Market Access, Technology and Plant Lifecycle:
A Natural Experiment from Opening of Japan in 1859

Tomohiro Machikita (IDE-JETRO)

and

Tetsuji Okazaki (The University of Tokyo)

Motivation and literature

- Comparison of plant life cycle Between advanced countries and developing countries (Hsieh and Klenow 2014)
  - Difference in size distribution
  - Difference in age-size profile
  - Slower growth of plants in developing countries

- Why do plants grow more slowly in developing countries ?
  - Possible barriers for plant growth (Hsieh and Klenow 2014)
    - Contractual frictions in hiring nonfamily labor, higher tax enforcement on larger firms, financial frictions, difficulty in buying land or obtaining skilled managers, costs of shipping to distant markets etc.

Motivation and literature (cont.)

- Exogenous change in the trade regime of Japan
  - Opening the country in 1859 under the pressure from U.S.
  - An excellent opportunity for natural experiment
    - Bernhofen and Brown (2004, 2005)

- This paper
  - To measure the impact of the trade regime change on the plant life cycle by exploiting the opportunity of natural experiment
  - To Investigate the mechanisms that cause the difference in the plant lifecycle between the "underdeveloped" regime and "developed" regime

Historical background

- Seclusion policy by Tokugawa *Bakufu*
  - According to a series of seclusion acts, by 1639 trades and other international relationship were limited those with Netherland, China, Korea and Ryukyu, which were strictly controlled by *Bakufu*

- Opening the country
  - 1853 U.S. fleet under the control of General Matthew C. Perry visited Uraga, Japan
  - 1854 *Bakufu* concluded the Treaty of Kanagawa with U.S.
    - Establishment of a diplomatic relationship between Japan and U.S.
  - 1854-56 Diplomatic relationships were established with Britain, Russia and Netherland

Historical background (cont.)

- Opening the country (cont.)
  - 1858 Treaties for trades were concluded with U.S., Britain, Russia, Netherland and France
  - 1859 Three ports, Kanagawa, Nagasaki and Hakodate were opened for trades
    - Imposing conventional tariff rates of 5%
    - Close to the free trade regime
- Impact of the opening trades
  - Shinbo (1978)
    - Sharp change in prices
  - Bernhofen and Brown (2004)
    - Import per capita under the seclusion policy (nineteenth century)
      - Japan: 0.6 cents
      - China: 9 cents

Opening trades and change in the relative price (price index, 1858=100)
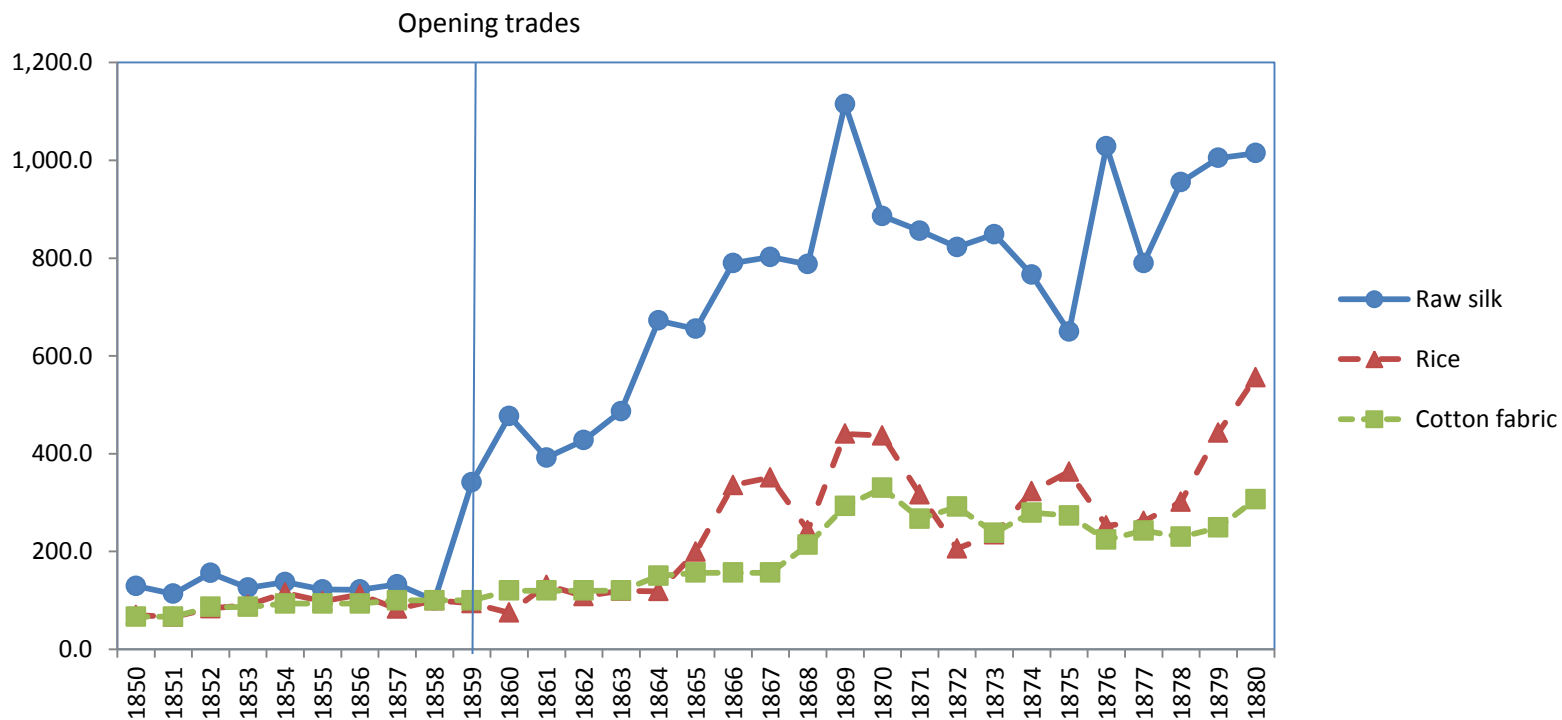
Source: Kin'yu Kenkyukai (1937), pp.13-15, 89-90 and 103-104.

Data

- Plant-level data from manufacturing censuses for 1902 and 1919
  - *Kojo Tsuran* (*Factory Handbook*)
    - Plant name, industry, product, location, owner, year of foundation, number of employees by sexuality, number and horse powers of engines by power source

- Long-term time series data on plant size for two individual plants that cover the period before and after 1859
  - Besshi copper mine
  - Yamasa soy sauce plant

Kojo Tsuran for 1902

Table 3: Summary statistics

Variable	Mean	Std. Dev.	Min	Max
Entry before opening (N=1056)				
Number of employees	25.475	35.092	4	810
Number of non-steam power	0.537	2.782	0	80
Years before opening	70.761	84.982	1	973
Years after opening	54.559	7.934	43	60
1902 year dummy	0.320	0.467	0	1
Metro region	0.410	0.492	0	1
Exporting industry	0.065	0.247	0	1
Entry after opening (N=30594)				
Number of employees	61.330	234.522	2	15344
Number of non-steam power	1.367	10.157	0	563
Years before opening	0.000	0.000	0	0
Years after opening	11.282	11.249	0	60
1902 year dummy	0.238	0.426	0	1
Metro region	0.382	0.486	0	1
Exporting industry	0.489	0.500	0	1

Source: Manufacturing Census, 1902 and 1919

Empirical strategy

- Identifying the impact of trade regime change on the age-size profile of plants
  - Age-size profile

    $$y_{ijpt} = \beta_1(\text{Years after entry})_{ijpt} + \beta_x (\text{other controls})_{ijpt} + u_{ijpt},$$

  - Allowing for difference in the age effects between the trade regimes

    $$y_{ijpt} = \beta_1 (\text{Years } \mathbf{before} \text{ opening})_{ijpt} + \beta_2 (\text{Years } \mathbf{after} \text{ opening})_{ijpt}$$

    $$+ \beta_x (\text{other controls})_{ijpt} + u_{ijpt},$$

Empirical strategy (cont.)
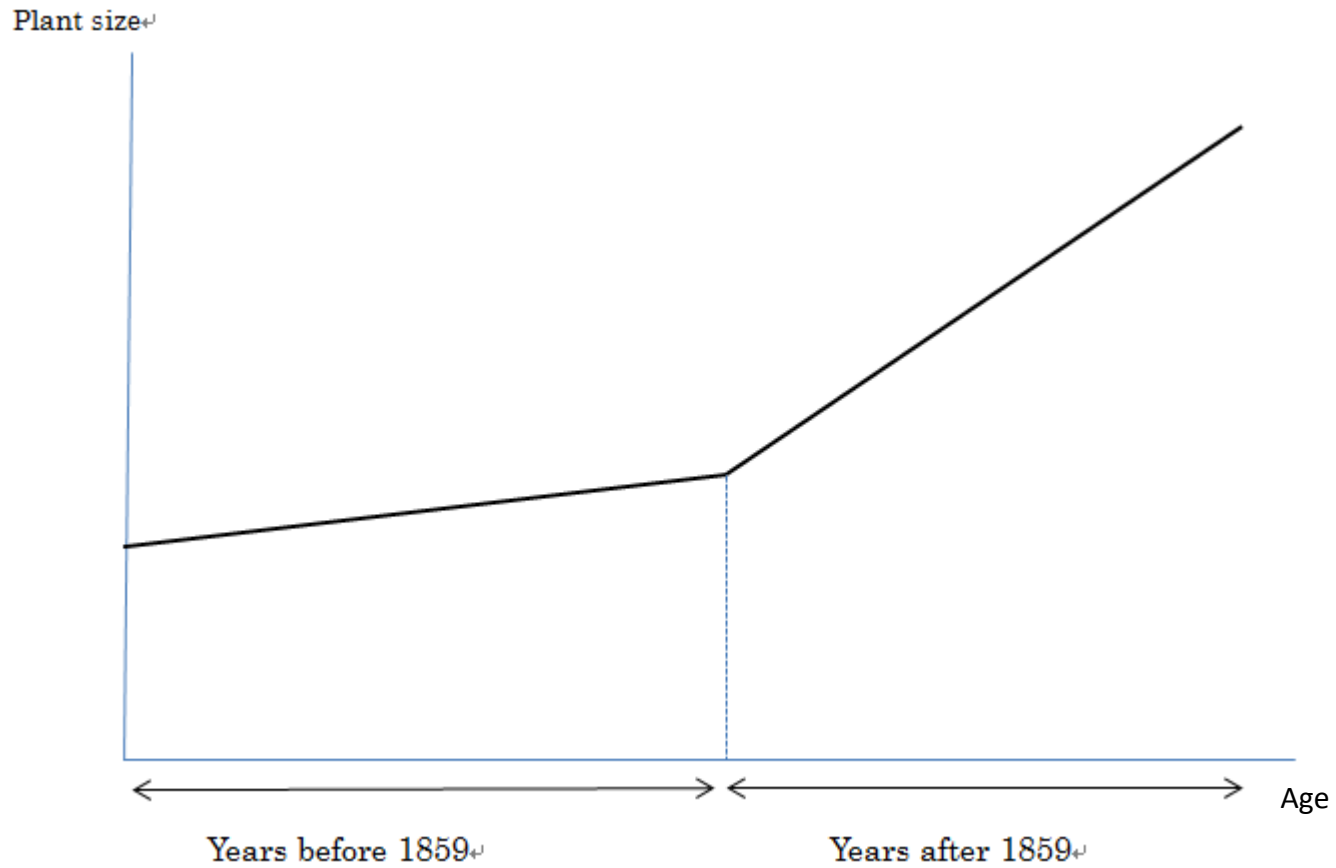
Table 5: Baseline results: Whole sample

	(1)	(2)	(3)
Larger as they age?			
Years after entry	0.001***	0.003***	
	(0.000)	(0.000)	
Years before opening			0.002***
			(0.000)
Years after opening			0.004***
			(0.000)
Are new entrants larger?			
Entry after opening (dummy)		0.392***	0.356***
		(0.036)	(0.034)
Other controls			
Use steam power (dummy)	0.836***	0.830***	0.831***
	(0.024)	(0.024)	(0.024)
Use nonsteam power (dummy)	0.413***	0.411***	0.412***
	(0.011)	(0.011)	(0.011)
Exporting industry (dummy)	0.231***	0.226***	0.227***
	(0.011)	(0.011)	(0.011)
Metro prefectures (dummy)	-0.003	0.000	0.001
	(0.012)	(0.012)	(0.012)
Urban county (dummy)	-0.047***	-0.054***	-0.054***
	(0.013)	(0.013)	(0.013)
ln of county population	0.037***	0.036***	0.036***
	(0.006)	(0.006)	(0.006)
1902 data (dummy)	0.045***	0.057***	0.058***
	(0.012)	(0.012)	(0.012)
Constant	2.464***	2.064***	2.093***
	(0.071)	(0.081)	(0.080)
Observations	31,638	31,638	31,638
R-squared	0.100	0.102	0.102

Results of the baseline regressions

- The case not distinguishing between the periods before and after 1859
  - The coefficient on age is 0.003 (statistically significant at 1% level)
  - Average annual growth rate of plant was 0.3%

- The case distinguishing the periods between before and after 1859
  - The coefficient on age is 0.002 before 1859 (statistically significant at 1% level)
  - The coefficient on age is 0.004 after 1859 (statistically significant at 1% level)
  - Annual rate of plant growth was accelerated from 0.2% to 0.4% after 1859

Mechanisms of plant lifecycle change

- Dividing plants according to their potentials to enjoy the impact of the trade regime change
    - Exporting industries vs non-exporting industries
        - Exporting industries: silk reeling, cotton spinning, weaving, knitting, stich work, floss silk, and twining
    - Plants in metropolitan areas vs those in non-metropolitan areas
        - Metropolitan areas: Tokyo, Kanagawa, Aichi, Osaka and Hyogo
    - Plants that used modern technologies intensively vs those that did not use modern technology intensively
        - Modern technology intensive industries: Those industries where the ratio of plants using steam power or electric power was higher than average

Table 6: Mechanisms: Exporting vs. Non-exporting industries

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Exporting			Non-exporting		
Larger as they age?						
Years after entry	0.012***	0.013***		-0.001***	0.000	
	(0.001)	(0.001)		(0.000)	(0.000)	
Years before opening			0.007			0.002***
			(0.005)			(0.000)
Years after opening			0.011***			-0.001*
			(0.001)			(0.001)
Are new entrants larger?						
Entry after opening (dummy)		0.910***	0.944***		0.162***	0.181***
		(0.110)	(0.134)		(0.037)	(0.036)
Other controls						
Use steam power (dummy)	1.003***	0.998***	0.997***	0.637***	0.633***	0.630***
	(0.029)	(0.029)	(0.029)	(0.041)	(0.041)	(0.041)
Use nonsteam power (dummy)	0.446***	0.441***	0.442***	0.369***	0.370***	0.367***
	(0.016)	(0.016)	(0.016)	(0.014)	(0.014)	(0.014)
Metro (dummy)	-0.098***	-0.096***	-0.095***	0.108***	0.109***	0.108***
	(0.018)	(0.018)	(0.018)	(0.016)	(0.016)	(0.017)
Urban (dummy)	-0.042*	-0.043*	-0.042*	-0.027*	-0.031*	-0.030*
	(0.022)	(0.022)	(0.022)	(0.016)	(0.016)	(0.016)
ln of county population	0.077***	0.079***	0.078***	0.003	0.003	0.003
	(0.013)	(0.013)	(0.013)	(0.007)	(0.007)	(0.007)
1902 data (dummy)	-0.057***	-0.051***	-0.050***	0.163***	0.171***	0.167***
	(0.017)	(0.017)	(0.017)	(0.018)	(0.018)	(0.018)
Constant	2.153***	1.218***	1.196***	2.848***	2.678***	2.677***
	(0.153)	(0.195)	(0.209)	(0.084)	(0.094)	(0.093)
Observations	15,027	15,027	15,027	16,611	16,611	16,611
R-squared	0.120	0.122	0.122	0.069	0.070	0.071

Table 7: Mechanisms: Metro vs. Non-metro   prefectures

	(1)	(2)	(3)	(4)	(5)	(6)
Sample		Metro			Non-metro	
Larger as they age?						
Years after entry	0.003***	0.006***		0.001*	0.002***	
	(0.001)	(0.001)		(0.000)	(0.000)	
Years before opening			0.002**			0.002***
			(0.001)			(0.001)
Years after opening			0.006***			0.002***
			(0.001)			(0.001)
Are new entrants larger?						
Entry after opening (dummy)		0.555***	0.491***		0.300***	0.288***
		(0.063)	(0.062)		(0.044)	(0.043)
Other controls						
Use steam power (dummy)	0.931***	0.924***	0.923***	0.793***	0.789***	0.789***
	(0.047)	(0.047)	(0.047)	(0.027)	(0.027)	(0.027)
Use nonsteam power (dummy)	0.383***	0.385***	0.385***	0.429***	0.428***	0.428***
	(0.019)	(0.019)	(0.019)	(0.013)	(0.013)	(0.013)
Exporting industry (dummy)	0.120***	0.116***	0.117***	0.279***	0.274***	0.275***
	(0.022)	(0.022)	(0.022)	(0.013)	(0.013)	(0.013)
Urban (dummy)	0.024	0.012	0.011	-0.074***	-0.077***	
	(0.027)	(0.027)	(0.027)	(0.016)	(0.016)	(0.016)
ln of county population	0.001	-0.001	-0.000	0.035***	0.036***	0.037***
	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)
1902 data (dummy)	-0.008	0.009	0.011	0.058***	0.067***	0.067***
	(0.022)	(0.022)	(0.022)	(0.015)	(0.015)	(0.015)
Constant	2.922***	2.359***	2.418***	2.460***	2.133***	2.145***
	(0.132)	(0.150)	(0.147)	(0.112)	(0.123)	(0.123)
Observations	12,135	12,135	12,135	19,503	19,503	19,503
R-squared	0.074	0.078	0.078	0.123	0.125	0.125

Table 9: Mechanisms: Intensive-use vs. Non-intensive use of power

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Intensive-use			Non-intensive		
Larger as they age?						
Years after entry	0.006***	0.011***		-0.002***	-0.002***	
	(0.001)	(0.001)		(0.000)	(0.000)	
Years before opening			0.002**			0.003***
			(0.001)			(0.001)
Years after opening			0.013***			-0.002***
			(0.001)			(0.000)
Are new entrants larger?						
Entry after opening		1.181***	0.805***		0.021	0.107***
		(0.098)	(0.087)		(0.036)	(0.038)
Other controls						
Use steam power (dummy)	0.826***	0.818***	0.822***	0.607***	0.606***	0.605***
	(0.031)	(0.031)	(0.031)	(0.051)	(0.051)	(0.051)
Use steam power (dummy)	0.392***	0.389***	0.389***	0.378***	0.378***	0.378***
	(0.019)	(0.019)	(0.019)	(0.012)	(0.012)	(0.012)
Exporting industry (dummy)	0.477***	0.457***	0.457***	0.016	0.016	0.012
	(0.021)	(0.021)	(0.021)	(0.013)	(0.013)	(0.013)
Metro (dummy)	-0.076***	-0.067***	-0.065***	0.076***	0.076***	0.075***
	(0.023)	(0.023)	(0.023)	(0.013)	(0.013)	(0.013)
Urban county (dummy)	-0.139***	-0.155***	-0.158***	0.031**	0.030**	0.031**
	(0.022)	(0.022)	(0.022)	(0.015)	(0.015)	(0.015)
ln of county population	0.050***	0.046***	0.046***	0.022***	0.022***	0.021***
	(0.010)	(0.010)	(0.010)	(0.007)	(0.007)	(0.007)
1902 data (dummy)	-0.218***	-0.199***	-0.196***	0.166***	0.167***	0.163***
	(0.022)	(0.022)	(0.022)	(0.014)	(0.014)	(0.014)
Constant	2.406***	1.245***	1.597***	2.615***	2.592***	2.522***
	(0.119)	(0.154)	(0.145)	(0.084)	(0.094)	(0.093)
Observations	14,331	14,331	14,331	17,307	17,307	17,307
R-squared	0.115	0.121	0.123	0.073	0.073	0.074

# Results of regressions for identifying mechanisms

- Exporting industries vs non-exporting industries
  - Exporting: 0.007 (not significant) → 0.011
  - Non-exporting: 0.002 → -0.001 (marginally significant)

- Metropolitan plants vs non-metropolitan plants
  - Metropolitan: 0.002→0.006
  - Non-metropolitan：0.002→0.002

- Modern technology intensive vs Not modern technology intensive
  - Intensive: 0.002→0.013
  - Not intensive: 0.003→-0.002

Historical evidence Ⅰ: The case of Besshi Copper Mine

- Besshi Copper Mine
  - A plant for mining copper ores and refining them to produce crude copper, located in Ehime Prefecture
  - A major business of Sumitomo *Zaibatsu* since the late seventeenth century
  - A long-term data of copper production are available from the late seventeenth century

Figure 3: Production of copper at Sumitomo Besshi Mine (Unit: Tons), 1691–1899
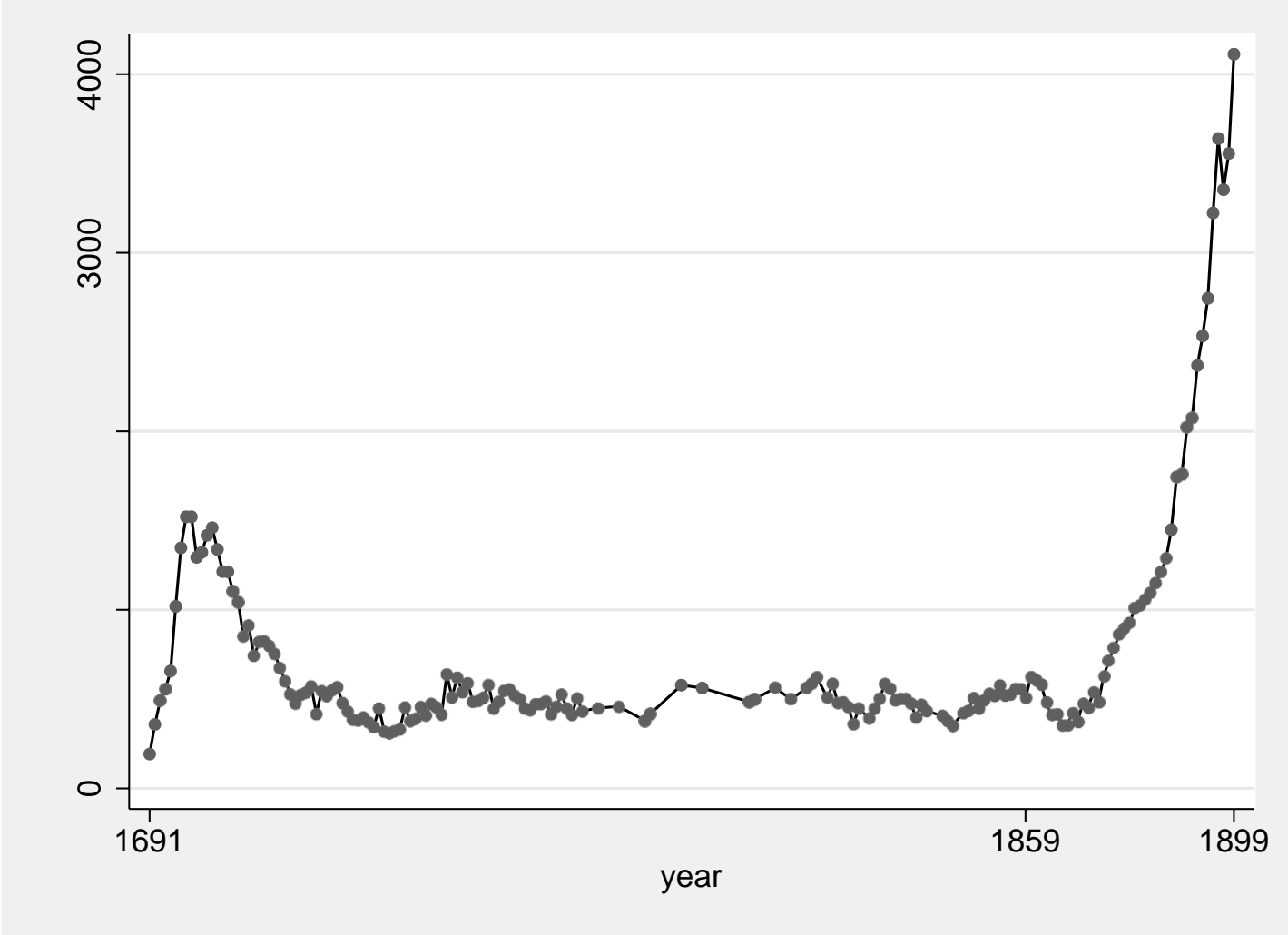
Reasons for stagnation and growth of copper production at Besshi

- Constraints of production before 1859
  - The headways were getting longer
    - High costs for transportation of ores and drainage
    - A typical problem for mines getting older in Tokugawa Period

- Changes after 1859
  - Technological changes
    - Inviting a French engineer
    - Introduction of steam engines and machine drills
  - Market access
    - Meiji government liberalized domestic trade and export of copper in 1871
    - Sumitomo founded the Kobe branch to sell copper to foreign trading houses there

Figure 4: Number of employees at Yamasa Soy Sauce (Unit: Persons), 1774–1893
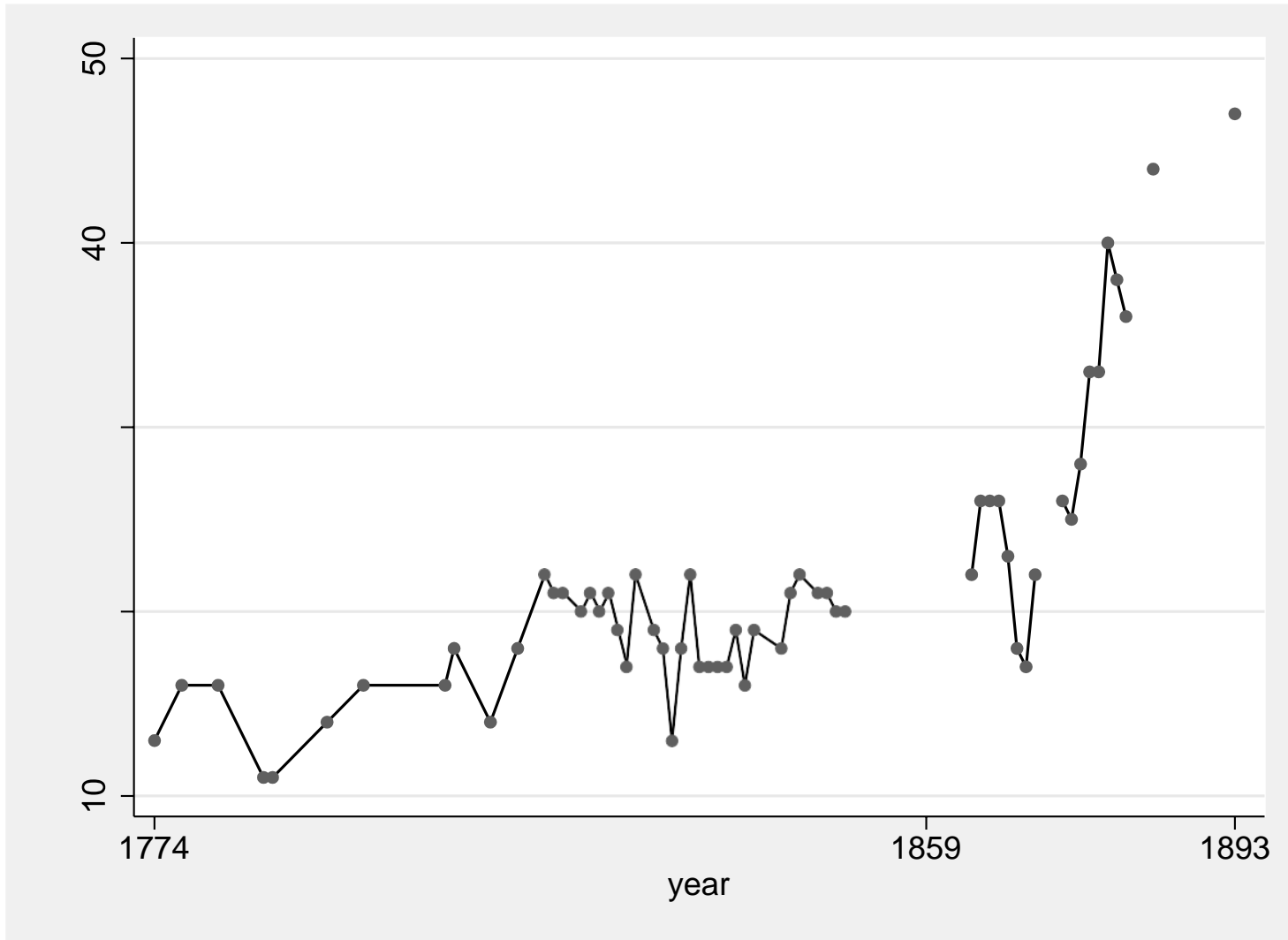
Historical evidence Ⅱ : Yamasa Soy Sauce Co.

- Yamasa Soy Sauce Co.
  - Founded in Choshi in Chiba Prefecture in the early eighteenth century

- Growth and stagnation in Tokugawa period
  - Increase in sales in Edo market
  - Stagnation of sales in Edo market from the early nineteenth century
    - Regulation by the soy sauce merchant guild in Edo
    - Compensating the decline in sales in Edo by sales in local markets

- Restart of growth in the 1870s
  - Expansion of sales in the Tokyo market

Historical evidence Ⅱ : Yamasa Soy Sauce Co.

- Company History of Yamasa Soy Sauce Co.
  - There was an old saying that the upper limit of a plant growth was 3,500 koku (=631 kl), but under the new economic regime after the Meiji Restoration a new trend of capitalistic mass production came, and our company got on the trend.
  - Furthermore, our company shifted sales to the Tokyo market with the largest population. While the percentages of the Tokyo market and the local market were 50 and 50, respectively until 1871, they became 90 and 10, respectively in 1887. This was indeed a drastic change.

Conclusion

- Difference in plant lifecycles between developed and developing countries in the present

- Investigating the mechanisms of the different lifecycles, exploiting a natural experiment from Japan's opening the country in 1859

- Indeed, the growth effect of the experience under the open regime after 1859, is larger than that of the experience under the closed regime before 1859

- The difference is larger for the exporting industries, the plants located in metropolitan areas, and the industries that intensively used modern technologies
  - Suggesting the importance of the access to larger markets and advanced technologies

Conclusion (cont.)

- Long-term time series data covering the periods both before and after 1859
  - Besshi Copper Mine and Yamasa Soy Sauce Co.
  - Indeed, the plant growth was slower before 1859, and it was accelerated after that
  - Narrative materials indicate:
    - Constraints of market and technology checked the plant growth before 1859
    - Removal of these constraints after 1859 accelerated the plant growth