China's Industrial Policy: An Empirical Evaluation

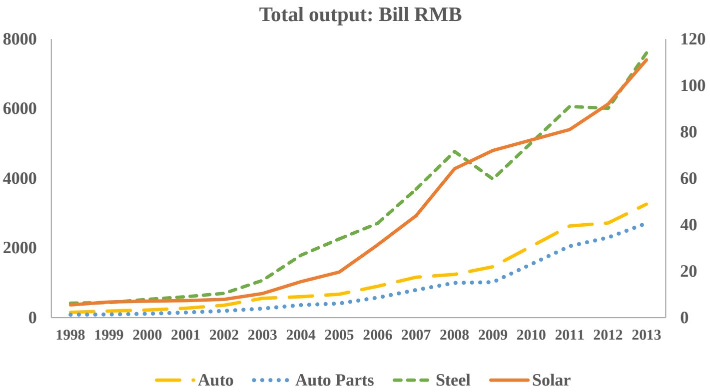
Panle Jia Barwick
Cornell and NBER

Myrto Kalouptsidi
Harvard and NBER

Nahim Zahur
Cornell

November 2019

China's Rapid Expansion



- These industries grew by 20-30 times during a 15-yr period

China's Industrial Policies

These expansions are partially fueled by China's massive industrial policies

- National and regional five-year plans
- "Made in China 2025": dominate industries of the future by 2025
  - Major push in 10 sectors, including robotics, aerospace and clean-energy cars
  - World leader in latest-generation ships and marine equipment

Low concentration, excess capacity, and regional "industry duplication"

This Paper

- Despite the importance of industrial policies, few welfare analyses exist
- We examine China's industrial policy and the global shipbuilding industry
  - Quantify government support to domestic production, investment, and firm entry using a dynamic model
- And conduct counterfactual analysis:
  - Benchmark effectiveness of different policies on revenue, profit, and welfare
  - Simulate industry evolution and welfare under alternative policies

Summary of Findings

- Magnitude of industrial policies large:
  - Subsidy for production, investment, and entry is 159/51/330 bn RMB 2006-2013 (aggregate industry revenue 1700 bn RMB)
  - Boosted China's investment by 270% and entry by 200%
  - Enhanced China's world market share by 40%
- Significant impact on world ship prices:
  - 2006-08, reduction on price of bulk (8%), tanker (6%), and container (3%)
  - 2009-13, reduction on price of bulk (17%), tanker (11%), and container (4%)
  - Bigger impact in later periods due to increased capacity, num. of firms

Findings: II

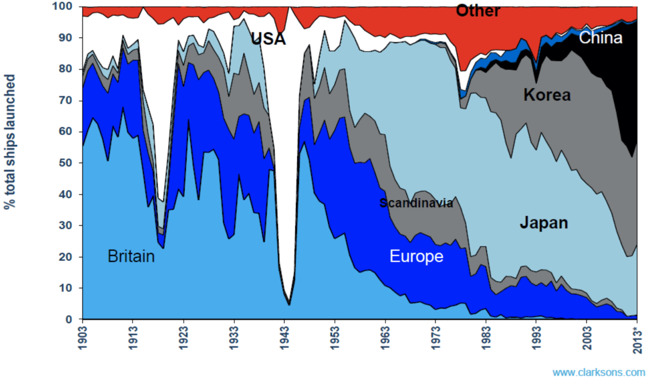
- Evaluation of different policies
  - Effectiveness in boosting profit/revenue mixed: production and investment subsidies can be justified by output considerations; entry subsidies are wasteful
  - Industry (discounted lifetime) profit increased by 145 bill RMB; subsidy 'rate of return' merely 18%
  - Subsidy reduces HHI by 40% and lowers capacity utilization by 20%
- Insights from this study:
  - Distortions are convex and deteriorate with the magnitude of subsidies
  - Dynamic sorting and targeting instrumental
  - Timing (pro-cyclical vs. counter-cyclical) highly relevant

Outline

1. Industry Description and Facts
2. Model
3. Data and Empirical Strategy
4. Estimation results
5. Counterfactual analysis
6. Conclusion

(Chinese) Shipbuilding

History of Shipbuilding



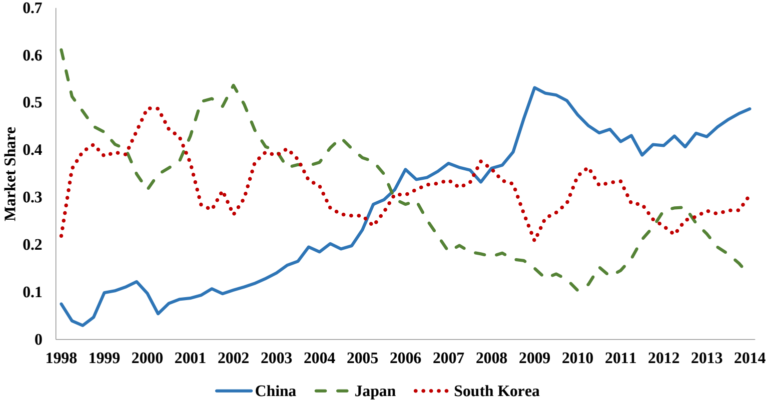
- Shipbuilding a classic target and one of major subsidy recipients
- 1850s Britain; 1950s Japan; 1970s S. Korea; 2000s China

Major Policies in China

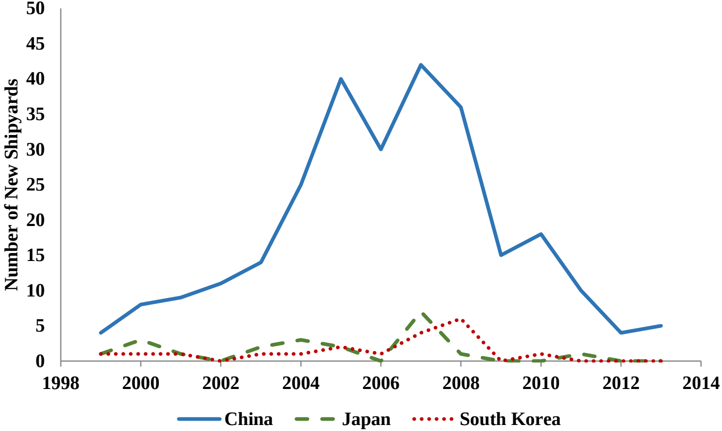
Table: Shipbuilding National Industrial Policies

Year	Shipbuilding National Industrial Policies	Plan Period
2003	National Marine Economic Development Plan	2001-2010
2006	The 11th Five-Year Plan for National Economic and Social Development	2006-2010
2006	The Medium and Long Term Development Plan of Shipbuilding Industry	2006-2015
2007	The 11th Five-Year Plan for the Development of Shipbuilding Industry	2006-2010
2007	The 11th Five-Year Plan for the Development of Shipbuilding Technology	2006-2010
2007	11th Five-Year Plan for the Development of Ship Equipment Industry	2006-2010
2007	Guideline for Comprehensive Establishment of Modern Shipbuilding (2006-2010)	2006-2010
2007	Shipbuilding Operation Standards	2007-
2009	Plan on the Adjusting and Revitalizing the Shipbuilding Industry	2009-2011
2010	The 12th Five-Year Plan for National Economic and Social Development	2011-2015
2012	The 12th Five-Year Plan for the Development of the Shipbuilding Industry	2011-2015
2013	Plan on Accelerating Structural Adjustment and Promoting Transformation and Upgrading of the Shipbuilding Industry	2013-2015
2013	Shipbuilding Industry Standard and Conditions	2013-

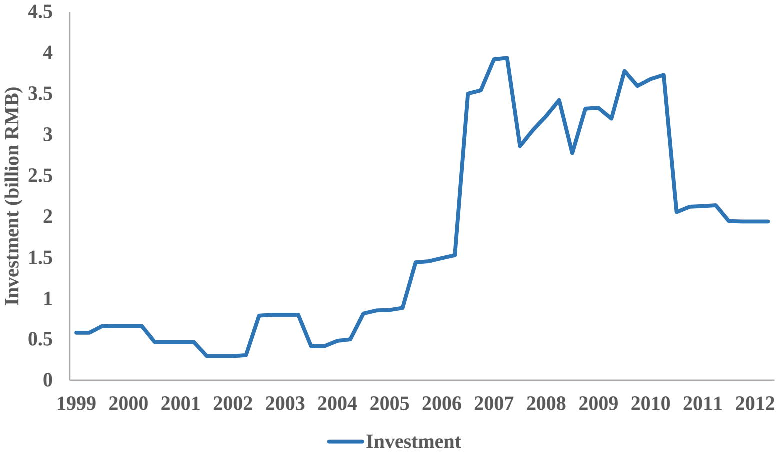
China's Market Share Expansion



Entry of New Shipyards



Investment



▸ Capital Expansion ▸ Capital Expansion of Existing Firms

- Capacity expansion is universal across firm age, ownership status, and geographical area

Model

Model Overview

- Agents:
  - Chinese firms
  - Foreign firms (Japanese and S. Korean shipyards)
- Decisions:
  - Capital accumulation; entry and exit (dynamic)
  - Production (static)
- Products: M ship types
  - Segregated markets
  - Ships homogeneous within a type

Chinese Industrial Policy

- Chinese central and regional government policies (T_t) may provide:
  - Production subsidies that lower $C(q_{jt})$
    - input subsidy, export credits, preferential buyer financing
  - Capital subsidies that lower $C^I(i_{jt})$
    - low-interest credit, tax credits for accelerated capital depreciation
  - Entry subsidies that lower κ_{jt}
    - cheap land, simpler registration procedure
- A simple model of T_t:
  - Two policy shocks (2006 and 2009)
  - They arrive unexpectedly and are considered permanent
- The transition process of payoff relevant variables (including prices) are assumed to satisfy the Markovian property pre- and post- policy intervention.

Model: Static Decisions

- Market demand for ships (omitting subscript on ship type):

$$Q_t^d = d_t - \eta P_t$$

  - d_t is "market size", determined by world demand shifters, such as freight rates, commodity prices, total fleet

- Shipyard j solves (s_{jt} denotes cost shifters):

$$\max_{q \geq 0} P_t q - C\left(q, s_{jt}\right)$$

which leads to profit

$$\pi\left(P_t, s_{jt}, q^*(P_t, s_{jt})\right)$$

- The market clears when total supply $Q_t = \sum_j q^*\left(P_t, s_{jt}\right)$ equals demand $Q_t^d = d_t - \eta P_t$
  - Equilibrium ship price $P\left(s_t, d_t\right)$

Model: Dynamic Decisions

- Each incumbent receives a random scrap value ϕ_{jt} and decides whether to exit
- Shipyard j with capital k_{jt} invests i_{jt} to accumulate capital:

$$k_{jt+1} = (1-\delta)k_{jt} + i_{jt}$$

- Bellman equation (s_{jt} includes all state variables):

$$V(s_{jt}, \phi_{jt}) = \pi(s_{jt}) + \max_{\chi_{jt}} \begin{cases} \phi_{jt}, \\ \max_{i_{jt}} \left(-C^I(i_{jt}, s_{jt}) + \beta E\left[V(s_{jt+1}) | s_{jt}, i_{jt}\right]\right) \end{cases}$$

- Investment cost is $C^I(i_{jt}, s_{jt})$, inclusive of adjustment costs
- Optimal policies:

$$\chi^*(s_{jt}, \phi_{jt}),\, i^*(s_{jt}),\ \text{and similarly } \chi^{e*}(s_{jt}, \kappa_{jt})$$

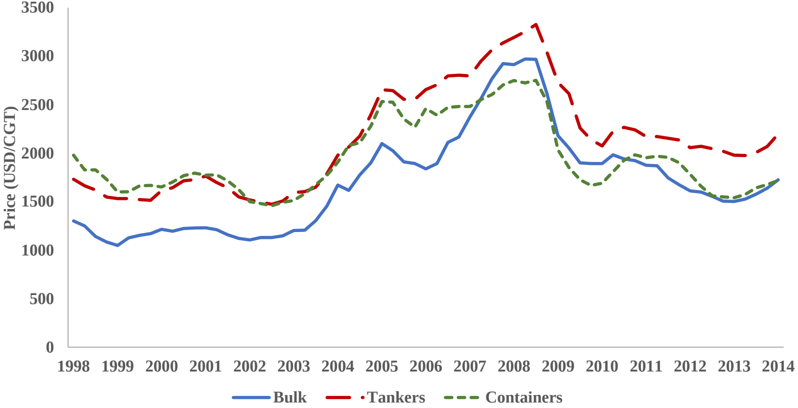
Bellman for entry

Data

Data

- Clarksons (1998-2014) :
  - Quarterly level data on prices P_{mt}
  - Orders received by type for each shipyard q_{mjt}
  - Characteristics for Japan and S. Korea shipyards
- Annual survey of Chinese Manufacturing firms (1998-2013)
- Official documents on industrial policies (1998-2013)
- More than 10,000 firm-quarterly observations in total

Ship Prices



Price (USD/CGT)
3500
3000
2500
2000
1500
1000
500
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Bulk
Tankers
Containers

Empirical Estimation

Empirical Estimation

- Primitives to recover:
  - Shipyard production costs:
  $$C\left(q_{jt}, T_t\right)$$
  - Investment cost:
  $$C^I(i_{jt}; T_t)$$
  - Distribution of entry and exit costs:
  $$\phi_{jt}, \kappa_{jt}(T_t)$$
  - Ship demand curves (for counter-factual analysis):
  $$P_m\left(d_{mt}, Q^d_{mt}\right)$$

Estimate Cost Function

- The marginal cost of producing q_{jmt} equals:

$$MC(q_{jmt}) = z_{jmt}\beta_m + \delta_m q_{jmt} + \omega_{jmt}$$

  - z_{jmt}: capital, backlog, age, province, size, ownership, and subsidies
  - Backlog captures economies of scale and learning
  - ω_{jmt}: a cost (productivity) shock
  - Firms are price takers. Largest firm's market share $< 5\%$.
  - Results incorporating market power (via Cournot) are similar.
- There are J_t^c Chinese firms and J_t^f foreign firms (in Japan and S. Korea)
  - foreign firms' marginal cost function similar $MC_f\left(q_{jmt}\right)$

Production Cost Estimates

	Bulk		Tanker		Container	
Type-specific	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
MC (thousand RMB / CGT)						
β_q	7.34	9.52	13.60	5.54	9.69	5.63
σ_ω	8.49	10.43	14.40	7.08	12.14	5.71
Constant (1000 RMB/CGT)	19.26	15.88	36.58	9.18	32.30	8.39
Steel price (1000 RMB/Ton)	1.55	7.49	1.10	3.04	0.63	1.65
Capital (bill RMB)	-2.43	-2.96	-2.61	-1.80	-2.19	-2.01
Capital^2	0.19	0.83	0.06	0.25	0.06	0.32
Backlog	-1.56	-5.29	-4.44	-5.04	-2.88	-3.34
Backlog^2	0.07	4.04	0.24	3.43	0.18	1.97
Backlog of other types	0.13	0.94	0.35	1.65	0.46	2.66
Common						
2006-2008	-1.51	-2.62				
2009+	-1.38	-2.37				
Large firms	-3.85	-6.97				
Jiangsu	-2.64	-4.75				
Zhejiang	-1.42	-2.80				
Liaoning	-1.87	-2.05				
CSSC/CSIC	-0.77	-1.20				
Private	0.14	0.30				
Foreign JV	-0.78	-1.45				
Age	0.18	3.14				
N	4886		4977		2504	

Cost Function Estimates

- δ suggests firms are responsive to prices:
  - Bulk / tanker / container production goes up by 21% / 28% / 22% with a 10% price increase
  - Convex cost: at $\bar{q}$, $\delta * q$ accounts for 24-58% of a firm's marginal cost
- Larger capital associated with lower cost of production
  - Setting capital to 0 reduces profit by 38%
- Marginal cost decreases with backlog initially (economies of scale) and then increases (capacity constraints)
  - Increasing backlog by 100k CGT reduces marginal cost by 11-27%

Cost Function Estimates

- Production subsidy from 2006 to 2008 equals to 10-13% of the price
- MC for firms in Jiangsu/Liaoning/Zhejiang is lower by 18-22%, 13-16%, and 10-12%, respectively
- Fixed cost c_0 sizable (15% of profits)
- Results robust across alternative specifications
  - pooling across countries
  - drop new shipyards
  - firm- and industry-level learning by doing

  ▸ Robustness
- Limited evidence of industry-wide spillovers

Empirical Estimation

- Primitives to recover:
  - Shipyard production costs:
  $$C\left(q_{jt}, T_t\right)$$
  - Investment cost:
  $$C^I(i_{jt}; T_t)$$
  - Distribution of entry and exit costs:
  $$\phi_{jt}, \kappa_{jt}(T_t)$$
  - Ship demand curves (for counter-factual analysis):
  $$P_m\left(d_{mt}, Q^d_{mt}\right)$$

Bellman Equation

- The Bellman equation for incumbents is:

$$V(s_{jt}, \phi_{jt}) = \pi_{jt} + \max_{\chi_{jt}} \{\phi_{jt}, CV(s_{jt})\}$$

- Assume $\phi_{jt} \sim F_{\phi}(\sigma)$ (exponential), ex-ante value fn is:

$$\begin{aligned} V(s_{jt}) &= \pi_{jt} + p^x \sigma + CV(s_{jt}) \\ CV(s_{jt}) &= E_{\nu_{jt}} \{ \max_{i_{jt}} [-C^I(i_{jt}, \nu_{jt}) + \beta E[V(s_{jt+1}) | s_{jt}, i_{jt}]] \} \end{aligned}$$

- Cost of investment:

$$C^I(i_{jt}, \nu_{jt}) = c_1 i_{jt} + c_2 \nu_{jt} i_{jt} + c_3 i_{jt}^2 + c_4 T_t i_{jt}$$

  - Random investment shocks ν_{jt}
  - Quadratic adjustment costs (c_3).
  - Investment subsidy (c_4)
  - Other types of adjustment costs ($\frac{i^2}{k}$, random fixed costs, irreversibility) insignificant

Investment Cost Estimates

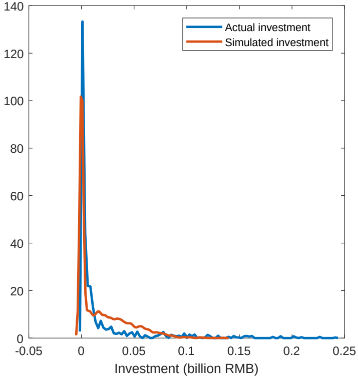
$$C^I(i_{jt}, \nu_{jt}) = c_1 i_{jt} + c_2 \nu_{jt} i_{jt} + c_3 i_{jt}^2 + c_4 T_t i_{jt}$$

Table: Investment Cost Estimates

	Coeff.	t-stat
c_1	1.00	
c_2	1.55	8.27
c_3	21.72	10.57
c_4 2006-08	-0.25	-1.89
c_4 Post 2009	-0.49	-4.07
N	4286	

- Standard errors from 500 block bootstrap simulations
- Importance of ν_{jt}

Goodness of Fit for Investment



- Quadratic adj. costs: 28% of investment costs; $> 50\%$ for large investments ($>$ 50mill)
- Proportion of investment costs subsidized high

Entry Cost Estimates

Table: Entry Cost Distribution (Mean), billion RMB

	κ_{pre}	κ_{06-08}	% of pre-06 cost	κ_{09+}	% of pre-2006 costs
Jiangsu	60	22	36%	69	114%
Zhejiang	91	37	41%	194	214%
Liaoning	56	29	51%	-	-
Other	25	10	38%	44	172%

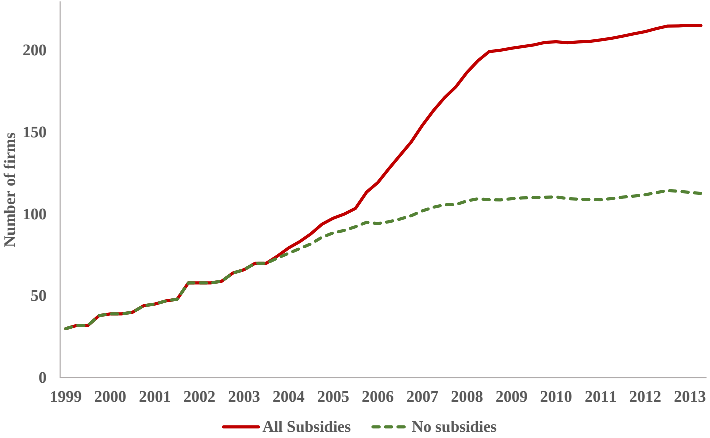
- $\kappa_{jt}(T_t)$ (exponentially distributed) differs across regions and policy regimes
- Subsidies during 06-08 reduced entry costs by 50-60%, robust to $\bar{N}^e$
- Mean entry cost paid per entrant is 2.3 bn RMB; close to accounting estimates
- Mean of the scrap value distribution is 0.69 bill RMB, t-stat 11.8

Empirical Estimation

- Primitives to recover:
  - Shipyard production costs:
    $$C\left(q_{jt}, T_t\right)$$
  - Investment cost:
    $$C^I(i_{jt}; T_t)$$
  - Distribution of entry and exit costs:
    $$\phi_{jt}, \kappa_{jt}(T_t)$$
  - Ship demand curves (for counter-factual analysis):
    $$P_m\left(d_{mt}, Q^d_{mt}\right)$$

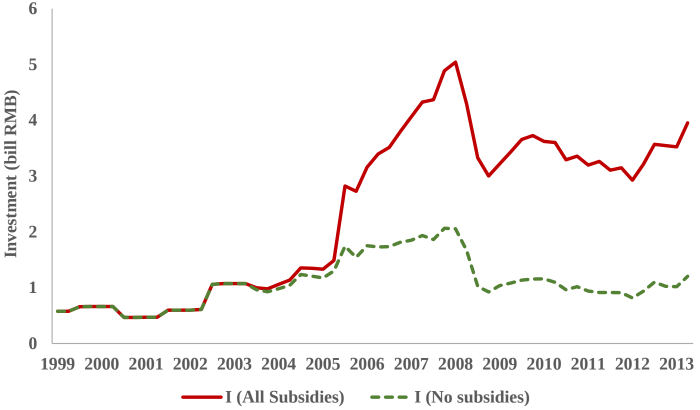
Evaluation of China's Industrial Policy

Number of Firms



- From 2006-2013, 148 firms enter with subsidies vs. 65 without
- Subsidies depress number of exits (37 vs. 46) and change distribution of exitting firms: fewer incumbents exit but more entrants exit in downturn

Investment



- Total investment during 2006-2013 is 114 bill RMB with subsidies vs. 42 bill RMB without subsidies

Concentration

- HHI is 40% lower with subsidies in 2009-2013 (more fragmentation)
- Q/K is 20% lower with subsidies in 2009-2013

Impact on World Prices

Table: Impact of Subsidy on World Price

	Bulk	Tanker	Container
Subsidies, 2006-08	16.3	20.0	17.2
No subsidies, 2006-08	17.6	21.2	17.7
% difference	8.2%	6.2%	3.1%
Subsidies, 2009-13	8.8	8.1	9.2
No subsidies, 2009-13	10.2	9.0	9.5
% difference	16.5%	10.6%	3.7%

Note: Prices in 1000 RMB/CGT

- Magnitude depends on supply and demand elasticity
  - Demand for containers more elastic hence effect smaller
- Effect larger in later period due to increased capacity and larger num. of firms

Impact on the World Industry

- Subsidies increased China's market share by 40%
  - China stole roughly equal market share from Japan and S. Korea
  - Profits by Japanese and South Korean shipyards reduce by 140 bn RMB
- Worldwide shippers benefit by 230 bill RMB
  - China accounts for less than 10% of world shippers

Subsidy Comparison

- How effective are these policies in generating profit and/or revenue?
- Production subsidy is static, while investment and entry subsidies have dynamic consequences
  - More investment and entry today imply more production and higher profit tomorrow
- Simulate long-run industry equilibrium from 2006-2099 (discounted profit post 2099 negligible)
  - Turning on and off subsidies as needed
  - Equilibrium prices are determined by supply and demand

Subsidy Comparison

Table: Comparison of Different Subsidies: Bill RMB

	All Subsidies	Only Production	Only Investment	Only Entry	No Subsidies
Lifetime Revenue 2006-2099	2320	2091	1796	1830	1696
Lifetime Profits 2006-2099	854	788	618	590	570
Production Subsidies	256	216	0	0	0
Investment Subsidies	86	0	44	0	0
Entry Subsidies	302	0	0	171	0
Δ Revenue/Subsidy	97%	183%	226%	78%	
Δ (Profit-Inv. Cost)/Subsidy	44%	93%	148%	11%	
Δ Net Profit/Subsidy	18%	56%	87%	24%	

- Net Profit = (Profits-Investment Cost+Scrap Value-Entry Cost)
- Entry subsidies from 2006 to 2008 while production and investment subsidies from 2006 to 2099

Subsidy Comparison

- Production and investment subsidies can be justified by output considerations
- Entry subsidies attract high-cost firms and are wasteful
- Aggregate return to subsidies merely 18%
- Subsidies lead to higher aggregate fixed costs incurred, which augment inefficiency
  - Absent fixed costs, rate of return would increase from 18% to 29%
- Convexity: subsidies much more distortionary when combined

Comparing Production and Investment Subsidies

Table: Production vs. Investment Subsidies: Bill RMB

	100% Production subsidies	50% Production subsidies	Investment subsidies
Lifetime Revenue 2006-	2104	1937	1851
Lifetime Profits 2006-	783	682	641
Production subsidies	219	97	0
Investment subsidies	0	0	93
Entry subsidies	0	0	0
Δ Revenue /Subsidies	161%	192%	106%
Δ (Profit-Invest Cost)/Subsidies	82%	93%	98%
Δ Net Profit/Subsidies	51%	62%	82%

- The larger the magnitude of subsidies, the lower the per-unit return
- Investment subsidies lead to higher industry net profits
- Production subsidies more effective instrument for achieving output/revenue targets

Targeting

Table: Subsidizing Efficient vs. Inefficient Firms: Bill RMB

	Inefficient Firms	Efficient Firms
Lifetime Revenue 2006-2099	406	1911
Lifetime Profits 2006-2099	70	779
Production Subsidies	40	215
Investment Subsidies	26	60
Entry Subsidies	157	146
Δ Revenue/Subsidies	71%	113%
Δ (Profit-Invest Cost)/Subsidies	19%	58%
Δ Net Profit/Subsidies	-4%	29%

- Subsidizing efficient firms based on initial attributes more effective
  - Efficient firms less likely distorted in all margins: entry, production, investment, exit
  - Efficient firms benefit more from economies of scale: backlog and capital
- Entry subsidies particularly poorly targeted: over 50% go to low-profit firms

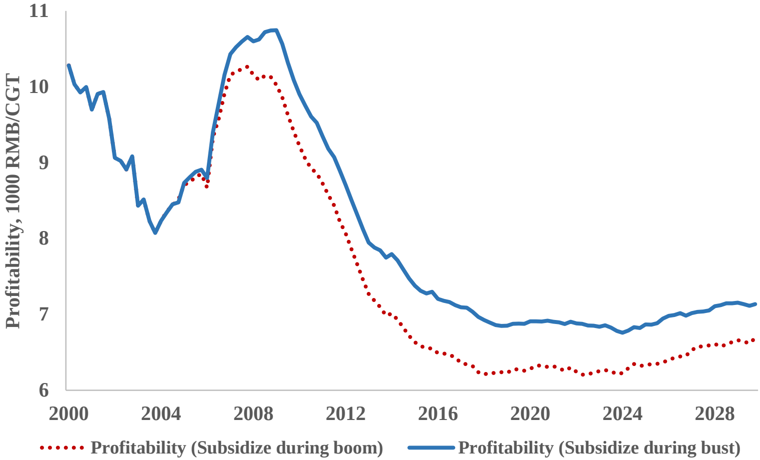
Business Cycle

Table: Pro-Cyclical vs. Counter-Cyclical Industrial Policy: Bill RMB

	Subsidize During Boom (2006-2008)	Subsidize During Recession (2009-2013)
Lifetime Revenue 2006-2099	1792	1795
Lifetime Profits 2006-2099	609	624
Production Subsidies	34	35
Investment Subsidies	16	16
Δ Revenue/Subsidies	222%	225%
Δ (Profit-Invest Cost)/Subsidies	86%	126%
Δ Net Profit/Subsidies	29%	78%

- Timing important: counter-cyclical policies out-perform pro-cyclical policies
  - expansion more costly during boom; firm composition different
- Actual policy mix is pro-cyclical: 442 bn of subsidies during boom, 106 bn during recession

Dynamic Composition



- Subsidizing during recession selects more efficient firms over the long run
- Through more efficient entry and exit

Discussion

Traditional rationale of industrial policies:

- Marshallian externality
  - No evidence of industry wide learning-by-doing
- Strategic trade considerations
  - Market power negligible
- Spillover to other sectors and the labor market
  - Shipbuilding a small component of steel demand and total employment
  - Input-Output table suggests little spillover to other sectors
  - China is not a big player in international transportation service
- Impact on trade volume
  - Could be considerable but welfare benefit difficult to quantify
- Military (national security) considerations and the desire to be world no. 1
  - We provide cost estimates for achieving these objectives

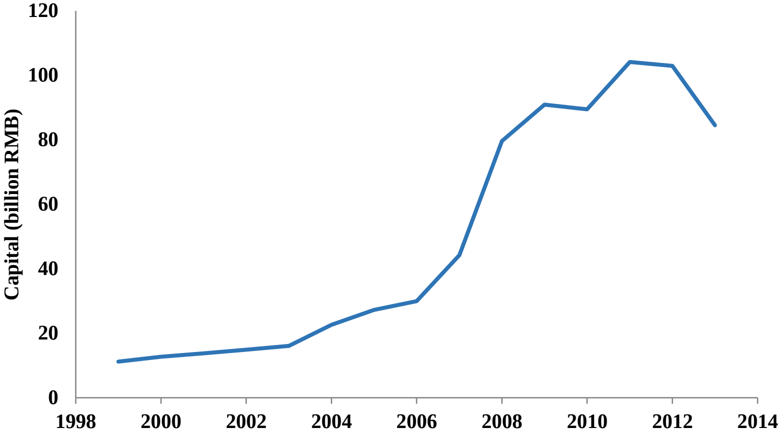
Conclusion

- Massive (and wasteful) subsidies for the shipbuilding industry 2006-2013
  - China's world market share increased by 40%
  - At the cost of low concentration and capital utilization
- Effectiveness of the policies mixed:
  - Prod/inv subsidies could be justified by market share considerations
  - Entry subsidies are wasteful and increase fragmentation and idleness cost
  - Prod subsidy better at raising revenue; inv subsidy delivering a higher return
- Broad lessons:
  - Distortions are convex and deteriorate with the magnitude of subsidies
  - Dynamic sorting and targeting instrumental
  - Timing (pro-cyclical vs. counter-cyclical) highly relevant

Thanks and Comments Welcome!

Appendix

Capital Expansion



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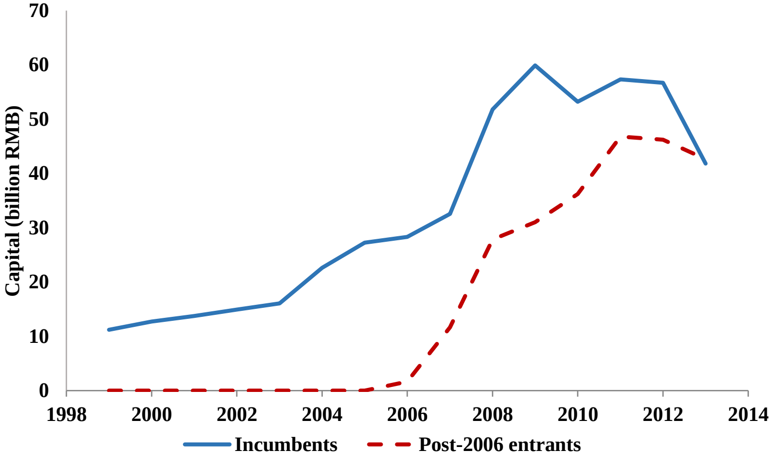
Capital Expansion of Existing Firms



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Model: Dynamic Decisions

- J^e potential entrants. Each with a random entry cost κ_{jt}
- Value function

$$VE\left(s_{jt}, \kappa_{jt}\right) = \max_{\chi^e_{jt}} \left\{ \begin{array}{c} \kappa_{jt}, \\ -C^I(K_{jt}) + \beta E\left[V(s_{jt+1}) | s_{jt}, \chi^e_{jt} = 1\right] \end{array} \right.$$

- Optimal entry policy

$$\chi^{e*}\left(s_{jt}, \kappa_{jt}\right)$$

Go Back

Estimate Cost Function: Alternative Approach

- One approach is to back out the cost function using the estimated production function (OP/LP)
$$q_{jt} = f(k_{jt}, l_{jt}, m_{jt}, \omega_{jt})$$
- Construct C_{jt} = labor costs + material costs + capital costs associated with quantity q_{jt}
- Challenge: data quality low
  - Reported costs unreliable
  - No inputs after 2007, etc. Go Back

Production Cost: Other Specifications

	Baseline		*Trend*		*Existing yards*		*Learning*	
	(1) Coeff.	t-stat	(2) Coeff.	t-stat	(3) Coeff.	t-stat	(4) Coeff.	t-stat
Bulk								
Capital	-2.92	-3.06	-2.91	-3.11	-3.33	-3.18	-1.94	-2.12
Backlog	-2.09	-6.63	-2.09	-6.41	-3.16	-6.38	-1.45	-5.05
Cumul. Q.							0.07	4.72
Tanker								
Capital	-2.06	-1.55	-2.06	-1.56	-2.49	-1.41	-1.95	-1.52
Backlog	-4.50	-6.38	-4.50	-6.42	-5.15	-6.13	-4.41	-5.06
Cumul. Q.							0.09	5.59
Container								
Capital	-1.41	-1.33	-1.41	-1.33	-0.44	-0.40	-1.11	-1.22
Backlog	-3.06	-4.40	-3.06	-4.40	-3.66	-4.25	-0.90	-1.30
Cumul. Q.							0.01	4.00
Common								
China 2006-2008	-2.79	-4.57	-2.78	-4.19	-2.08	-2.72	-2.43	-4.43
China 2009+	-0.90	-1.56	-0.89	-1.35	-1.01	-1.25	-0.95	-1.73
Trend			-0.02	-0.03				

Back