (3.5)**

Table 4: Static cost function. Time t measured in quarters. Countries refer to country dummy variables. Stars indicate significance at the 0.05 level. Standard errors computed from 500 bootstrap samples.

China Region A	28.49 (4.58)**
China Region B	28.63 (4.37)**
China Region C	25.29 (3.98)**
China Region A,POST	-6.08 (2.08)**
China Region B,POST	-6.96 (2.06)**
China Region C,POST	-3.96 (2.69)**
Europe	29.55 (4.8)**
Japan	23.11 (2.94)**
S. Korea	28.75 (4.36)**
Backlog	-0.57 (0.13)**
Docks/Berths	-0.12 (0.14)**
Max Length	-0.0009 (0.0009)**
Steel price	0.38 (0.19)**
t	0.31 (0.05)**
c_2	1.05 (0.25)**
σ	11.3 (2.46)**

Table 5: Static cost function estimates with administrative regions. Time t measured in quarters. Countries refer to country dummy variables. Region A includes Jiangsu and Post refers to Q3-2005. Region B includes Hebei, Shandong, Tianjin, Hainan, Fujian and Hubei and Post refers to Q4-2006. Region C includes Liaoning, Shanghai, Zhejiang, Guangdong, Anhui and Guizhou and Post refers to Q3-2007. Stars indicate significance at the 0.05 level. Standard errors computed from 500 bootstrap samples.