Does innovation create jobs: Evidence from the Korean Industry

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Does innovation create jobs?
: Evidence from the Korean manufacturing industry

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1. Motivation

1. Motivation

- Innovation does not only have negative but also have positive effect on employment.
- Therefore, the final employment effect of innovation should be thoroughly determined by considering these two distinctive effects and is impossible to be determined in a theoretical way, but should be determined by an empirical way.
- As a result, this topic has been developed by empirical analyses. Especially, firm-level analysis is used as basic methodology for many researchers and one of the most interesting research subject is to see the effect of different type of innovations on employment.

- However, the previous literatures have following limitations

(1) They give different empirical findings according to the data, different econometric model and estimation strategies etc.

=> They do not give us clear answer for the relationship between innovation and employment.

(2) Furthermore, firm-level analysis cannot take into account the Business stealing effect (BSE) of other firms.

=> They can over-estimate the employment effect of innovations.

- Thus, this study uses the similar methodology as per Harrison et al. (2008, 2015) and Greenan and Guellec (2000) in order to estimate the different type of innovations on employment using both firm and sector-level analysis.

- However, there are mainly 3 differences to the previous research.

(1) We use Korean manufacturing firm data (KIS) from 1999 to 2009

(2) We carry out the sector-level analysis using Korean manufacturing firm data

(3) We additionally consider the 'Market structure' and show how employment effect of innovations can be differently determined by different market structure.

2. Previous Literatures

2.1. Employment effect of different type of innovations
2.2. The necessity for the industry-level analysis
2.3. Market structure and employment effect of innovations

2.1 Employment effect of different type of innovations

- Theoretically, new technologies have two distinctive effects on employment.

(1) Displacement effect (-):
New technology displaces the workers
(2) Complementary effect (+):
New technology creates new demand and
it needs more workers to produce and
has jobs creating effect

- (1) > (2):
  innovation has negative effect on employment
- (2) > (1):
  innovation has positive effect on employment

⇒ Product innovation: (2) > (1)
: positive effect on employment
⇒ Process innovation: (1) > (2)
: negative effect on employment

- According to Harrison et al. (2008, 2015), it is desirable work to distinguish the innovation type into two, process and product, and see the employment effect of each type of innovation separately. They said this work helps to understand the employment effect of innovation better.
- Many researches actually divide the innovation type and see the effect of different type of innovations separately. (Van Reene, 1997; Greenan and Gullec, 2000; Hall et al., 2008; Lachenmeier and Rottman, 2011; Harrison et al.; 2008, 2015)
- They hypothesized
  H1: product innovation has positive employment effect.
  H2: process innovation has negative employment effect.

- However, most of firm-level analysis do not support the negative employment effect of process innovations, while positive effect of product innovations are mostly supported. (Hall et al., 2008; Lachenmaier and Rottman, 2011)

- Furthermore, there have been some research for the relationship between other type of innovations, such as OIs and GIs, and employment in these days. However, these are not proven to be significant or have similar employment effect with the product innovations. (Licht et al. 2013; Kwon et al., 2015)

Microeconomic Evidences; Abroad

Authors	Data	Results
Entorf and Pohlmeier (1990)	- 2276 West German manufactruring firms - Cross-section data: 1984	- Product innovation: (+) significant effect
Brower, Kleinknecht and Reijnen (1993)	- 859 Dutch manufacturing firms - Cross-section data	- R&D expenditure: (-) significant effect
Doms, Dunne and Robert (1994)	- US manufacturing firms - Period: 1987-1997	- Advanced manufacturing technologies: (+)
Klette and Forre (1998)	- 4333 Norwegian manufacturing firms - Period: 1982-1992	- R&D intensity: no siginifant (+) effect
Van Reenen (1997)	- 598 British manufacturing firms - Period: 1976-1982	- Innovation : (+) significant effect
Blanchflower and Burgess (1998)	- British fims: 1990 - Australian firms: 1989	- Innovation: (+) significant effect
Smonly (1998)	- West German 2405 manufactruring firms - Period: 1980-1992	- Product innovation: (+) significant effect
Greenan and Guellec (2000)	- 15186 French manufacturing firms - Period: 1986-1990	- overall effect : (-) significant effect - only product innovation: (+) significant effect
Piva and Vivarelli (2004 and 2005)	- 575 Italian manufacturing firms - Period: 1992-1997	- Innovation: (+) significant effect
Harrison, Jaumandreu, Mairesse and Peters (2008)	- CIS data from 4 European countries - Germany, France, UK, Spain	- Product innovation: (+) significant effect - Process innovation: (-) significant effect
Hall, Lotti and Mairesse (2008)	- Italian firms - Period: 1995-2003	- Product innovation: (+) significant effect - Process innovation: no signifant effect
Lachenmaier and Rottmann (2011)	- German manufacturing firms - Period: 1982-2002	- Product innovation: (+) significant effect - Process innovation: (+) significant effect
Coad and Rao (2011)	- US high-tech manufacturing firms - Period: 1963-2002	- Innovativeness index (R&D, patents): (+) significant effect
Bongliacino, Piva and Vivarelli (2011, 2012)	- 677 European manufacturing & service firms - Period: 1990-2008	- R&D expenditure: (+) in service & high-tech manufacturing indus tries - R&D expenditure: no significant in traditional industries

Microeconomic Evidences ; Domestic

Authors	Data	Model & Methods	Results
Moon and Juhn (2008)	- 1874 Korean manufacturing firms - Period: 1999-2001	- Harrison et al. (2008) - OLS/2SLS	- process innovation: no significant effect - product innovation: (+) siginificant effect
Park and Kim (2011)	- 445 Korean service firms - Period: 2002-2005	- Harrison et al. (2008) - OLS/2SLS	- process innovation: (-) significant effect in SS sectors - product innovation: (+) significant effect in SB sectors
Shin, Song and Choi (2012)	- 841 Korean manufacturing firms - Period: 2000-2007	- Van Reenen (1997) - OLS/FE/GMM	- process innovation: (+) significant effect - product innovation: no significant effect

- Thus, this study uses the most renowned-methodology as per Harrison et al. (2008, 2015) and see the employment effect of different type of innovations separately.
- H1-1: Firms' product innovation has positive effect on employment.
  H2-1: Firms' process innovation has negative effect on employment.

2.2 The necessity for the industry-level analysis

- However, the effect of innovation influence not only the firms who innovate but also the firms who compete with the innovating firms.
- Therefore, positive employment effect of innovation at firm-level does not necessarily mean that in general. This is because innovation increase the sales of innovating firms but also can decrease the sales of other firms within the same market.
- We call it as 'Business Stealing Effect (BSE)' and aggregate-level of employment can be decreased if BSE is considered and it considerably lower the employment level of other firms.

- Therefore, the industry-level analysis should have been accompanied by the firm-level analysis for the completeness of the study.
- Nonetheless, only few researches deal with both firm and sector-level analysis in line with this theoretical considerations. (Greenan and Guellec, 2000; Merikull, 2010)
- But, many firm-level researches (Harrison et al., 2014; Vivarelli, 2012) agree with that their empirical evidences are not sufficient for explaining the general employment effect of innovations and they needs more aggregate-level of research.

- Therefore, industry-level analysis are required in order to generalize the firm-level employment effect of innovations.
- Thus, this study uses Greenan and Gullec's (2000) method for sector-level analysis, which is useful methodology for both firm and sector-level analysis, and check this firm-level employment effect of innovations is consistently supported by industry-level analysis.
- H2-1: Sectors with more product innovation have positive employment effect than sectors with less product innovations.
  H2-2: Sectors with more process innovation have negative employment effect than sectors with less process innovations.

2.3 Market structure and Employment effect of innovations

- According to Marx's compensation theory, the compensation mechanisms are divided into 6 different categories.
  1) "via decrease in **prices**"
  2) "via **new investments**"
  3) "via **new products**"
  4) "via **decrease in wages**"
  5) "via **increase in incomes**"
  6) "via additional employment in the **capital goods sector**"

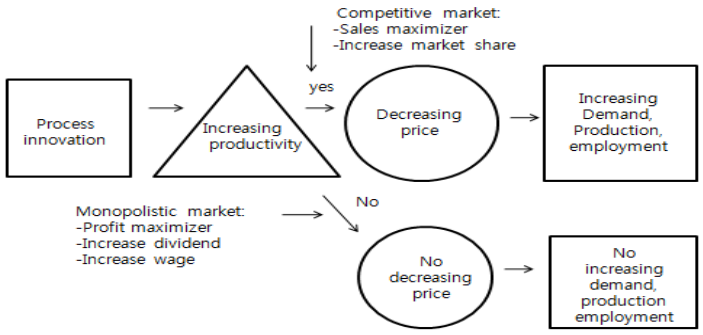
* Compensation effect is the positive employment effect of innovations. Compensation mechanism happens when innovation creates the new demand of the products that can lead more production and more workers to produce or during the firms' innovational activities.

- The size of compensation effects can be differently determined by
  (1) demand elasticity
  (2) degree of market competition
  (3) capital-labor substitution
  (4) demand expectations etc. (Vivarelli, 2012)

- Thus, process innovation can have positive employment effect if the compensation effect is large enough that it exceeds the displacement effect.

- However, there is no empirical evidences that how these factors affect the demand side of firms and make different employment effect of the innovations.
- They just explained that these factors are different across the countries in which firms belong, so the size of compensation effect can be different and they can have different employment effect with the previous literatures. (Harrison et al.;2014, Juhn and Moon; 2008)
- Thus, here, we propose ‘market structure’, which can affect the product market competition, can affect the compensation effect of innovations and make different employment-level of firms.

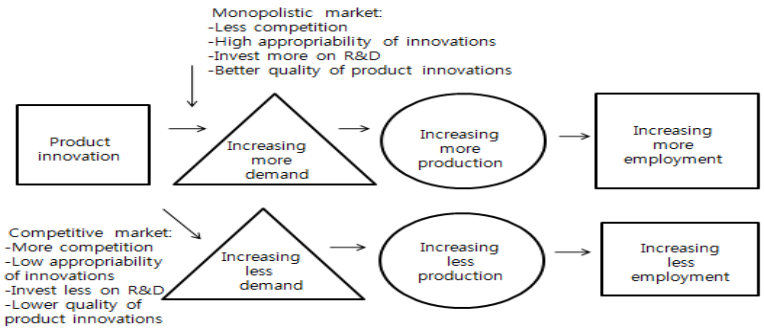
Market structure and compensation mechanisms of process innovation



H3-1: Process innovation in monopolistic market has greater negative effect than that in non-monopolistic market.

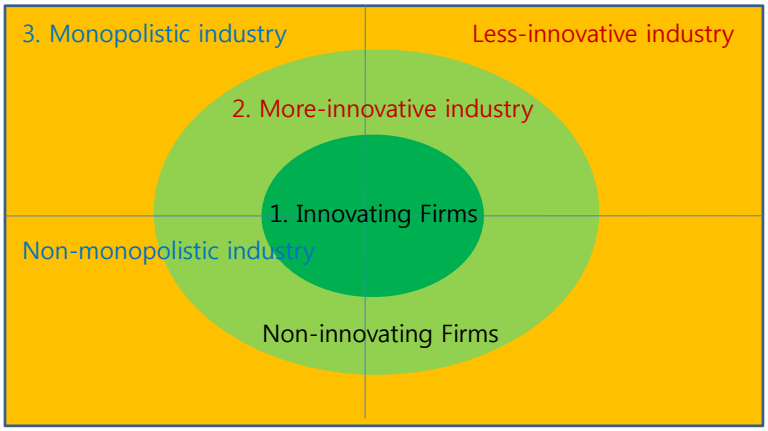
- On the one hand, Schumpeter (1950) argued that firm size and market concentration are critical elements for firm's innovative activities. This is because a) firms in monopolistic market can expect higher returns from the innovations and b) have extra money for investing R&D.
- In this case, we can expect that product innovation in monopolistic market has greater positive effect than that in non-monopolistic market, since firms in monopolistic market spend more money on R&D, make better quality of the products, sell more products and hire more workers to produce.

Market structure and compensation mechanisms of product innovations



H3-2: Product innovation in monopolistic market has greater positive effect than that in non-monopolistic market.

Proposed Hypotheses



3. Empirical Analysis

3.1 Data
3.2. Econometric model and estimation strategies
3.2.1 Firm-level analysis
3.2.2 Sector-level analysis
3.3. Regression results
3.3.1
3.3.2
3.3.3

3.1 Data

- KIS (Korea Innovation Survey) by STEPI
  : Firm-level data
  : Cross-section data
  : Financial information and technological activities of firms
  : KIS 2002, 2005, 2008, 2010, 2012 for manufacturing firms
  KIS 2003, 2006, 2009, 2012 for service firms
  : Based on *Oslo manual* (comparable with other countries)

- Here, we use 11,369 firms in KIS 2002, 2005, 2008, 2010 and some missing variables and outliers are excluded.

Sample firms by industry and period

Industry code	Industry name	KIS2002	KIS2005	KIS2008	KIS2010	Total
15	Food and Beverages	115	151	157	268	691
17	Textiles	137	138	145	158	578
18	Apparel, Clotheing Accessories and Fur Articles	33	57	126	133	349
19	Leathers, Luggage and Footwear	35	31	94	82	242
20	Wood Products of Wood and Cork	29	43	121	124	317
21	Paper and Paper Products	26	65	129	158	378
22	Printing and Reproduction of Recorded Media	41	63	129	124	357
23	Coke, Hard-coal and Lignite Fuel Briquettes and Refined Petroleum Products	13	31	41	41	126
24	Chemicals and Chemical Products	293	234	238	427	1192
25	Rubber and Plastic Products	148	146	140	212	646
26	Other Non-metallic Mineral Products	134	92	165	205	596
27	Basic Metal Products	187	110	160	200	657
28	Fabricated Metal Products	135	164	161	217	677
29	Machinery and Equipment	296	273	195	250	1014
30	Office Machinery and Equipment	11	34	69	14	128
31	Other Electric Equipment and generators	131	179	136	212	658
32	Electronic Components and Communication Equipment and Apparatuses	326	196	152	185	859
33	Medical, Precision and Optical Instruments, Watches and Clocks	55	58	114	146	373
34	Motor Vehicles, Trailers and Semitrailers	259	170	178	213	820
35	Other Transport Equipment	63	56	79	113	311
36	Furniture and others	67	63	136	134	400
Total		2,534	2,354	2,865	3,616	11,369

3.2 Econometric model and methodologies

3.2.1 Firm-level analysis (Harrison et al., 2008, 2014)

$$l - (g_1 - \pi) = \alpha_0 + \alpha_1 d + \beta g_2 + v$$

$$where,\ v = -(\pi_1 - \pi) - \beta\pi_2 y_2 + u$$

Dependent variable: Employment growth – Real sales growth of old products
Independent variables: (1) Process innovation only dummy (d)
(2) Sales growth due to new products (g2)
(3) Industry dummies are included

Instrument variables (IVs) for g2: correlates with g2 but uncorrelated with π_2
(1) The purpose of innovation is replacement of old products:0-5
(2) The purpose of innovation in increase range of the products:0-5

Variables

	Korean manufacturing firms				
	KIS 2002	KIS 2005	KIS 2008	KIS 2010	Total
No of firms	**2534**	**2354**	**2865**	**3616**	**11369**
Non-innovators (%)	53.9	50.3	60.9	46.6	52.63
Process only (%)	4.8	6.3	5.9	7.9	6.38
Product innovators (%)	41.4	43.3	33.1	45.5	41.0
[Of which product & process innovators]	[23.5]	[25.5]	[21.5]	[29.9]	[25.5]
Employment growth (%)					
All firms	6.7	9.0	6.7	6.1	7.0
Non-innovators	2.6	7.2	6.1	4.4	5.0
Process only	6.1	17.4	9.0	8.5	10.0
Product innovators	12.2	10.0	7.5	7.4	9.1
Sales growth (%)					
All firms	23.1	29.5	22.4	22.4	24.0
Non-innovators	18.3	26.1	21.4	17.5	20.5
Process only	27.9	37.1	29.7	24.5	28.9
Product innovators	28.7	32.4	23.0	27.0	27.8
of which:					
Old products	-38.0	-35.5	-19.0	-14.4	-25.3
New products	66.7	67.9	42.0	41.5	53.0

- On the other hand, we adopt a new variable for the analysis of market structure, industry-level CR3, in order to show the different employment effect in different market structure.

$$CR3 = \frac{Sales\ of\ Top\ 3\ \ firms\ in\ an\ industry}{Total\ sales\ of\ \ firms\ in\ an\ industry}$$

- We define the industries as monopolistic industries if CR3 is over 0.75 and non-monopolistic industries if vice versa.

- As a result, (a) paper and paper products, (b) coke, hard-coal, lignite fuel equipment and refined petroleum products, (c) office machinery and equipment and (d) other transportation equipment industries are defined as monopolistic industries.

Concentration Ratio (CR) by industry

KSIC code	Industry name	CR1	CR3	CR5
15	Food and Beverages	17.94%	35.28%	46.30%
17	Textiles	9.15%	23.48%	35.04%
18	Apparel, Clotheing Accessories and Fur Articles	20.68%	40.49%	54.31%
19	Leathers, Luggage and Footwear	23.05%	46.46%	58.86%
20	Wood Products of Wood and Cork	23.27%	62.64%	83.02%
21	Paper and Paper Products	41.25%	76.86%	89.08%
22	Printing and Reproduction of Recorded Media	21.36%	34.78%	46.22%
23	Coke, Hard-coal and Lignite Fuel Briquettes and Refined Petroleum Products	71.82%	97.77%	99.00%
24	Chemicals and Chemical Products	24.15%	33.88%	41.05%
25	Rubber and Plastic Products	39.80%	52.60%	60.57%
26	Other Non-metallic Mineral Products	26.63%	48.29%	63.25%
27	Basic Metal Products	14.68%	30.84%	43.89%
28	Fabricated Metal Products	54.12%	59.20%	63.53%
29	Machinery and Equipment	20.51%	34.74%	45.33%
30	Office Machinery and Equipment	33.44%	75.72%	91.49%
31	Other Electric Equipment and generators	19.00%	34.77%	44.92%
32	Electronic Components and Communication Equipment and Apparatuses	5.66%	14.38%	21.38%
33	Medical, Precision and Optical Instruments, Watches and Clocks	27.84%	51.54%	57.85%
34	Motor Vehicles, Trailers and Semitrailers	22.59%	36.50%	44.33%
35	Other Transport Equipment	70.65%	92.88%	94.40%
36	Furniture and others	14.61%	36.85%	52.11%
Total		23.10%	37.60%	46.80%

Variables

	KIS2002 (1999-2001)		
	Competitive	Monopolistic	Total
No of firms	**2421**	**113**	**2534**
Non-innovators (%)	53.7	58.4	53.9
Process only (%)	4.8	5.3	4.8
Product innovators (%)	41.6	36.3	41.4
[Of which product & process innovators]	[23.8]	[16.8]	[23.5]
Employment growth (%)			
All firms	6.6	9.6	6.7
Non-innovators	2.2	10.2	2.6
Process only	5.6	15.5	6.1
Product innovators	12.4	7.8	12.2
Sales growth (%)			
All firms	22.6	33.3	23.1
Non-innovators	17.8	28.4	18.3
Process only	23.3	116.1	27.9
Product innovators	28.7	29.1	28.7
of which:			
Old products	-37.6	-48.8	-38.0
New products	66.3	77.8	66.7

3.2.2 Sector-level analysis (Greenan and Guellec, 2000)

- For the sake of comparability, we use the same database with the firm-level analysis. We distinguish 21 industries and 5 enterprise size groups using G&G methods. Thus, the total number of groups is 100, since some groups remain empty due to a lack of observations.
- The basic econometric model is like this:

$$Y = \alpha + \beta X + u$$

- We use 3 dependent and 4 independent variables, which are calculated as follows (Davis and Haltiwanger, 1992) using notation from G&G (2000).

(1) Dependent variables:

Job flow indicators; $g_{st}^{pos}, g_{st}^{neg}, g_{st}^{net}$

Let E_{et} be the size of the firm or the establishment e at a date t.
We measure x_{et}, which is the average employment between t and t - 1 :

$$x_{et} = \frac{E_{et} + E_{et-1}}{2}.$$

Let g_{et} be the time t growth rate of employment :

$$g_{et} = \frac{E_{et} - E_{et-1}}{x_{et}}.$$

- Then they have four different measures of job flow within a given category s that can be the sector, age, size etc.:

$$g_{st}^{pos} = \sum_{\substack{e \in E_{st} \\ g_{et} > 0}} \frac{x_{et}}{x_{st}} g_{et}$$

$$g_{st}^{neg} = \sum_{\substack{e \in E_{st} \\ g_{et} > 0}} \frac{x_{et}}{x_{st}} |g_{et}|$$

$$g_{st}^{net} = g_{st}^{pos} - g_{st}^{neg}$$

Job flow rates, by industry (KIS2002)

Industry code	Industry name	g_pos	g_neg	g_net	g_exc	Employment share	Mean size
15	Food and Beverages	0.0608	0.0406	0.0203	0.0811	4.29	127
17	Textiles	0.0564	0.1041	-0.0476	0.1129	6.59	148
18	Apparel, Clotheing Accessories and Fur Articles	0.0869	0.1426	-0.0557	0.1738	0.70	68
19	Leathers, Luggage and Footwear	0.1549	0.0384	0.1165	0.0768	1.23	97
20	Wood Products of Wood and Cork	0.0143	0.0643	-0.0500	0.0285	0.92	94
21	Paper and Paper Products	0.0648	0.0248	0.0400	0.0496	1.02	95
22	Printing and Reproduction of Recorded Media	0.1187	0.0605	0.0582	0.1209	1.36	76
23	Coke, Hard-coal and Lignite Fuel Briquettes and Refined Petroleum Products	0.0229	0.0373	-0.0144	0.0457	0.99	297
24	Chemicals and Chemical Products	0.0783	0.0674	0.0108	0.1349	14.15	153
25	Rubber and Plastic Products	0.1088	0.0611	0.0478	0.1222	3.44	73
26	Other Non-metallic Mineral Products	0.0706	0.0709	-0.0003	0.1412	3.78	94
27	Basic Metal Products	0.0912	0.0513	0.0399	0.1027	8.29	147
28	Fabricated Metal Products	0.0649	0.0584	0.0065	0.1167	5.01	117
29	Machinery and Equipment	0.1483	0.0553	0.0929	0.1107	9.02	94
30	Office Machinery and Equipment	0.1699	0.1136	0.0563	0.2272	0.66	233
31	Other Electric Equipment and generators	0.1020	0.0903	0.0117	0.1807	3.93	95
32	Electronic Components and Communication Equipment and Apparatuses	0.2018	0.0751	0.1267	0.1502	8.81	66
33	Medical, Precision and Optical Instruments, Watches and Clocks	0.2192	0.1031	0.1161	0.2062	2.34	102
34	Motor Vehicles, Trailers and Semitrailers	0.1250	0.0246	0.1004	0.0492	9.54	117
35	Other Transport Equipment	0.0475	0.0333	0.0142	0.0667	11.47	568
36	Furniture and others	0.0853	0.1032	-0.0179	0.1707	2.46	102
Total		0.1006	0.0606	0.0400	0.1212	100	118

(3) Independent variables:

Indicators of innovation; innovs, prods, procs, innorels

- On the other hand, we calculate the three indicators of innovation at the sector level as G&G methods.

(1) Innovs: the intensity of innovation
Employment of innovating firms/ sector employment
(2) Prods: the intensity of product innovation
Employment of product innovating firms/ sector employment
(3) Procs: the intensity of process innovation
Employment of process innovating firms/ sector employment
(4) Innorels: product-orient innovating sectors
prods/procs

Indicators of innovation, by industry (KIS 2002)

ind_code	industry name	prods	procs	innovs	innorels
15	Food and Beverages	0.6821	0.4443	0.7063	1.54
17	Textiles	0.3131	0.2547	0.3304	1.23
18	Apparel, Clotheing Accessories and Fur Articles	0.3838	0.2923	0.4058	1.31
19	Leathers, Luggage and Footwear	0.3833	0.2876	0.4475	1.33
20	Wood Products of Wood and Cork	0.5417	0.2117	0.5417	2.56
21	Paper and Paper Products	0.2564	0.0768	0.3032	3.34
22	Printing and Reproduction of Recorded Media	0.0622	0.0635	0.0713	0.98
23	Coke, Hard-coal and Lignite Fuel Briquettes and Refined Petroleum Products	0.9107	0.8885	0.9365	1.02
24	Chemicals and Chemical Products	0.7604	0.6094	0.8040	1.25
25	Rubber and Plastic Products	0.5447	0.4703	0.6137	1.16
26	Other Non-metallic Mineral Products	0.3945	0.5841	0.6260	0.68
27	Basic Metal Products	0.6041	0.5290	0.6238	1.14
28	Fabricated Metal Products	0.7500	0.7003	0.8067	1.07
29	Machinery and Equipment	0.7072	0.4464	0.7911	1.58
30	Office Machinery and Equipment	0.8786	0.8261	0.8786	1.06
31	Other Electric Equipment and generators	0.7850	0.6113	0.8072	1.28
32	Electronic Components and Communication Equipment and Apparatuses	0.5634	0.4049	0.6236	1.39
33	Medical, Precision and Optical Instruments, Watches and Clocks	0.7734	0.5287	0.8312	1.46
34	Motor Vehicles, Trailers and Semitrailers	0.6628	0.4999	0.7142	1.33
35	Other Transport Equipment	0.8756	0.5703	0.8789	1.54
36	Furniture and others	0.5267	0.3591	0.5414	1.47
Total		0.6524	0.5056	0.7056	1.33

3.3. Regression results

- We do both firm and sector-level analysis in order to provide comprehensive evidences for employment effect of innovations in case of Korean manufacturing firms and sectors.
- However, we additionally consider ‘the market structure’ in order to find out the conditions that can be favorable for increasing the employment.
- In order to provide the consistent estimation results, we use 4 different sets of KIS data from 1999-2009, but the same econometric model and methodologies as per Harriosn et al. (2008, 2014) and Greenan and Guellec for international comparison.

3.3.1 Firm-level analysis (by period)
: Korean manufacturing firms from 1999-2009

	Dependent variable: employment growth due to innovation (l-(g1-p))							
	OLS				2SLS			
	KIS2002	KIS2005	KIS2008	KIS2010	KIS2002	KIS2005	KIS2008	KIS2010
process innovation (d)	0.01	-0.04	-0.07+	-0.05	-0.06	0.01	-0.05	-0.03
	(0.13)	(-0.80)	(-1.84)	(-1.61)	(-1.12)	(0.28)	(-1.33)	(-1.03)
Sales growth due to new products (g2)	0.76**	0.74**	0.70**	0.63**	0.99**	1.06**	0.94**	0.79**
	(24.00)	(24.31)	(13.71)	(19.42)	(17.51)	(13.39)	(13.72)	(13.10)
product and process innovation (d*)	0.09**	0.12**	0.12**	0.08**	-0.04	-0.05	0.03	0.03
	(3.23)	(4.74)	(5.20)	(4.36)	(-0.90)	(-1.05)	(1.06)	(1.24)
_cons	-0.09	-0.01	-0.06+	0.03	-0.13**	-0.04	-0.08*	0.01
	(-1.63)	(-0.34)	(-1.75)	(0.79)	(-2.75)	(-0.98)	(-2.07)	(0.42)
N	2534	2354	2865	3616	2534	2354	2865	3616
r2_a	0.41	0.44	0.23	0.24	0.39	0.39	0.22	0.23
rmse	0.49	0.46	0.45	0.44	0.5	0.49	0.46	0.44

** industry dummies are included*

**Notes (1): Process innovation is measured by dummy variable.*
Product innovation is measured by sales growth due to new products.
**Notes (2): OLS means ordinary least square method, while 2SLS means 2 stage least square method.*
**Notes (3): IVs for 2SLS: the purpose of innovation is replacement of old products: 0-5*
the purpose of innovation is increase range of the products: 0-5

3.3.1 Firm-level analysis (overall)
: Korean manufacturing firms from 1999-2009

	Dependent variable: Employment growth due to innovation only (l-(g1-p))			
	OLS		2SLS	
	(1)	(2)	(1)	(2)
Process innvation only dummy *(d)*	-0.02	-0.03+	-0.01	-0.02
	(-1.15)	(-1.69)	(-0.58)	(-1.22)
Sales growth due to new product *(g2)*	0.71**	0.71**	0.93**	0.95**
	(42.41)	(41.57)	(30.33)	(29.37)
Process and product innovation dummy *(d*)*	0.11**	0.10**	0.02	0.00
	(9.60)	(8.65)	(1.15)	(0.02)
year_2005		0.03*		0.03*
		(2.14)		(2.24)
year_2008		-0.04**		-0.01
		(-3.24)		(-0.76)
year_2010		0.08**		0.11**
		(6.65)		(8.57)
_cons	-0.03	-0.05*	-0.05**	-0.10**
	(-1.40)	(-2.39)	(-2.68)	(-4.53)
N	11369	11369	11369	11369
r2_a	0.33	0.34	0.31	0.31
rmse	0.47	0.46	0.47	0.47

**Notes (1): Process innovation is measured by dummy variable.*
Product innovation is measured by sales growth due to new products.
**Notes (2): OLS means ordinary least square method, while 2SLS means 2 stage least square method.*
**Notes (3): IVs for 2SLS: the purpose of innovation is replacement of old products: 0-5*
the purpose of innovation is increase range of the products: 0-5

3.3.1 Firm-level analysis
: Korea vs. European firms in manufacturing industry

	Dependent Variable: Employment growth due to innovation				
	Korea	France	Germany	Spain	UK
process innovation (*d*)	-0.06	-1.26	-6.20*	2.47	-3.50+
	(-1.12)	(-0.81)	(-2.12)	(1.38)	(1.89)
product innovation (*g2*)	0.99**	0.90**	1.04**	1.05**	0.92**
	(17.51)	(10.00)	(14.86)	(15.00)	(13.14)
process and product innovation (*d**)	-0.04	2.59+	-1.98	-1.49	4.94+
	(-0.90)	(1.81)	(-0.71)	(-0.56)	(1.93)
_cons	-0.13**	-3.51**	-6.96**	-6.14**	-6.33**
	(-2.75)	(4.50)	(5.08)	(6.75)	(7.19)
N	2534	4631	1319	4548	2533

** Note: industry dummies are included*

*** Korea is based on KIS2002, which is conducted in 1999-2001.*

**** Other European countries (France, Germany, Spain, UK) are based on CIS3, which is conducted in 1998-2000.*

Summary

- Overall, process innovation of Korean manufacturing firms does not give significant effect on employment, while product innovation give positive effect on their employment.
- However, positive employment effect of product innovation is not that big comparing with the European countries. (Germany>Spain>Korea>UK>France)
- But, negative effect of process innovation is also not that serious comparing with the European countries. (Germany, UK: negative and siginficant)

3.3.2 Sector-level analysis
: Korean manufacturing industry from 1999-2001

	job creating rate	job destrution rate	net employmet growth rate
innovation intensity	0.08+	-0.04	0.12*
(innovs)	(1.81)	(-1.21)	(1.99)
1.size	-0.05+	-0.01	-0.04
	(-1.73)	(-0.61)	(-0.97)
2.size	-0.05+	-0.04*	-0.01
	(-1.76)	(-2.13)	(-0.38)
3.size	-0.10**	0.01	-0.10*
	(-2.86)	(0.31)	(-2.29)
4.size	-0.15**	-0.01	-0.13**
	(-5.45)	(-0.49)	(-3.06)
_cons	0.13**	0.12**	0.01
	(3.74)	(5.08)	(0.36)
N	100	100	100
r2_a	0.2	0.02	0.13
rmse	0.09	0.07	0.12

** innovs means intensity of innovation.*

3.3.2 Sector-level analysis
: using Korean manufacturing firms from 1999-2001

	job creating rate	job destrution rate	net employmet growth rate
Product innovation intensity	-0.04	0.06	-0.1
(procs)	(-0.54)	(0.96)	(-0.86)
Process innovation intensity	0.1	-0.08+	0.18*
(prods)	(1.48)	(-1.67)	(2.04)
1.size	-0.05+	-0.01	-0.04
	(-1.70)	(-0.63)	(-0.95)
2.size	-0.05+	-0.04*	-0.01
	(-1.74)	(-2.15)	(-0.36)
3.size	-0.10**	0.01	-0.10*
	(-2.81)	(0.29)	(-2.24)
4.size	-0.15**	-0.01	-0.13**
	(-5.35)	(-0.51)	(-3.04)
_cons	0.14**	0.11**	0.03
	(4.23)	(5.28)	(0.77)
N	100	100	100
r2_a	0.18	0.01	0.11
rmse	0.09	0.07	0.13

** procs means intensity of process innovations*
** prods means intensity of product innovations*

Robustness check

	job creating rate		job destruction rate		net employment growth rate	
	model1	model2	model1	model2	model1	model2
innovation intensity		0.08		0.16*		-0.08
(innovs)		(0.58)		(2.15)		(-0.53)
product-orient innovation	-0.01		-0.02*		0.01	
(innorels)	(-0.60)		(-2.31)		(0.55)	
product-orient innovation		0.00		-0.22*		0.22
(innorels1)		(-0.00)		(-2.59)		(1.36)
1.size	-0.05+	-0.05+	-0.01	-0.01	-0.04	-0.04
	(-1.67)	(-1.72)	(-0.67)	(-0.63)	(-0.92)	(-0.97)
2.size	-0.05+	-0.05+	-0.04*	-0.04*	-0.01	-0.01
	(-1.69)	(-1.75)	(-2.35)	(-2.11)	(-0.34)	(-0.37)
3.size	-0.10**	-0.10**	0.01	0.01	-0.10*	-0.10*
	(-2.75)	(-2.84)	(0.28)	(0.30)	(-2.22)	(-2.27)
4.size	-0.14**	-0.15**	-0.01	-0.01	-0.13**	-0.13**
	(-5.21)	(-5.42)	(-0.59)	(-0.44)	(-2.99)	(-3.12)
_cons	0.19**	0.13	0.11**	-0.01	0.08+	0.14
	(5.73)	(1.50)	(5.33)	(-0.32)	(1.75)	(1.46)
N	100	100	100	100	100	100
r2_a	0.17	0.19	0.02	0.04	0.09	0.13
rmse	0.09	0.09	0.07	0.07	0.13	0.12

* 'innorel' is the sector ratio of prods on procs (=prods/procs)

* 'innorel1',a residual of a regression of innorel on innovs, is used for product-orient innovation

Summary

- Overall, innovation of Korean manufacturing industry give positive effect on sector-level employment. This is because more innovative sectors have bigger job creating rate and higher net employment growth rate.
- Especially, sectors with high intensity of product innovation give positive effect on sector-level employment growth. However, interesting fact is that this positive effect is not coming from higher job creation rate, but lower job destruction rate.
- On the other hand, process innovation of Korean manufacturing industry does not give any significant effect on sector-level employment growth, too.

3.3.3 Market structure and employment effect of innovations : Korean manufacturing firms from 1999-2001

	Dependent Variable: Employment growth due to innovation			
	OLS		2SLS	
	Cometitive	Monopolistic	Cometitive	Monopolistic
process innovation (*d*)	0.04	-0.82+	-0.02	-0.96**
	(1.00)	(-1.86)	(-0.30)	(-3.32)
product innovation (*g2*)	0.75**	1.01**	0.98**	1.20**
	(23.04)	(8.23)	(17.04)	(4.98)
process and product innovation *(d*)*	0.09**	-0.02	-0.03	-0.15
	(3.30)	(-0.15)	(-0.80)	(-0.69)
_cons	-0.09	-0.01	-0.13**	-0.03
	(-1.62)	(-0.17)	(-2.76)	(-0.31)
N	2421	113	2421	113
r2_a	0.41	0.55	0.38	0.53
rmse	0.49	0.5	0.5	0.51

**Notes (1): Process innovation is measured by dummy variable.*
Product innovation is measured by sales growth due to new products.
**Notes (2): OLS means ordinary least square method, while 2SLS means 2 stage least square method.*
**Notes (3): IVs for 2SLS: the purpose of innovation is replacement of old products: 0-5*
the purpose of innovation is increase range of the products: 0-5

3.3.3 Market structure and employment effect of innovations : Korean manufacturing firms from 1999-2001

	Dependent Variable: Employment growth due to innovation			
	OLS		2SLS	
	(1)	(2)	(1)	(2)
process innovation (*d*)	0.25	0.04	0.18	-0.02
	(1.27)	(0.97)	(0.89)	(-0.36)
product innovation (*g2*)	0.70**	0.76**	1.11**	0.98**
	(10.71)	(23.14)	(8.65)	(17.57)
process and product innovation *(d*)*	0.09**	0.09**	-0.04	-0.03
	(3.21)	(3.23)	(-1.18)	(-0.88)
Monopolistic Industry (m)	-3.06	-0.11	-2.08	-0.1
	(-0.69)	(-1.08)	(-0.47)	(-0.93)
MI*process innovation (m*d)	-0.6	-0.82*	-0.57	-0.91*
	(-1.21)	(-1.96)	(-1.11)	(-2.19)
MI*product innvoation (m*g2)	0.18	0.22*	-0.27	0.19
	(1.23)	(2.28)	(-0.99)	(1.16)
_cons	0.99	-0.09	0.6	-0.13*
	(0.61)	(-1.61)	(0.37)	(-2.21)
N	2534	2534	2534	2534
r2_a	0.41	0.42	0.42	0.42
rmse	0.49	0.49	0.49	0.49

* Model (1): Monopoly Industry (m) is measured by CR3, the sales share of Top 3 firms in an industry.

* Model (2): Monopoly industry (m) is measured by dummy varaible = 1, if CR3>0.75 and 0 , otherwise.

Robustness check: Monopolistic firm? or Monopolistic industry?

	Dependent variable: Employment growth due to innovation							
	OLS				2SLS			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
process innovation (*d*)	0.02	0.03	0.03	0.03	-0.04	-0.04	-0.04	-0.03
	(0.37)	(0.55)	(0.55)	(0.56)	(-0.79)	(-0.76)	(-0.76)	(-0.70)
product innovation (*g2*)	0.75**	0.75**	0.75**	0.75**	0.98**	0.97**	0.98**	0.97**
	(23.04)	(23.70)	(23.68)	(23.49)	(17.76)	(18.18)	(18.21)	(18.04)
process and product innovation *(d*)*	0.09**	0.09**	0.09**	0.09**	-0.04	-0.03	-0.03	-0.03
	(3.38)	(3.41)	(3.40)	(3.38)	(-0.95)	(-0.91)	(-0.93)	(-0.90)
Monopolistic Firms (m2)	0.02	-0.06	0.18	-0.02	0.08	-0.03	0.21	-0.05
	(0.03)	(-0.44)	(0.61)	(-0.14)	(0.10)	(-0.28)	(0.71)	(-0.24)
MF*process innovation (m2*d)	0.53			-0.07	0.54			-0.07
	(0.40)			(-0.71)	(0.42)			(-0.67)
MF*product innvoation (m2*g2)	0.31	0.19	-0.1	0.13	0.2	0.1	-0.17	0.2
	(0.53)	(1.59)	(-0.35)	(1.01)	(0.22)	(1.03)	(-0.59)	(0.72)
_cons	-0.13**	-0.13**	-0.13**	-0.13**	-0.17**	-0.17**	-0.17**	-0.17**
	(-10.56)	(-10.91)	(-10.95)	(-10.88)	(-11.12)	(-11.59)	(-11.65)	(-11.53)
N	2525	2534	2534	2534	2525	2534	2534	2534
r2_a	0.4	0.4	0.4	0.4	0.41	0.41	0.41	0.41
rmse	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49

* Model (1): Monopoly Firms (m2) is measured by market share= sales of firm/ sales by an industy

* Model (2): Monopoly Firms (m2) is measured by dummy varaible = 1, if marketshare>0.5 and 0 , otherwise.

* Model (3): Monopoly Firms (m2) is measured by dummy varaible = 1, if marketshare>0.25 and 0 , otherwise.

* Model (4): Monopoly Firms (m2) is measured by dummy varaible = 1, if marketshare>0.10 and 0 , otherwise.

Summary

The effect of monopolistic industry	Firm-level	The effect of monopolistic firm	Firm-level
Process innovation	-0.02	Process innovation	-0.04
Product innovation	0.98**	Product innovation	0.98**
Monopolistic industry (MI)	-0.1	Market share (MS)	0.08
MI*process innovation	-0.91*	MS* process innovation	0.54
MI*product innovation	0.19	MS* product innovation	0.2
Net employment growth rate due to the process innovation In monopolistic industry	-0.91*	Net employment growth rate Of a monopolistic firm Due to the process innovation	0.00
Net employment growth rate due to the product innovation In monopolistic industry	0.98	Net employment growth rate Of a monopolistic firm Due to the product innovation	0.98

* MI: If CR3 of an industry is over 0.75, then 1, otherwise 0

* MS: market share of a firm=sales of a firm/sales of an industry

Summary

- Process innovation in monopolistic market has greater job displacement effect than that in non-monopolistic market.
- However, product innovation in monopolistic market does not have bigger job creating effect than that in non-monopolistic market.
- Furthermore, this effect is not based on the monopolistic firms, but based on the monopolistic sectors.

4. Conclusion

Conclusion

- "Does innovation create jobs?" To answer this simple question, this study distinguish the innovation type into two, process and product, and estimate the employment effect of innovations using both firm and sector-level analysis (11,369 Korean manufacturing firms from 1999-2009 are used).
- As a results, we find that
  (1) product innovation has positive effect on employment.
  (2) process innovation does not have significant effect on employment.
- This result is not only supported by firm-level analysis but also supported by sector-level analysis.

- This is very powerful evidence since the product innovation has positive employment effect even though business stealing effect is considered.
- However, interesting fact in sector-level analysis is that this positive employment effect of product innovation is not actually coming from higher job creating rate, but from lower job destruction rate.
- It means product innovation does not actually create the jobs, but to defend the jobs which has to be disappeared if there is no product innovations.

- On the other hand, there is no previous literatures, which explicitly consider the role of ‘market structure’ and provide the empirical evidence for this.
- However, ‘market structure’ is highly correlated with ‘the product market competition’, which is one of the major determining factors for the compensation effect of innovations, that can result in different employment-level.
- Thus, this study consider the market structure and it might be the first empirical paper to adopt the market structure.

- As a result, we find that
  (1) process innovation in monopolistic market has greater job displacement effect than that in non-monopolistic market
  (2) product innovation in monopolistic market does not have greater job creating effect than that in non-monopolistic market.
- It means that the market structure only affect the compensation effect of process innovations and gives more negative influence on the firms who are in more monopolistic market conditions.

- On the other hand, the previous empirical results show us that process innovation of Korean manufacturing firms, which seem to be in highly monopolistic industries, do not have significant effect on employment.
- However, according to the regression results above, process innovation of Korean manufacturing firms should have greater job displacement effect than others. (since they are in more monopolistic market conditions)
- Therefore, we can conjecture that the product market competition, which Korean manufacturing firms actually face, seems to be monopolistic but it is not. It is actually very competitive.

- This paper have following limitations:
  (1) A proxy for market structure, industry-level of CR3, cannot reflect the product market competition in which firms face
  (2) The quality of employment is not considered
  (3) The specific features of technology (such as K/L, wage etc.) is not reflected
- Nonetheless, this paper is the first attempts to
  (1) use Korean manufacturing firm data from 1999-2009 and provide more reliable empirical evidences
  (2) provide both firm and sector-level evidence in case of Korea
  (3) explicitly consider the role of ‘market structure’ and try to explain the reason for different employment effect of process innovations using different ‘market structure’

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Design-Flow-Based Concept of Manufacturing: Capability, Architecture, and Competitiveness

Takahiro Fujimoto

Design-Flow-Based Concept of Manufacturing

- Capability, Architecture, and Competitiveness -

October 2015

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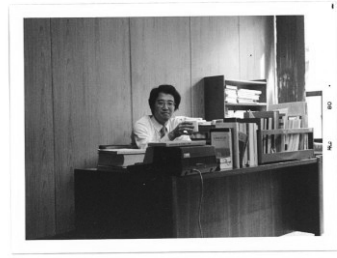
Executive Director, Manufacturing Management Research Center

Fujimoto at KDI, October 1980

ＫＤＩ's 具本英博士 and Staff and Fujimoto (then MRI)

Fujimoto at KDI, October 1980

35th Anniversary for Fujimoto's Korea-Japan Cooperation



At KDI Office

KDI Athletic Meeting

The Origin of Architecture Theory

-- Comparative Study of Korea-Japan Steel Industries

Process Architecture of Steel for Automobile Outer Panel (Exported to Korea)

Function / Process	Surface Appear-ance	Corrosion Resist-ence	Dent Resist-ence	Form-ability	Weld ability	Paint ability	Dimen-sional Accuracy	Rigidity
Iron Making								
Converter	○	○	○	○	○			
Secondary refining	○	○	○	○	○			
Continuous casting	○			○				
Hot Rolling	○			○				
Pickling	○							
Cold Rolling	○		○	○			○	○
Continuous Annealing	○		○	○	○	○	○	
Continuous Galvannealing	○	○	○	○	○	○	○	

Integral Architecture Index = 0.48 = 33 ÷(9X8)

Relatively integral

Process Architecture of Steel for Automobile Inner Panel (Imported from Korea)

Function / Process	Surface Appear-ance	Corrosion Resist-ence	Dent Resist-ence	Form-ability	Weld ability	Paint ability	Dimen-sional Accuracy	Rigidity
Iron Making								
Converter		○		○	○			
Secondary refining		○		○	○			
Continuous casting				○				
Hot Rolling				○				
Pickling					○			
Cold Rolling				○	○		○	○
Continuous Annealing				○			○	

Integral Architecture Index = 0.23 = 15 ÷(8X8)

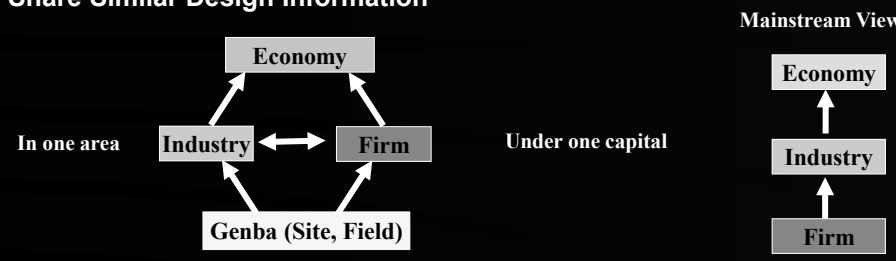
Relatively modular

An Important Part of My Work

Yamagata, Japan, 2011.8

Genba(Field)-Based View of Industries and Firms

An Industry as a Collection of Manufacturing Sites (Fields, Genba) that Share Similar Design Information

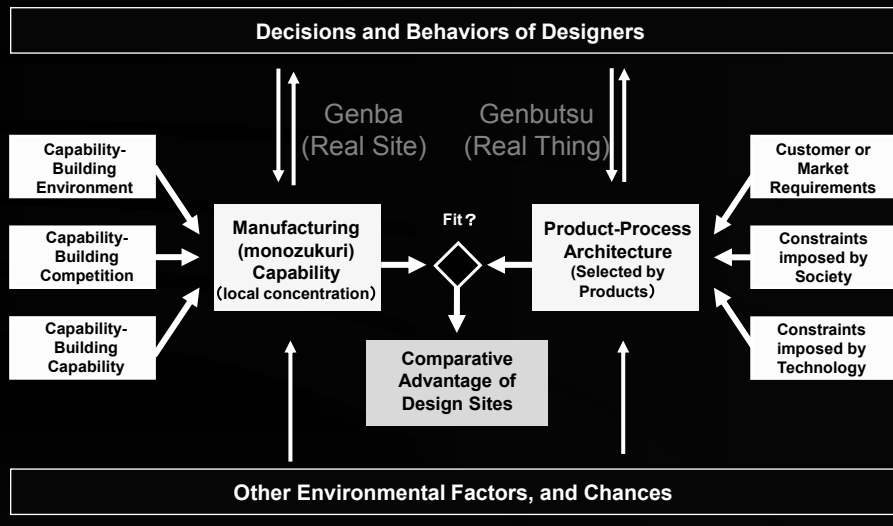


Two Pillars of Field-Based (Site-Based) Industrial Analysis

① ***Organizational Capability in Manufacturing***
＝ **The Way a Firm Creates Good Flows of Design Information to Customers better than Rivals.**

② ***Architecture*** ＝ **The Way Design Elements (Functional, Structural and Process) Are Divided and Connected to the Whole**

Design-Based Comparative Advantage



Japanese Economy, Industry, Firm, and Genba

Macro Economy –– Low Growth (1%) since the 1990s
- Productivity Did Not Decline (Up in Manufacturing, Stagnant in Service)
- Decline in Labor Force and Labor Hour was the Major Cause

Industries – Mixed, as Comparative Advantage Theory Tells Us
- Down – Textile, Consumer Appliances, Computers – Modular Products
- Sustained – Automobile, Steel, etc. – Integral Products
- UP – Functional Chemical/Components, High-Performance Capital Goods

Firms – Profit Ratio Continued to be Low (5-3% ROS) and Mixed
- Poor Strategic/Brand Management in Many Large Companies.
- But Some Continued High-Profit Operations

Genba – Many Sustained and Strengthened in Global Competition
- Good Ones Continued Capability-Building and Kaizen for Survival

History of Japanese Genba

1945-50 1945 End of the War → 1947 Start of Cold War
- Japan's Geographic Position (West End of the West)
- Restoration: Japan's Trade Strategy Restarted (MITI)

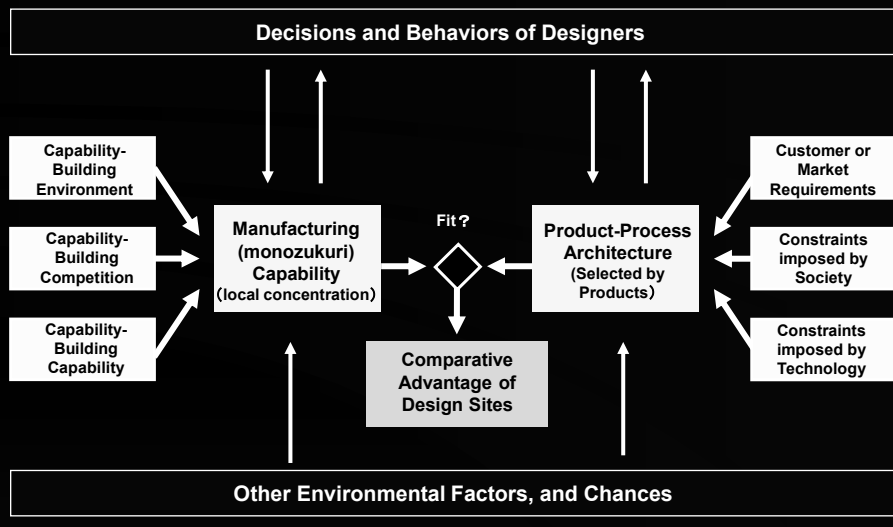
1950s-60s・・ Rapid Growth without Massive Immigrants
- Difference from UK, US and China – Labor Shortage
- "Economy of Scarcity"→ Coordination-Rich Sites (Genba)
- Teamwork of Multi-Skilled Workers

1970s-80s・・ Global Competition under Cold War
- vs. Advanced Counties –– Wage Indifference in 1980s
- Lower Growth (10%→4%). Yen Appreciation – But ––
- Capability-Building, Productivity Increase, Trade Surplus
- Lean Manufacturing Praised in Coordination-Intensive Pdt

1990s-2000s Global Competition after Cold War (vs. Emerging Cs)
- End of Cold War, Emergence of China (1/20 Wage Rate)
- Digital Innovations (Coordination-Saving Products); Higher Yen
- Max. Handicap for Genba, But Capability-Building Continued

2010s-2030s Wage Handicap vs. Emerging Nations Decreases
- Darkness before Dawn for Genba? (Media Misleading)

Design-Based Comparative Advantage (A Genba-Based Approach)



The Architecture - Capability Framework

1 Design-Information View of Manufacturing （Monozukuri)

2 Organizational Capability – Controlling Design Flows

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Design-Information View of Manufacturing (Monozukuri)

Key Concept: Design Information = Value

A firm's products and processes are artifacts that has been designed.

Manufacturing is essentially creation and transmission of design information to customers.

A firm's manufacturing (monozukuri) capability is its distinctive ability to handle flow of design information toward customers.

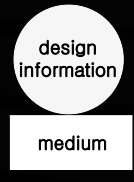
Product-process architecture is designers' basic way of thinking when creating design information for the product and processes.

"Design" is the common denominator for these analyses.

Open Manufacturing (Monozukuri) --Creating Design Information Flows to the Customers

We focus on design (as opposed to material) side of manufacturing

artifact = design information + medium



c.f., Aristotle: object = form + material

where form is more essential

Products (goods and services) are the artificial (= something designed)

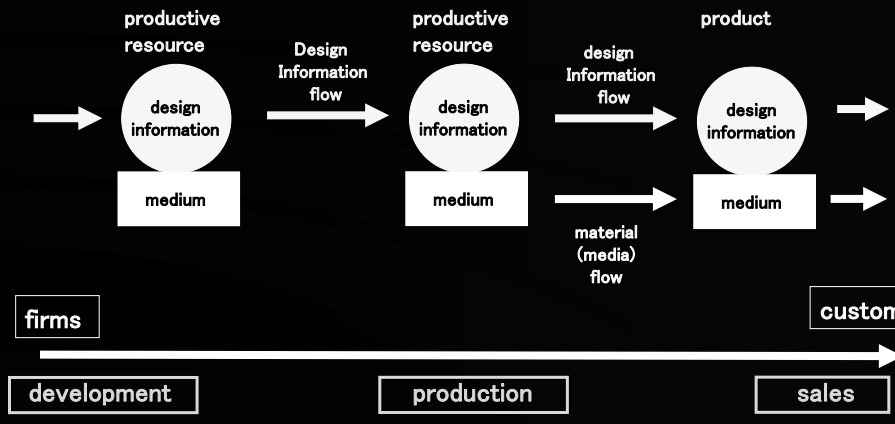
manufacturing, if medium is tangible

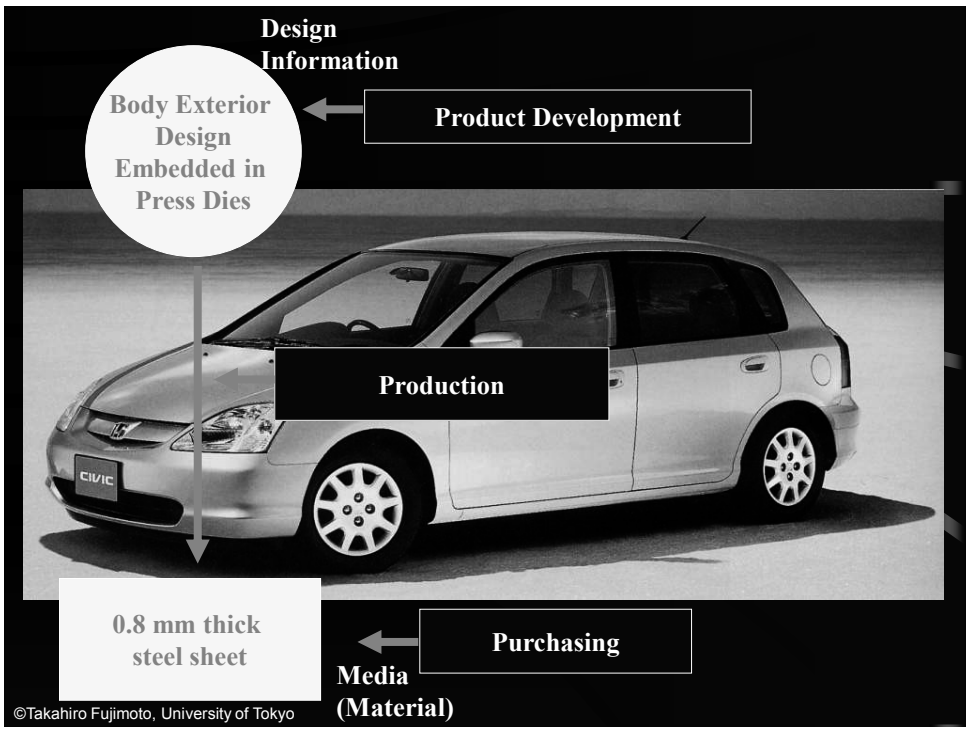
service if medium is intangible

Primary source of customer value is design information

Open Manufacturing (Monozukuri) as a System of Design Information between Productive Resources

Manufacturing activity is design information flows between productive resources

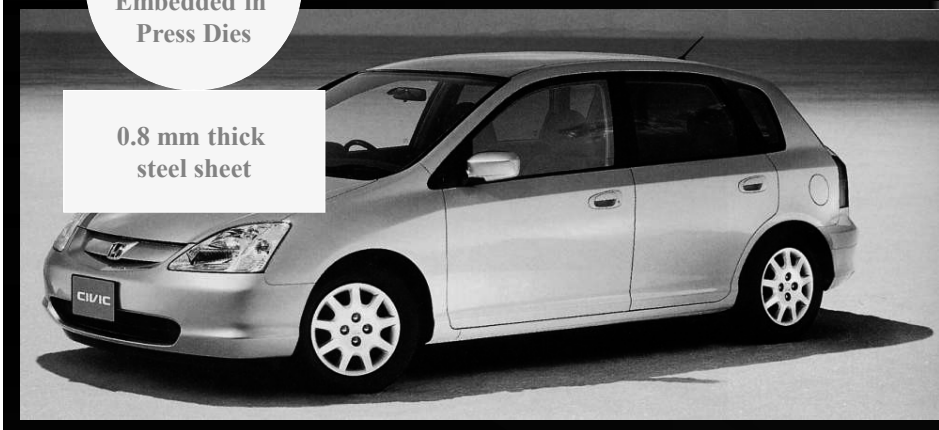




Product = Design Information + Media

Body Exterior Design Embedded in Press Dies

0.8 mm thick steel sheet



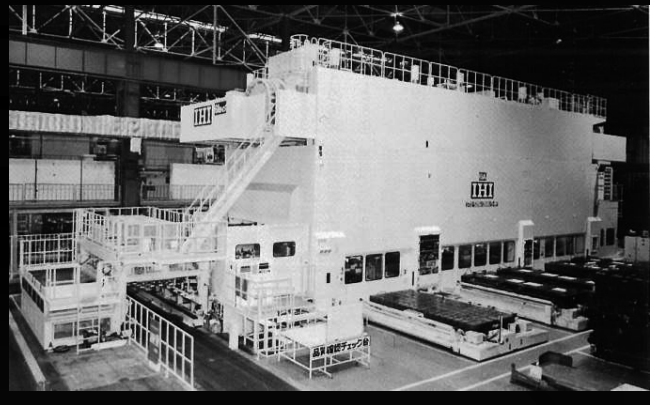
Production = Marriage of Design Information Media

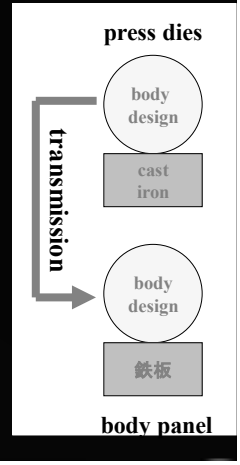
What is Going on at the Press Shop

Body exterior design information, embedded in press dies (steel block), is transmitted to 0.8 mm thick sheet steel (media)

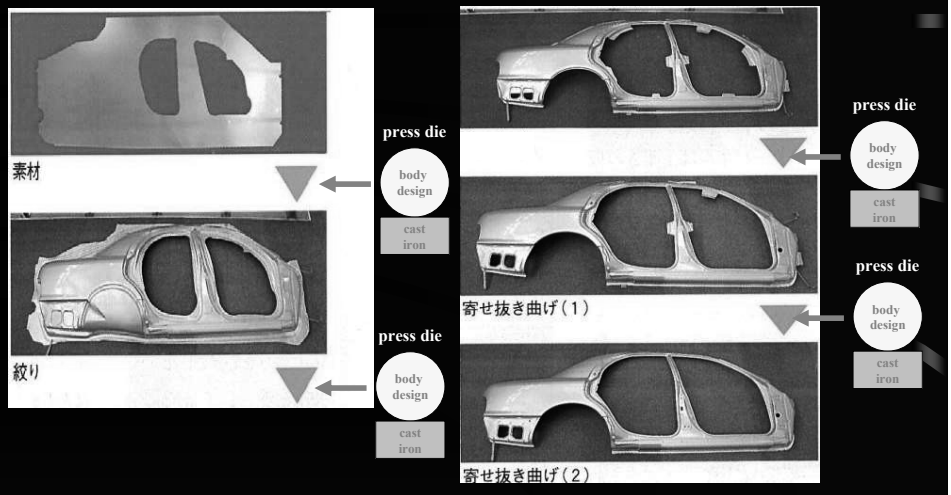
Information transmission time = value-adding time

Information non-transmission time = MUDA



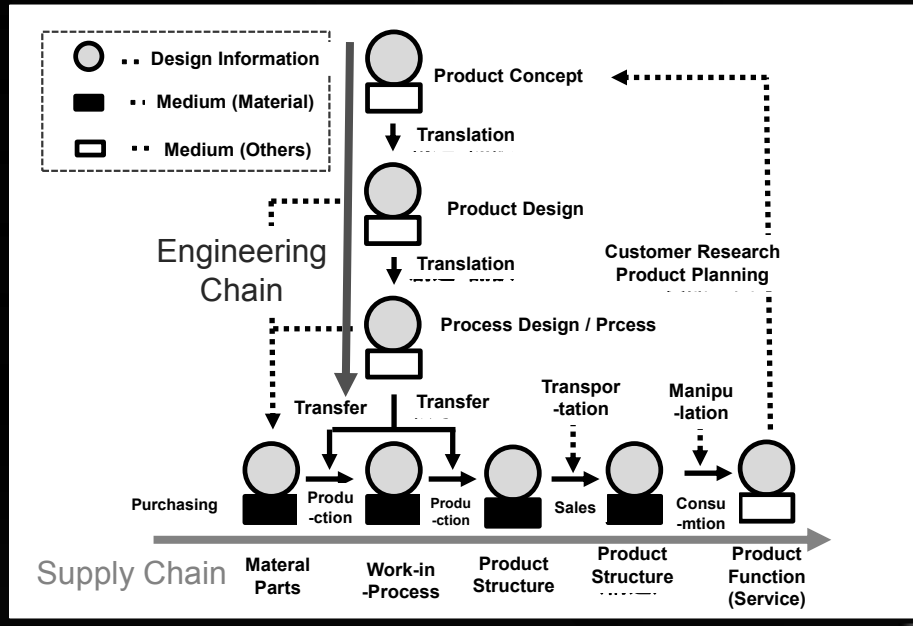


Sheet Steel (Media) Absorbs Design Information through the Press Operation



Design information, embedded in press dies, is transmitted to sheet steel

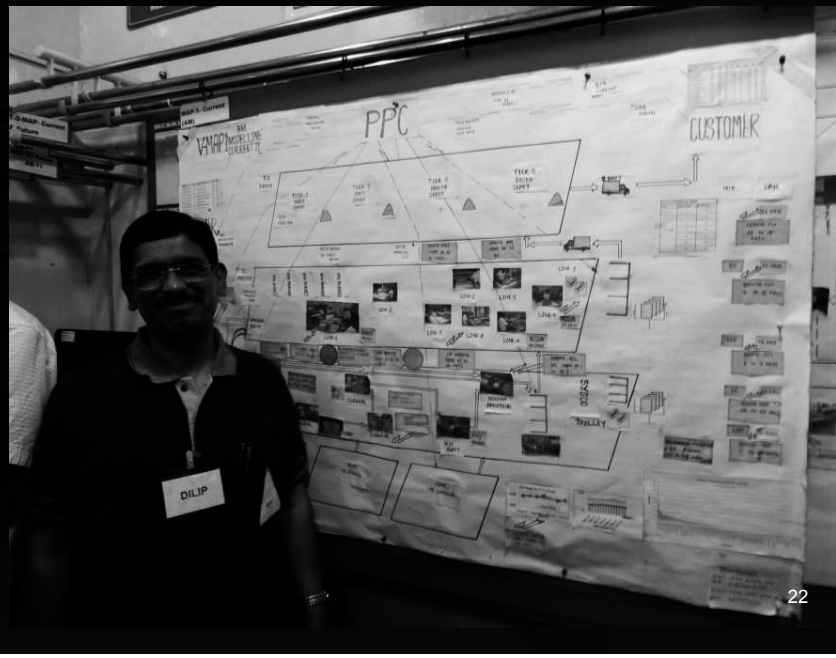
Integrating Supply Chain and Engineering Chain - Circulation of Design Information -



Victor Gasket, India

21

Value Stream Map Victor Gasket, India



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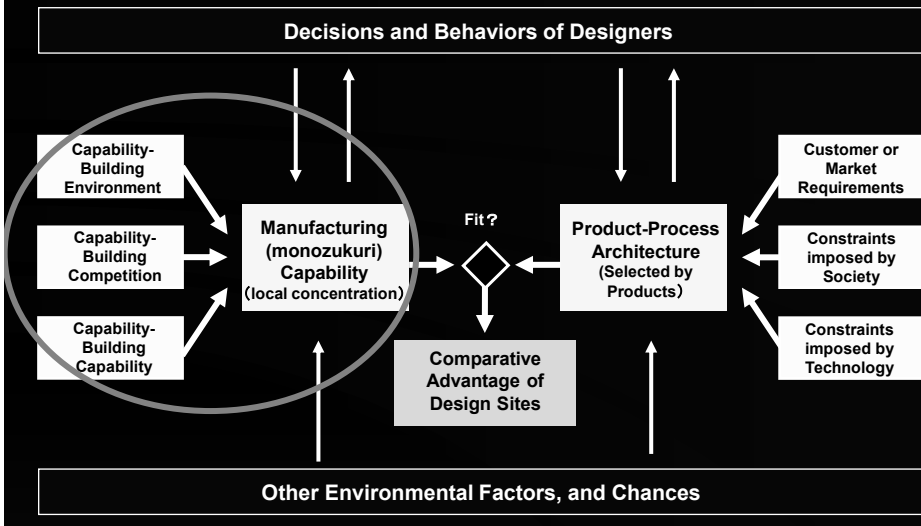
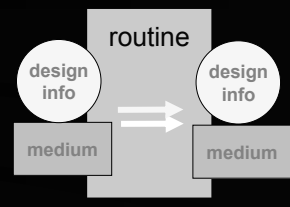


Organizational Routines and Capability of Manufacturing

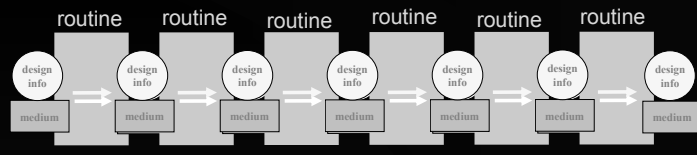
Organizational routine of manufacturing ------

Repeated control of design information flow between productive resource



Organizational capability of manufacturing -------

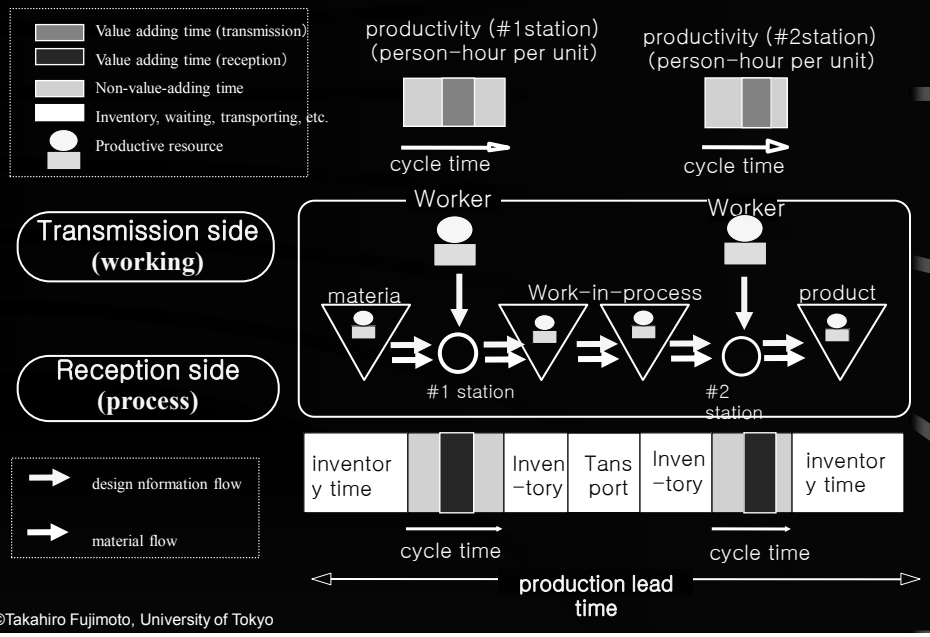
A system of organizational routines for fast, efficient and accurate flows of design information to customers



The Lean Principle (Manufacturing)

- Design Information is Transmitted to Materials
- Creating Good Flows of Design (Value) to Customers
- Reducing MUDA (Non-Value-Adding Time)
- Maximizing Value Adding Time Ratio
- Total Process First, Individual Operations Next
- Lead Time Reduction First, Cost Cutting Next
- Pursue High Quality – Quantity Follows as a Result

Information Transmission and Reception in Production



Toyota's Manufacturing Capability as Effective Information-Processing

Toyota's manufacturing capability -
Dense and accurate information transmission
***between flexible (information-redundant) productive resources*.**

(1) Higher Productivity and Shorter Throughput Time (TPS)

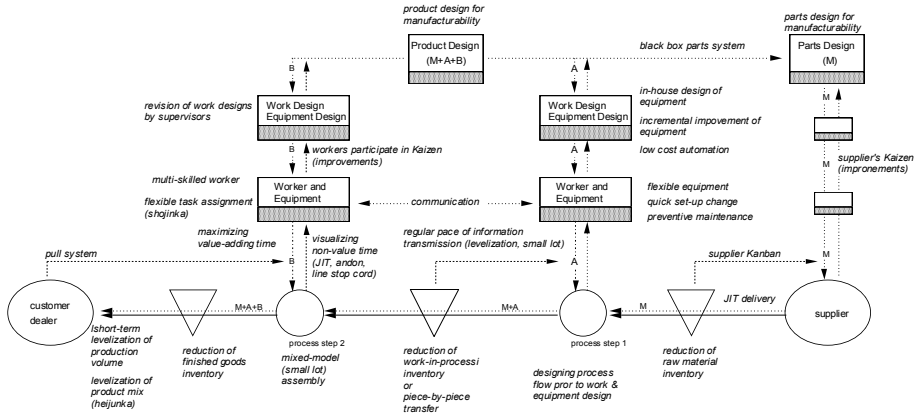
Muda is unnecessary non-transmission time,
which includes inventory, over-production,
and defects on the information receiver side,

(2) Higher Manufacturing Quality (Lower Defect Rate) (TQM)

Building-in quality: - Errors of information transmission are avoided in the first place (vs. inspection)

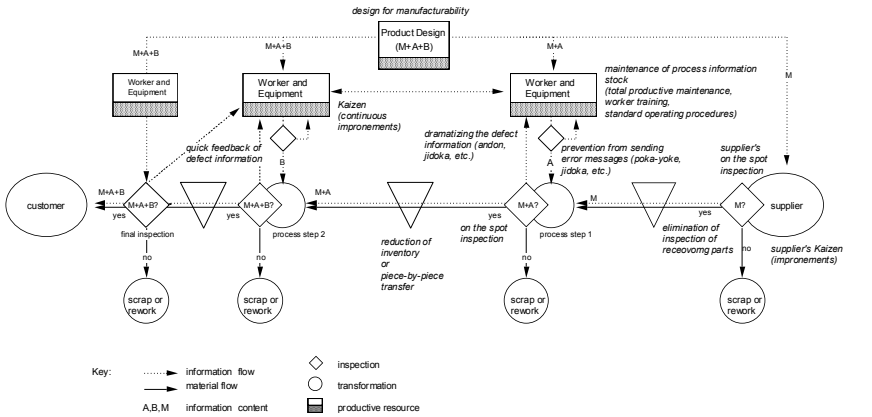
(1) Higher Productivity and Shorter Throughput Time

Organizational Capability Regarding Productuvity and Throughput Time (Toyota)



(2) Higher Manufacturing Quality

Figure 10 Organizational Capability Regarding Manufacturing Quality (Toyota)



Toyota-style system as an *integrative manufacturing capability*

Three Levels of Toyota's Capabilities

1. *Routinized Manufacturing Capability*

   Ability to Achieve Speed / Efficiency / Accuracy of
   Repetitive Information Transmission from Process to Product
   (e.g., Kanban, Multi-Task Work Assignment, Self-Inspection)

2. *Routinized Learning Capability (Kaizen Capability)*

   Ability to Achieve Speed / Efficiency / Accuracy of
   Repetitive Problem Solving Cycles
   (e.g., Kaizen, QC Story, Product Development Routines)

3. *Evolutionary Capability* (Capability-Building Capability)

   Ability to "Learn Anyway" in the Long Run --- or

   Ability to Establish Competitive Routines
   Despite Complicated *Multi-Path System Emergence*

Tokyo University Manufacturing Instructors' School

Educating Instructors Who Can Teach Lean Manufacturing Across Industries

Tokyo University Manufacturing Instructors' School

Over 100 people are now active as lean manufacturing instructors

韓日産業・技術協力財団東京Seminar (2014)

Held in 2014 and 2015 in Tokyo, At Monozukuri Kaizen Network (MKN)

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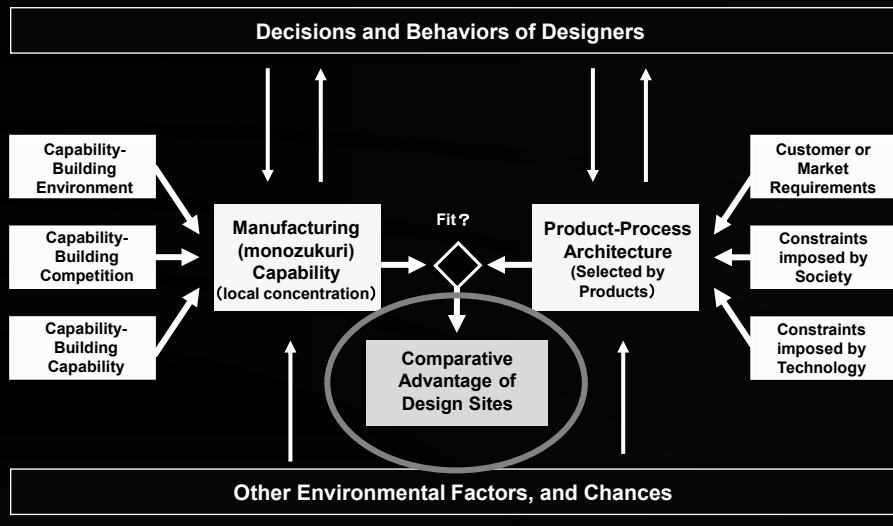
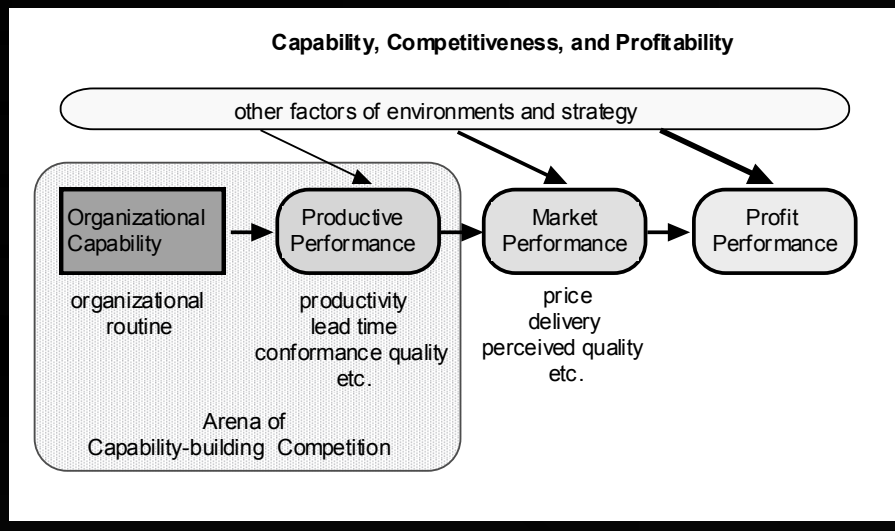
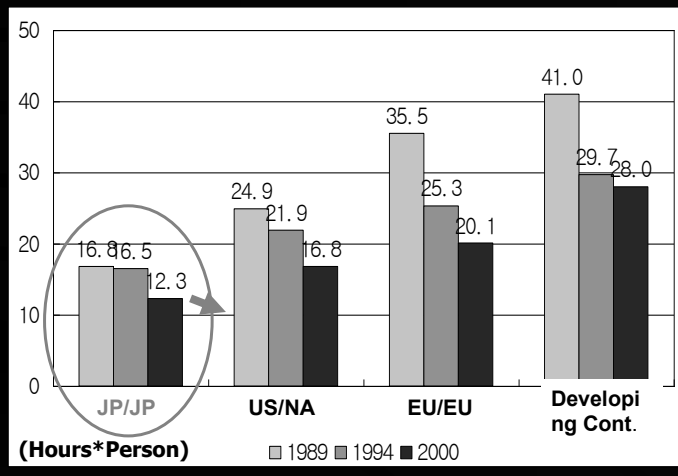


1 Measuring and Analyzing Industrial Performance -- From Competitiveness to Profitability

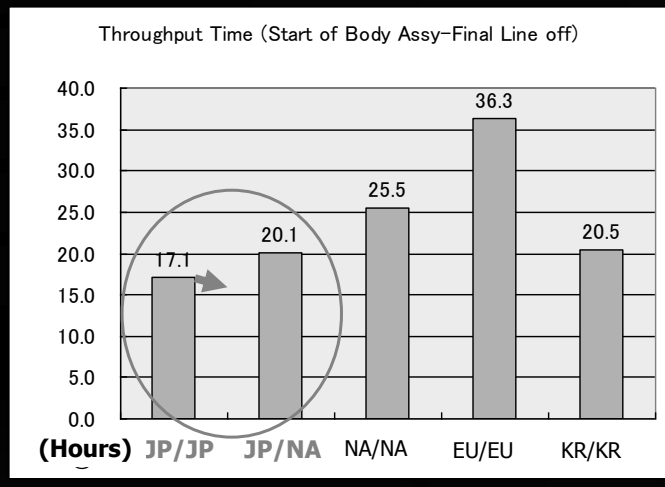


Example: Productive Performance of Japanese Auto Firms
-- Assembly Productivity (Adjusted Person-Hours per Vehivcle) --



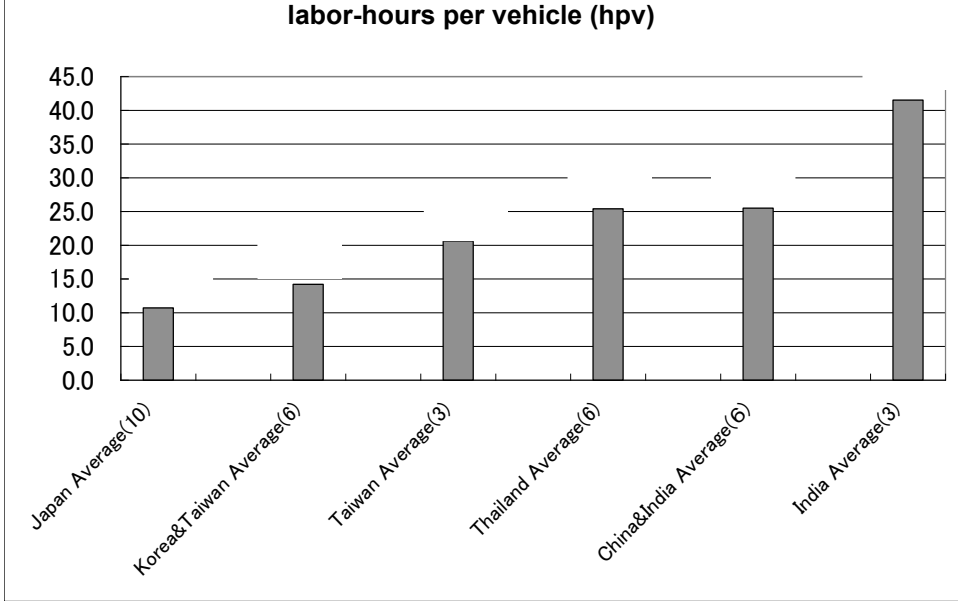
Source: M. Howleg & F.K. Pil, *The second century* (IMVP Survey)

Example: Productive Performance of Japanese Auto Firms
-- Assembly Throughput Time (from Welding to Assembly) --



Data: IMVP2000yr. Survey, made by Jeweon Oh, MMRC

Productivity of of Asian automaker plants in IMVP Survey, Round 4 (2006)



Throughput Time (from start of welding to line-off)

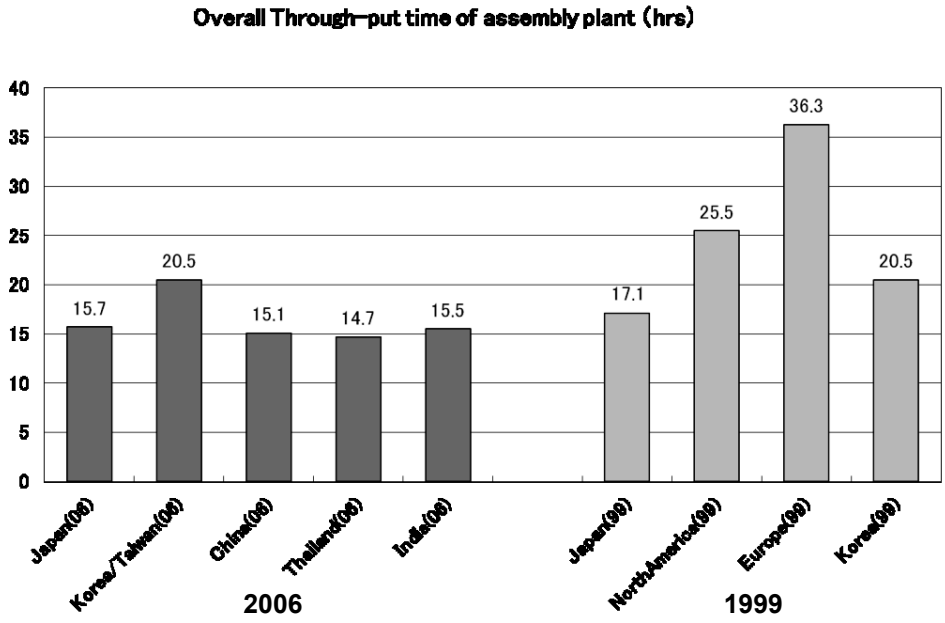


Figure created by: Je-Wheon OH, Meiji University

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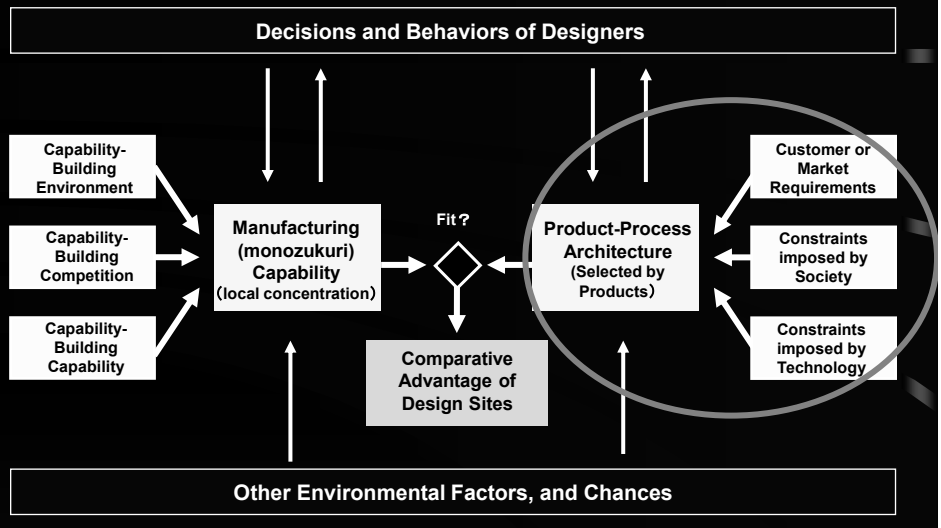
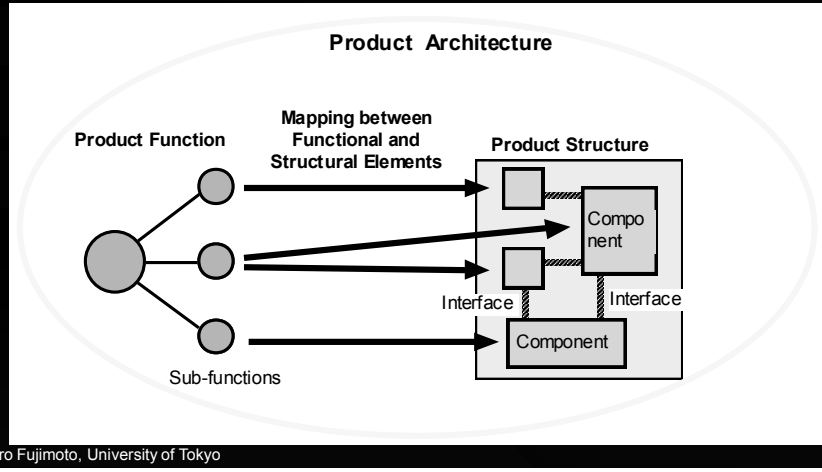


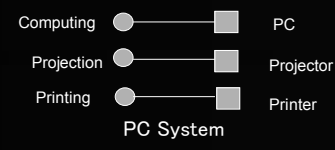
Architectural Thinking and Industrial Classification

***Product architecture*,**
Basic way of thinking of engineers
when they design functions and structures of a new product

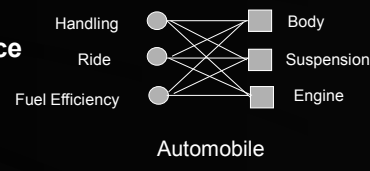


Basic Classifications of Product-Process Architecture

Modular architecture
one-to-one correspondence
between functional and structural elements



Integral architecture
***many-to-many* correspondence**
between the functional and structural elements



Open architecture : **"mix and match" of component designs across firm**

Closed architecture : **mix and match only within a firm**

Three Basic Types of Product Architecture

(1) *Closed-integral*, (2) *Closed-modular*, (3) *Open-modular*

Basic Types of Product Architecture

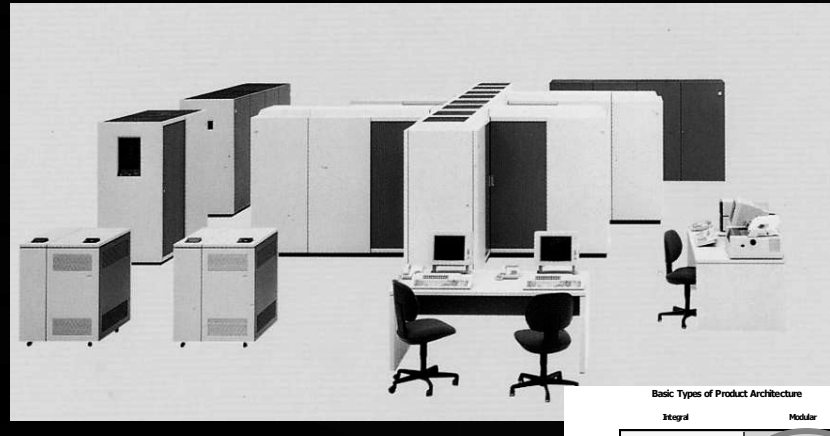
	Integral	**Modular**
Closed	small cars motorcycle game software compact consumer electronics	mainframe computer machine tools LEGO (building-block toy)
Open		personal computer (PC) bicycle PC software internet

Closed-Integral Architecture (Car)

Basic Types of Product Architecture

	Integral	Modular
Closed	small cars motorcycle game software compact consumer electronics	mainframe computer machine tools LEGO (building-block toy)
Open		personal computer (PC) bicycle PC software internet

Closed-Modular Architecture (Mainframe Computer)



Basic Types of Product Architecture

	Integral	Modular
Closed	small cars motorcycle game software compact consumer electronics	mainframe computer machine tools LEGO (building-block toy)
Open		personal computer (PC) bicycle PC software internet

Open-Modular Architecture (PC)

Basic Types of Product Architecture

	Integral	Modular
Closed	small cars motorcycle game software compact consumer electronics	mainframe computer machine tools LEGO (building-block toy)
Open		personal computer (PC) bicycle PC software internet

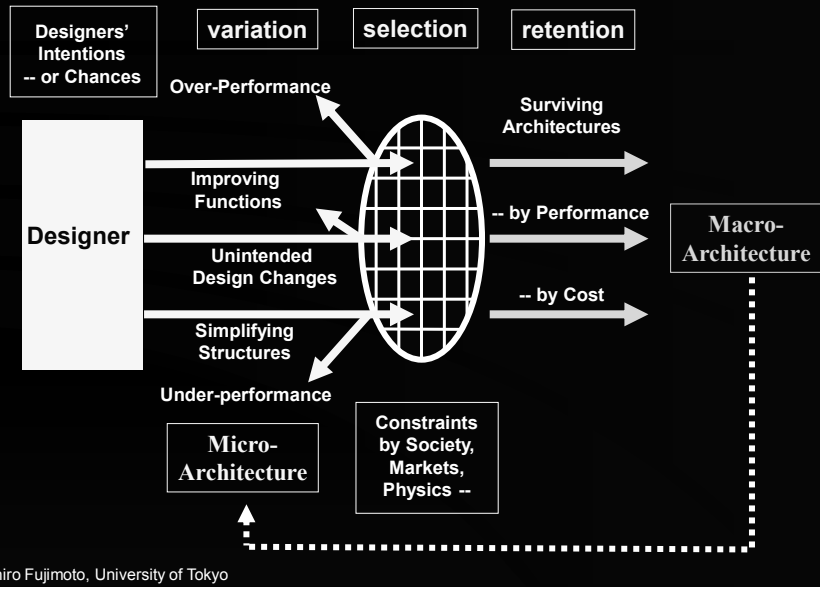
Closed-Integral Architecture (unit-body)

Basic Types of Product Architecture

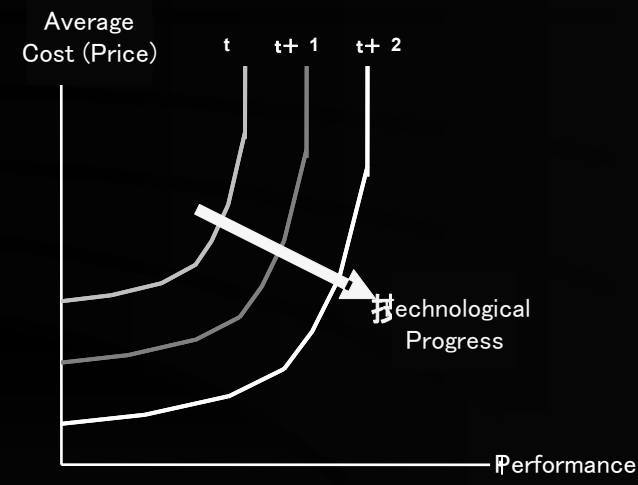
	Integral	Modular
Closed	small cars motorcycle game software compact consumer electronics	mainframe computer machine tools LEGO (building-block toy)
Open		personal computer (PC) bicycle PC software internet

Closed-Modular Architecture (Body-on-Frame, or Truck-type)

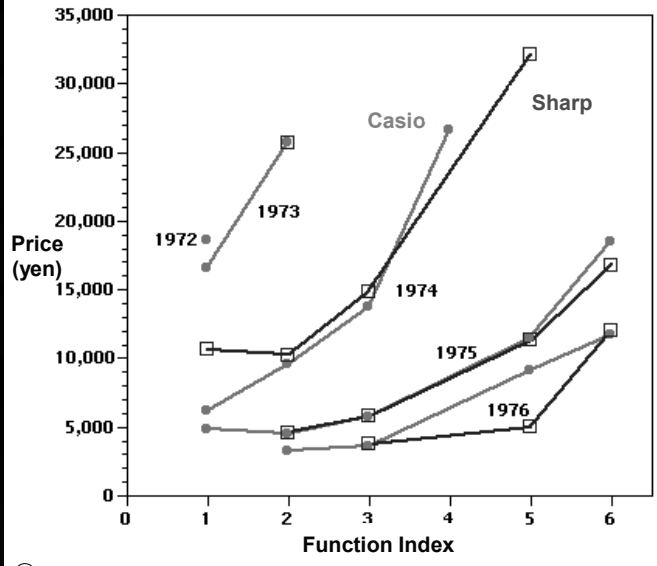
Evolutionary Dynamics of Macro-Micro Architecture



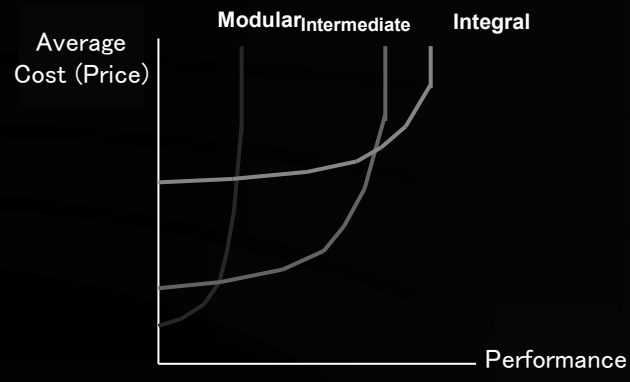
Technological Progress Expands Cost-Performance Frontier



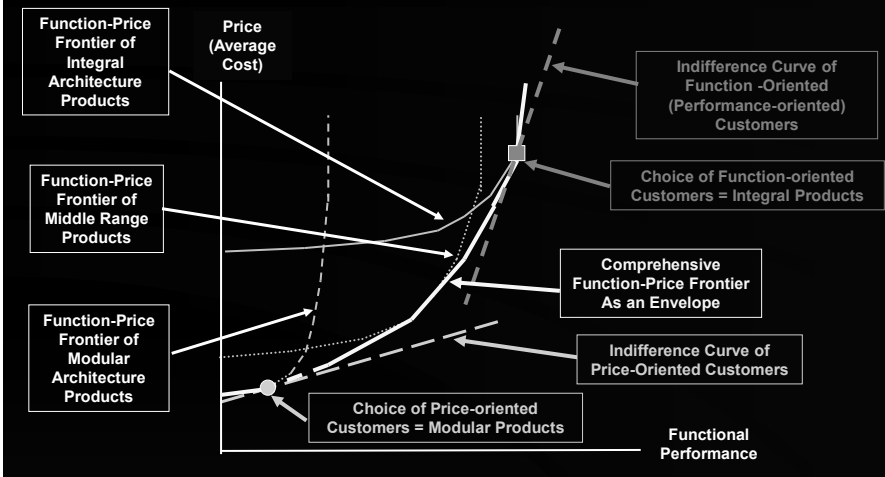
Expanding the Frontier (Electric Calculator)



Architectures and Cost-Performance Frontier



Macro Architecture is Determined by Market & Society



Note: Modified from Fujimoto (2012)

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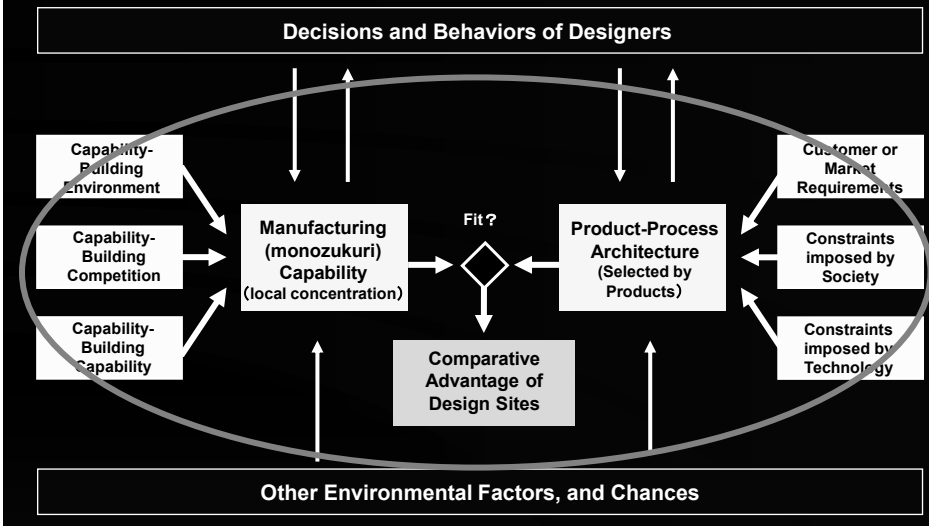


Japanese Model of Manufacturing

1 Design-based Concept of Manufacturing --
Creating Good (Efficient and Accurate) Flows of Value-Carrying Design Information to Markets

2 General Tendency of Post-War Japanese Manufacturing Sites --
Coordination-Rich Sites (Genba) by Team work of Multi-Skilled Employees

3 General Tendency of Japanese Competitive Advantage –
Coordination-Intensive Products – Integral Architecture

***Japanese Manufacturing Model* –**
Designing and Producing Competitive Integral-Architecture Products by Coordination-rich Manufacturing Sites (Genba)

This Model was Largely a Result of Industrial Evolution

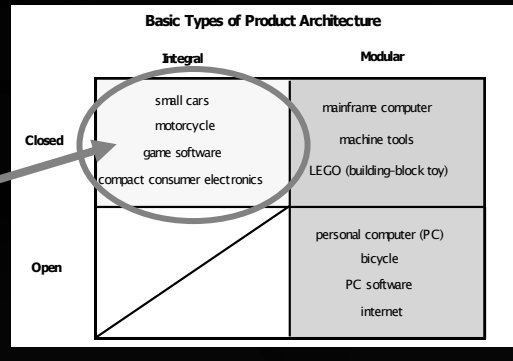
Hypothesis: Capability-Architecture Fit at National Level

A group of firms in the same country or region, facing similar environmental constraints, national-regional institutions, demand patterns or other forces specific to a particular geographical area may develop similar types of organizational capabilities

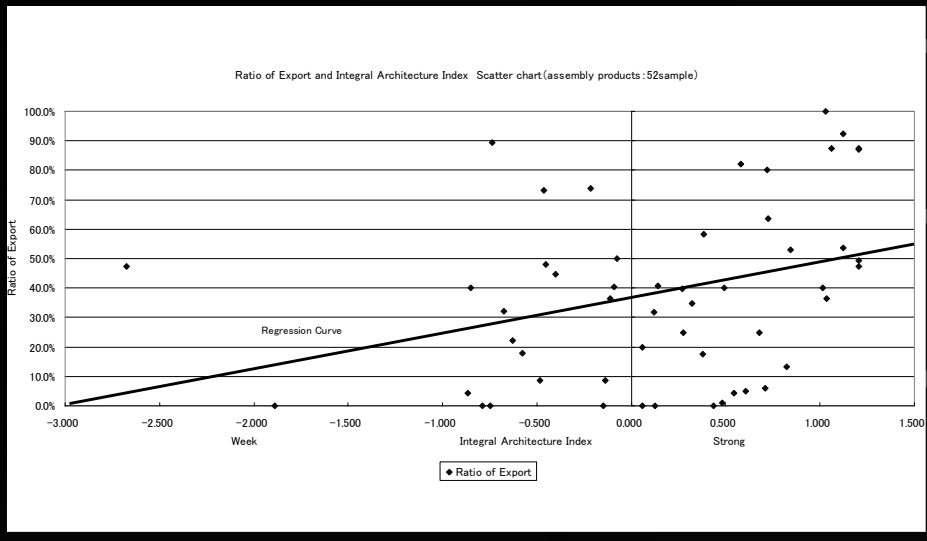
Products with the architecture which fits this organizational capability tend to demonstrate competitive advantage (-- if not profitability)

History matters

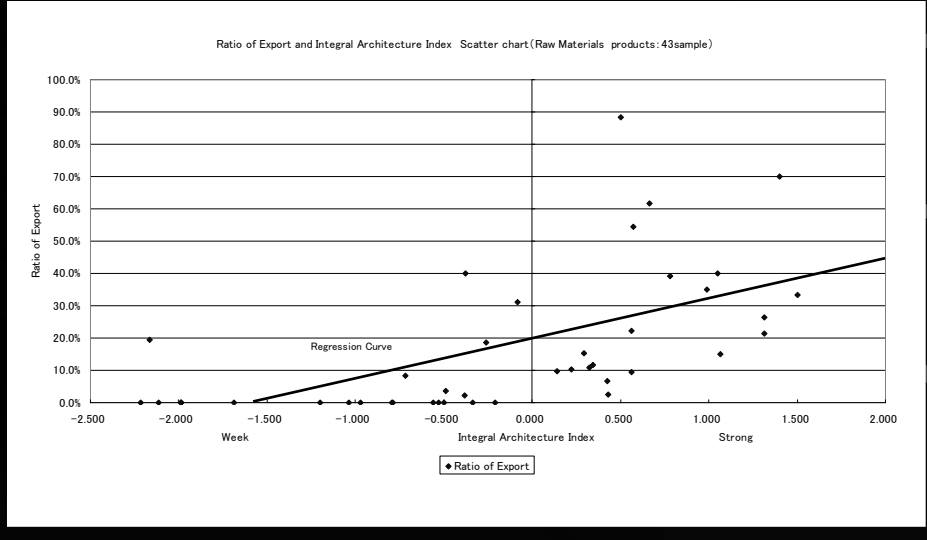
Japan's Architectural Comparative Advantage



Ratio of Export and Integral Architecture Index　Scatter chart(1)
（Regression Equation for Assembly products：52sample）



Ratio of Export and Integral Architecture Index　Scatter chart(2)
（Regression Equation for Process-Oriented Products：43 sample）



Thuru-Nakajima's Statistical Analysis (2012) Generally Sopported "Competitiveness = f(C-A Fit)" Hypothesis

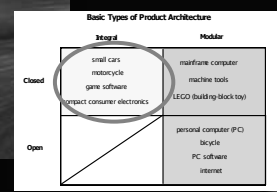
Linear Estimation	Japan		Korea		China	
Integral Architecture		significant		Not clear		
Modular Architecture	significant		Not clear		Not clear	
Non-Linear Estimation						
Integral Architecture		significant		significant		
Modular Architecture	significant		significant		Not clear	
	Specialization-oriented	Coordination-oriented	Specialization-oriented	Coordination-oriented	Specialization-oriented	Coordination-oriented

Data Concentrated here

C Takahiro Fujimoto,

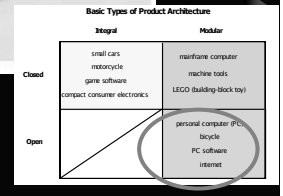
Case of Chinese Car Industry

Integral Architecture --- VW PASSART



Case of Chinese Car Industry

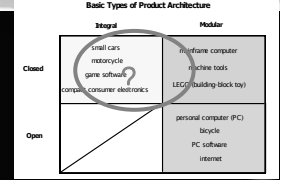
S－RV (Chinese Local)



Similar Exterior Design to Honda,
but Very Different Architecture
-- Rear Drive, Truck Architecture,
Toyota &Mitsubishi Engines Available

TATA NANO （India）

base model price = $2500 (upper model is more expensive)
More toward integral architecture than we expected



Different architectural strategies
between
Chinese and Indian local auto makers?

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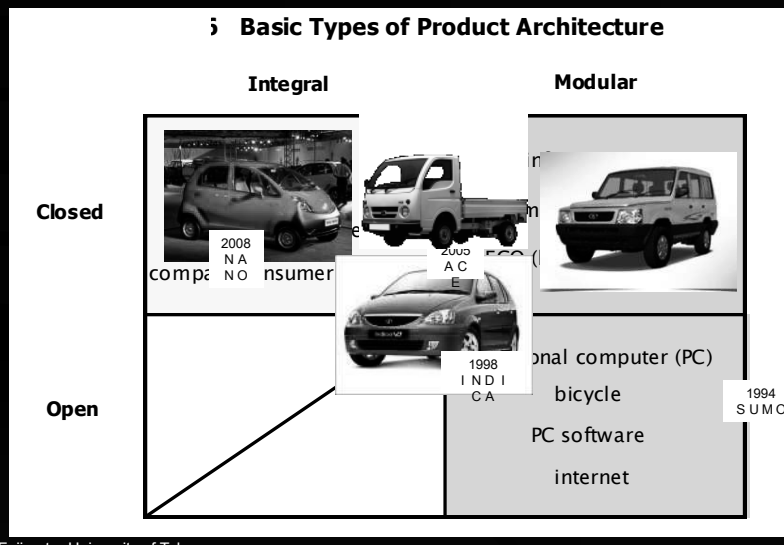
(1) *Closed-integral* , (2) *Closed-modular*, (3) *Open-modular*



Predictions on Architecture-based Comparative Advantage

Japanese firms -- integration capability
More competitive in products with *closed-integral architecture*.
based on *integration-based manufacturing capability*

Chinese firms – mobilization capability
More competitive in labor-intensive products
with *open-modular (or quasi-open) architecture*

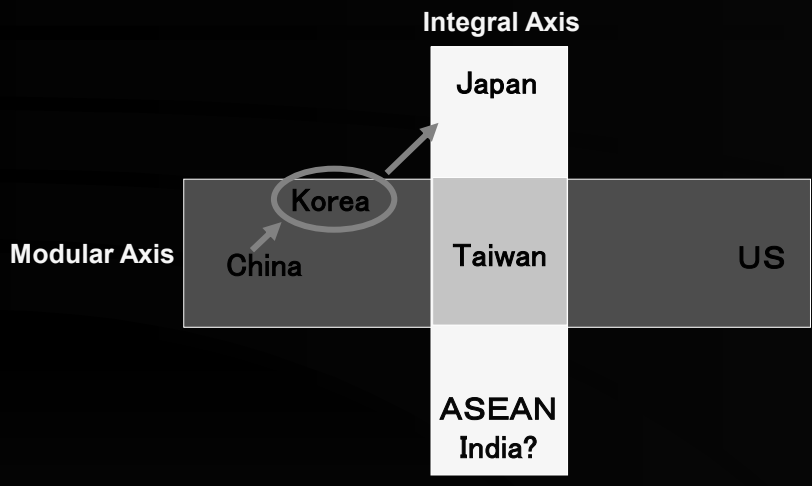
Korean (large) firms – concentration capability
More competitive in capital-intensive products
with modular architecture (moving toward integral?)

ASEAN firms – labor-retaining capability??
More competitive in labor-intensive products
with closed-integral architecture?

U.S. firms – conceptualization capability
More competitive in knowledge-intensive products
with *open-modular architecture*

European firms – expression capability
More competitive in *closed-integral products*
based on brand-design-marketing capability

Architectural Geopolitics: A Prediction in the Pacific Region



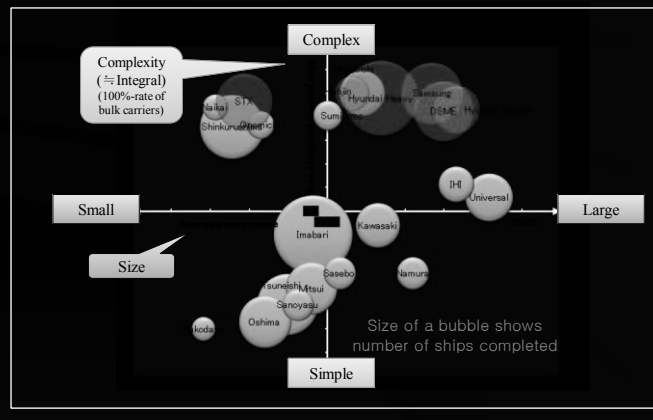
Performance of Japanese Shipbuilders

Korea – Jaoan - China

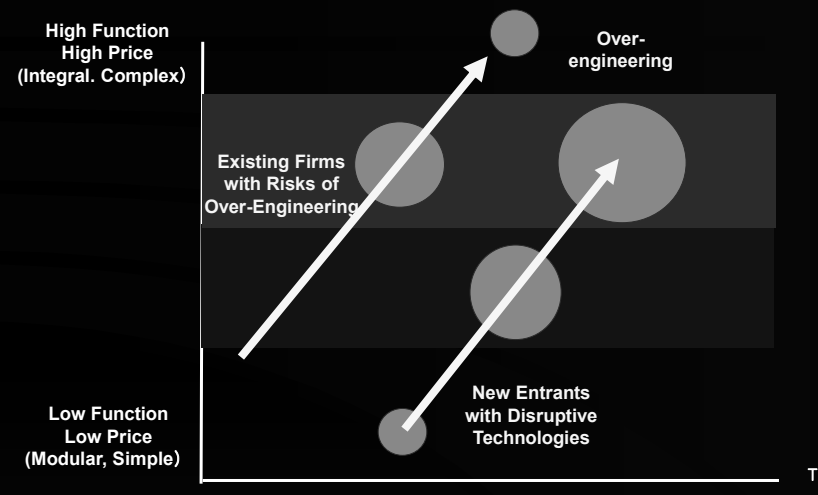
Performance of Japanese mid-size Shipbuilders for Non-High-Tech Products

Productivity – 3-5 times? Wage – 3 Times (welders)

Anticipating Market Changes

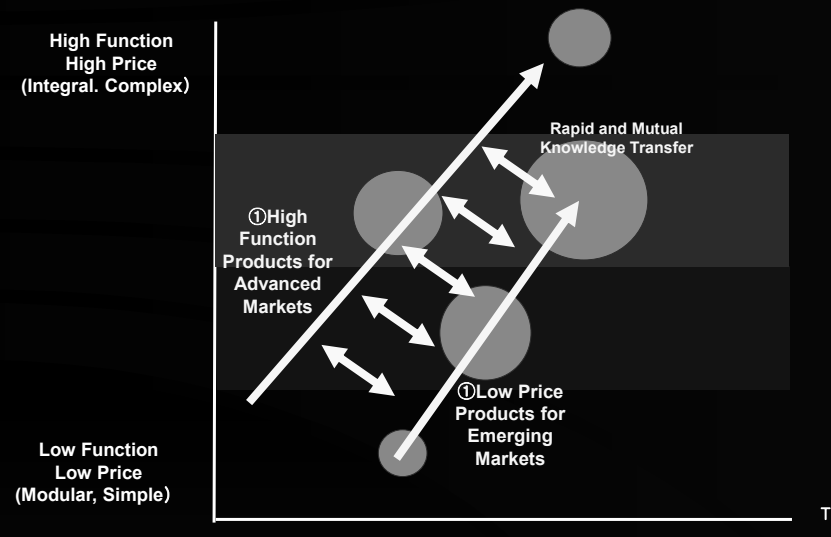


Transition of Product Functions and Prices (Christensen)



藤本隆宏（東京大学）

Double-Flow Strategy to Balance Complexity and Simplicity



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"Global Capability-Building Competition" is Back

What is Going On in the 2010s?

- Globalization – as Realization of International Division of Labor
- Microscopic Intra-industrial Trade based on Comparative Advantage
- End of Post-Cold-War Era?
  -- Wage Gaps vs. Emerging Countries Shrink

The Key Is

- Architecture-Capability Fit -- Comparative Advantage of Design
- Capability-Building Competition
- Evolutionary Learning Capability
- Strong Strategies and Strong Operations

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Causes for Changing Performance of Ownerships in China

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Causes for Changing Performances of Ownerships in China

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we analyze the longitudinal changes in the firm performance by ownership using the China enterprises database for the period from 2000 to 2009. Results show an upward trend in the relative performance of private ownership in China. Private firms have caught up with foreign-invested rivals in terms of labor productivity and even surpassed them after the mid-2000s. More importantly, we confirm that private enterprises have a higher propensity to invest than other ownerships firms. This investment preference leads to rapid growth of the labor productivity of private enterprises compared with those of foreign-invested enterprises and state-owned enterprises. In addition, the size effect from "economies of growth" in the later period is the main contributor to the increasing productivity of private enterprises. In contrast, foreign-invested enterprises have no active investment activity and no increase in size effect, which result in stagnant labor productivity. State-owned enterprises have enjoyed the growing size effect and have improved productivity in the later period. However, the improvement seems to come from the government policy and not from economies of growth because during this period, government policy has weeded out small and inefficient state-owned enterprises.

Keywords: Chinese economy, Ownership, Firm performance, Labor Productivity, Investment.

I. Introduction

Who owns the enterprise (state, private, and foreign ownership) has long been an important topic for academic research on firm performance. This paper estimate how much ownership contributes to firm performance and what factors causes the performance difference among ownerships. For it, we check the trends of performances of the various ownership types and endeavor to determine their main causes, specifically on selected factors (investment and firm size) related to firm performance.

We chose to conduct the study in China because it is a unique and ideal place to obtain data. In contrast with most developed countries in which the domestic private sector dominates the entire economy, China has a unique industrial structure in which private, foreign-invested and state-owned companies co-exist and compete with one another. These companies comprise a substantial portion of the economy in the 21st century (Bai et al., 2009). According to a recent report from the National Bureau of Statistics of China (NBSC), in 2012, private, foreign-invested,[1] and state-owned companies.[2] produce 49.7%, 23.9%, and 26.4 % of the total industrial outputs, respectively (NBSC, 2014). The coexistence of these types of ownership is an important outcome that originated from the gradual economic reform of China and its active induction policy for foreign capital (Naughton, 2007).

Many interesting questions related to this distinct feature of the Chinese economy have been brought up by many researchers. As one of them, the potential effects of the types of ownership on firm efficiency or productivity in China has drawn considerable attention from researchers in the fields of economics and business management (Dollar and Wei, 2007; Bai et al., 2009; Dougherty et al., 2007; Li et al., 2012). Dougherty et al. (2007) conducted an analysis of a database of firm micro-data of a quarter of a million industrial companies from the period of 1998 to 2003 and reported that the private sector operated much

1) Foreign-invested enterprises include Hong Kong, Macao, and Taiwan-invested enterprises as well as foreign-invested enterprises (China Statistical Yearbook, 2013).

2) State-owned enterprises in this paper refer to not only state-owned enterprises in which all assets are owned by the state, but also to state-holding enterprises. State-holding enterprises are a sub-classification of enterprises with mixed ownership, in which the percentage of state asset (or shares by the state) is larger than any other single shareholder of the same enterprise (China Statistical Yearbook, 2013).

more efficiently than the public sector, and that its higher productivity improved profitability. Bai et al. (2009) investigated the effects of privatization on firm performance indicators using a panel data set of Chinese state-owned enterprises (SOEs), and identified that privatization of SOEs resulted in higher labor productivity. The positive effect of privatization was also more extensive. Li et al. (2012) investigated the performance of SOEs following share-issue privatization and showed that their output and operating efficiency increased after privatization. Through a survey among a stratified random sample of 12,400 firms in 120 cities in China using firm-level accounting information from 2002 to 2004, Dollar and Wei (2007) found that, on average, private enterprises (PEs) have significantly higher returns of invested capital than SOEs even after a quarter-century of reforms. All the above studies consistently suggest that PEs are more efficient than SOEs in China. Compared with existing literature, this paper adopts a dynamic approach that focuses on the 'changing' performances of the various ownership types over time. Furthermore, we intend to reveal the main driving factors for changing performances of the different ownership types, especially on investment and firm size to draw higher labor productivity. We present how investment and firm size have affected a firm's labor productivity.

The remainder of this paper is organized as follows: Section 2 measures the longitudinal performances of firms under various types of ownership in China. Section 3 develops theoretical perspectives and main hypotheses. Section 4 tests the hypotheses through regression models and reports the results. Section 5 offers conclusions and implications.

II. Measuring the performance of firms under different ownership in China

1. Data source

Empirical work conducted in this paper utilizes the China Enterprises Database designed and developed by the GTA information Technology Company Limited. These enterprises compose a large proportion in Chinese enterprises, so

we believe this database reflect the reality of Chinese firms well. These data cover the period from 1998 to 2009[3] and include all industrial enterprises with annual sales in current yuan of 5 million or higher. The original dataset covers more than two million unique firms that report their principal financial and economic results to the government annually. Compared to many other countries, the set of available variables in the Chinese dataset is unusually extensive (Dougherty et al., 2007; Brandt et al., 2014). For each firm, the dataset provides both balance sheet data and basic information, such as ownership structure, industry, location, employment, and so on. Therefore, it represents detailed insights into the development of Chinese enterprises. One demerits of the database, as a result of firm exit and entry, is the smaller number of firms operating for consecutive years. Thus, we choose only the firms that reported for more than three consecutive years, and then excluded firms with incomplete data or extreme values to remove the effect of outliers and utilize the proper dataset for this study. And then, with the data, we reclassified firms and their data items based on types of ownership, thereby allowing us to appraise the dynamic effect of the various ownership types in China.

<Table 1> shows the number and percentage of sample firms under various types of ownership from 2000 to 2009. The share of PEs increased rapidly from 60.8% to 80.2%, whereas that of SOEs decreased significantly from 19.4% to 1.3%. The total shares of foreign-invested enterprises (FIEs) remained stable at approximately 20% for the period. This overall trend is showing the rapidly growing proportion of private ownership, the sharp drop in state ownership, and stagnation of foreign ownership. Thus, the sample in this paper provides a good reflection of the reality of the Chinese economy.

<Table 1> Sample firms by ownership

Ownership type	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
State	6,689	5,811	4,533	3,496	2,819	2,630	2,285	1,520	769	460
	19.4%	14.3%	11.3%	8.2%	4.5%	3.4%	2.7%	1.9%	1.5%	1.3%
Private	20,928	26,223	26,743	29,483	46,405	59,253	66,065	62,782	40,228	28,354
	60.8%	64.7%	66.9%	69.2%	73.7%	75.8%	77.4%	78.9%	79.6%	80.2%
Foreign	6,782	8,516	8,718	9,618	13,720	16,268	17,015	15,287	9,510	6,551
	19.7%	21.0%	21.8%	22.6%	21.8%	20.8%	19.9%	19.2%	18.8%	18.5%
Total	34,399	40,550	39,994	42,597	62,944	78,151	85,365	79,589	50,507	35,365

3) In this study, we analyze the period from 2000 to 2009 to focus on more current trends.

2. Time trends of labor productivity of firms by ownership

With this study's aim to compare the longitudinal performance trends of the different ownerships, <Table 2> show the trends of labor productivity measured as sales per worker.[4] The difference shows how PEs performed better than other ownership types based on average performance. The prominent feature in the trends is the significant advancement of PEs compared with their FEI rivals. For example, <Table 2> show that sales per worker of PEs in the sample doubled from 191.2 in 2001 to 440.2 in 2009, whereas those of FIEs increased minimally from 275.6 to 369.7 during the period. The labor productivity of PEs eventually surpassed that of FIEs in 2007. Consequently, the productivity difference of PEs compared with that of FIEs turns positive in 2007 from a gap of -84.3 in 2001. In recent years, private ownership has achieved significant improvement on economic performance.

A robust econometric analysis is necessary to confirm the changing performance of ownership while other variables that could affect firm performance are controlled. Given the conspicuous trend that PEs are on performance bound forward in China, determining the mechanism is worthwhile. The following chapter will proceed with the econometric analysis.

<Table 2> Labor productivity by ownership: sales per worker

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Sales per worker (1,000 yuan)	Full	n/a	195.3	218.0	241.9	256.2	282.7	322.8	353.0	372.8	425.0
	① State	n/a	99.1	110.8	124.3	145.8	174.8	202.0	249.8	273.9	320.0
	②Private	n/a	191.2	213.3	236.5	251.5	281.5	323.8	356.7	380.2	440.2
	③Foreign	n/a	275.6	290.1	303.2	295.8	305.8	336.4	348.9	350.9	369.7
	②-①	n/a	92.14	102.5	112.2	105.7	106.7	121.8	106.9	106.3	120.2
	T-test	n/a	***	***	***	***	***	***	***	***	***
	②-③	n/a	-84.3	-76.8	-66.7	-44.3	-24.2	-12.6	7.8	29.4	70.5
	T-test	n/a.	***	***	***	***	***	***	**	***	***

4) Labor productivity is estimated by sales per worker. Although value added per worker or value added per worker hour is generally used to measure labor productivity, calculating the exact value added from the data is difficult because of missing data and other data problems.

III. Theoretical perspectives on performance change based on ownership

Following the previous section wherein the upward trend in relative performance of PEs compared with FIEs and SOEs was confirmed, this section explores the factors enabling PEs to achieve the improvement. Hypotheses were formulated and developed from the nature and business goals of ownerships in China.

A firm's ownership type influences its performance for several reasons. First, differences in identity and resource endowments determine incentives and ability to attain economic goals. Second, the divergent goals of owners result in different influences on firm performance (Douma et al., 2006). Ownership type affects the distribution of profits among stakeholders and investment for profits for further growth (Coase, 1960). These different economic behaviors of various ownership types could lead to different influences at the firm level. In the following sections, investment and firm size are used as key variables to improve labor productivity as well as to develop several hypotheses based on the resource-based view and multinational corporations (MNCs) theory.

1. Ownership and investment

Investment is generally recognized as essential to improving labor productivity. Investment in physical capital, specifically machinery and equipment, is associated with the adoption of the latest technologies—a key to growth in labor productivity. By investing in machinery and equipment, workers are equipped with the latest technologies, which, in turn, allow them to improve their business processes and produce more and higher-quality goods and services. Capital accumulation improves labor productivity by increasing the capital-labor ratio (substituting capital for labor).

The resource-based view emphasizes that the competitive advantage of a firm lies primarily in the application of a bundle of valuable tangible or intangible resources at the firm's disposal (Wernerfelt, 1984; Penrose, 1959). However, the resource-based view of firm growth implies the existence of differences in the investment behavior of a firm between PEs in developing countries, such as China, and FIEs from developed countries. Matthews (2002)

stated that for firms in developing economies, diverse critical resources for business are not easily available either within the firm or from other neighboring firms. Thus, firms in developing economies are eager to acquire critically lacking resources and improve their availability, resulting in a higher propensity to invest. Profit is sought mainly for use in further expansion of the firm's resources, and not simply to distribute back to shareholders (Lee and Temesgen, 2008). A considerable proportion of accounting profit may be reinvested for additional growth. Through this process, firms in developing countries that began at a low productivity level can rapidly improve their labor productivity over time.

On the contrary, FIEs from advanced economies can access diverse resources easily from their parent corporation. Foreign subsidiaries share technical and managerial knowledge with the parent corporation because parent corporations transfer capabilities to host country subsidiaries (Javorcik et al, 2004). Therefore, the main task of foreign subsidiaries in China is to utilize the transferred resources and seek profits. Accordingly, unlike PEs, FIEs have no strong incentive to invest for further expansion of internal resources. Parent corporations maximize profits 'on a global basis'. Thus, they appear to be cautious with entering into long-term major investments in a specific host country compared with domestic capital in which it has its roots there. Rather, they tend to repatriate more profits over time and not to expand investments once they successfully settle in a host country (Seabra and Flach, 2005). Dunning (1981) also suggested that multinational corporations tend to withdraw from the host country or not to expand their international investment over time if they lose the location advantage because of increasing prices or the absence of tax breaks in the long run. Thus, investments in FIEs tend to be stagnant or to decrease in the long run. The low investment of FIEs could lead to the stagnation of capital-labor ratio and productivity.

Lastly, SOEs differ significantly from PEs and FIEs. The resources they need for business are largely offered by the government. Thus, SOEs are not as eager to acquire the resources as PEs. The goal of SOEs is to promote public interest rather than maximize profits. Hence, SOEs traditionally tend to invest in areas of nationwide priority, such as natural resources, utilities, telecommunication services, and defense without serious consideration on profit. SOEs can hardly be expected to use resources effectively without strong profit motive under government control. The above discussion implies that SOEs invest under government instructions and utilize resources acquired by

investment less effectively than PEs. Thus, SOEs invest inefficiently and thus do not attain high productivity by investment in the long run.

2. Ownership and firm size effect

The discussions in the previous section indicate the meaningful implications of the relation between firm size and labor productivity. If the main goal of PEs in China is to acquire and expand critically lacking resources as the resource-based view suggests, they could achieve improvements in productivity and higher growth at once by investing for further expansion of the firm's resources and exploiting the added resources, leading to 'economies of growth' (Penrose, 1959). PEs pay for 'growth costs' to improve capabilities in terms of machinery and equipment, workers, managers, R&D team, brand power, and so on (Lee and Temesgen, 2008), which are new and lacking resource for these firms. Acquiring new advanced resources allow PEs not only to improve their productivity but also to increase their firm size, which implies the 'economies of growth'. When the 'economies of growth' works, the size of a firm is significantly and positively related with labor productivity.

On the other hand, FIEs with advanced resources from their parent corporations have no need to search actively for new additional ones in a host country. They can access diverse resources easily from within the firm or from a parent corporation (Mathews, 2002). FIEs can bring significant resources from their parent companies into production process. Thus, their investments for resources are intended mainly to replenish the exhausted or augment the same ones for more production. Even in these cases, 'economies of scales' could exist, leading to an increase in productivity. However, increases in productivity through economies of scales with no change in average cost function are less than that through economies of growth with the reduction of average cost in case of PEs in developing countries. The size of a FIE is less positively related with labor productivity than that for a PE.

Lastly, SOEs are not as eager to acquire new advanced resources as PEs because they have no incentive to maximize profit by improving productivity under government control. Consequently, SOEs can hardly be expected to attain productivity and size growth simultaneously through investment as suggested by the 'economies of growth'. Therefore, the size of an SOE is less positively related with labor productivity than that of a private firm.

The theoretical discussions thus far suggest that the investment behavior of a firm and the effects of investment and firm size differ among PEs, FIEs, and SOEs. Thus, *H1, H2,* and *H3* derived from the discussions above are tested:

H1: Private ownership has higher propensity to invest than other ownership types, which leads to the rapid growth of labor productivity of private enterprises compared with other ownership types.

H2: The investment of a state-owned enterprise is unrelated with labor productivity than other ownership types.

H3: The size of a firm is positively related with labor productivity; however, the size effect of a private firm is larger than that of a foreign (or state-owned) firm.

IV. Testing the hypotheses

1. Key variables description: Investment and firm size

Two of the most important explanatory variables used in this chapter are investment and size variables. These variables are expected to highlight the differences in labor productivity based on ownership type as proposed in the hypotheses. H1 notes that private ownership has higher propensity to invest than other ownership types, which leads to the rapid growth of labor productivity of PEs compared with other ownership types. Thus, the investment by ownership type is examined using descriptive data from each year within the period of the sample. The question of whether PEs have invested more actively than SOEs and FIEs addressed via a two-group mean comparison test (t-test). And the study described the annual trends of firm size by ownership types as measured by average sales, which is related with H3.

Panel A in <Table 3> shows the longitudinal changes of investment ratio between PEs and FIEs (or SOEs). The difference is the average of capital

expenditures relative to sales ($\frac{\triangle Tangible\ Fixed\ Assets_{i,t}}{Sales_{i,t-1}}$) of PEs minus FIEs (or SOEs); hence, positive values in panel A indicate that on average, PEs tend to have higher propensity to invest than other ownership types during the period. T-test shows that the findings are significant at 1% level, which strongly supports H1, that is, private ownership has higher propensity to invest than other ownerships.

Panel B shows the time-trend of average sales by ownership types and indicates the changing size of a firm by ownership type over time. The most impressive feature in panel B is the significant increases in sizes of PEs and SOEs compared with FIEs in the later period of 2004 - 2009. During the period, the sizes of PEs and SOEs rapidly increased by more than 60%, whereas those of FIEs increased by approximately 40%. It is a striking contrast from the fact that the increases in the size of both PEs and FIEs stagnated in the early period, 2000-2004.

<Table 3> Time-trend of investment and size by ownership

Variable	Owner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
(A) Investment (Capital expenditures relative to sales: %)	Full	0.2	2.6	3.6	2.5	1.2	2.3	2.3	2.3	1.9	5.2
	State	–1.4	4.4	5.6	1.6	–3.8	–2.1	0.5	1.0	–2.1	9.9
	Private	1.1	2.7	3.8	3.0	1.9	2.8	2.6	2.7	2.4	5.6
	Foreign	–1.1	1.7	2.5	1.4	0.4	1.3	1.2	1.1	0.3	3.3
	Private-Foreign	2.2	1.0	1.3	1.6	1.5	1.5	1.4	1.6	2.1	2.3
	T-test	***	***	***	***	***	***	***	***	***	***
	Private-State	2.5	–1.7	–1.8	1.4	5.7	4.9	2.1	1.7	4.5	–4.3
	T-test	***	***	***	***	***	***	***	***	***	***
(B) Size (Average Sales: 1,000 yuan)	Full	39,206	36,623	39,028	41,154	36,200	41,335	44,751	48,328	45,808	53,860
	State	53,315	48,180	52,609	58,409	59,538	68,267	73,577	82,086	83,080	95,864
	Private	31,002	29,743	32,214	34,381	30,070	34,911	38,106	41,560	39,913	48,463
	Foreign	54,323	53,176	56,178	59,888	54,629	61,055	67,277	72,210	69,061	75,359

2. Estimation methodology

This paper utilizes the following regression methods to test the hypothesis explaining how the investment and size of a firm influence the changing labor productivity by ownership type. Panel regression method is adopted as in the previous section.

$$LP_{i,t} = \beta_0 + \beta_1 \begin{bmatrix} size \\ inv \end{bmatrix} + \beta_2 \begin{bmatrix} size \\ inv \end{bmatrix} O_p + \beta_3 \begin{bmatrix} size \\ inv \end{bmatrix} O_s + \beta_4 O_p + \beta_5 O_s + \alpha F_{i,t-1} + \mu_i + \mu_t + \epsilon_{i,t} \qquad (1)$$

where subscript t refers to time; $LP_{i,t}$ is the labor productivity of firm i at time t; and $F_{i,t-1}$ is a vector of variables including firm characteristics, such as firm age, leverage, and liquidity (one-year lagged values employed in the regression to escape possible simultaneity bias). These variables are measured by using the log of age, total debt ratio, and current ratio; *size* is a key variable representing firm size, measured by the log of total sales of a firm; *inv* is also a key variable showing investment propensity as measured by capital expenditures relative to sales ($\frac{\triangle Tangible\ Fixed\ Assets_{i,t}}{Sales_{i,t-1}}$); and O_s and O_p are dummy variables for state and private ownership, respectively. Thus, $\begin{bmatrix} size \\ inv \end{bmatrix} O_s$ and $\begin{bmatrix} size \\ inv \end{bmatrix} O_p$ are interacting terms of *size* (and *inv*) and ownership dummy variables; μ_i is the time-invariant heterogeneity across firms, that is, specific to firm i but not included in the explanatory variables; μ_t is a full set of year dummies; and $\epsilon_{i,t}$ is the error term.

The baseline firms are FIEs, and thus, the coefficient on interacting terms of *size* (and *inv*) and PEs β_2 indicates the differences in effect between PEs and FIEs. Similarly, β_3 shows the difference in effect between SOEs and FIEs. The estimation method adopted to analyze equation (1) is the panel FE model chosen by the Hausman test. The test results are reported.

The previous section shows that private ownership displayed increasing performance compared with other types of ownership over time. <Table 3> shows that the average sales of PEs and SOEs began to increase rapidly at approximately around the mid-2000s, compared with those of FIEs. Thus, a structural change or a turning point on the effect of key variables likely exists. The effect of investment and size by ownership, leading to performance

improvement of a firm, could also have changed over time. Thus, empirical analyses are undertaken on two different periods, 2000 - 2004 and 2005 - 2009, to investigate the changing effect on economic performance.

3. Regression results

Regression results are reported in <Table 4>. Results (1) - (3), (4) - (6), and (7) - (9) are designed to show the effects of investment and size by ownership types in the periods 2000 - 2004, 2005 - 2009, and the whole period, respectively. The focus is on the coefficients of interaction terms, such as the key variables interacting with ownership dummies.

First, in the changing effect of investment by ownership type on labor productivity, the *inv* has positive and significant estimators across regressions except for regression (6). The investment of an FE leads to labor productivity growth. The interaction term between O_p and *inv* has no significant estimate except in regression (6). Thus, the investment efficiency of a PE on productivity is not statistically different from that of a FIE. However, private ownership has a higher propensity to invest than other ownerships as confirmed in the previous section. Hence, H1 is well supported. More investments of PEs have contributed to the rapid growth of labor productivity compared with other ownership rivals. The coefficient of the interaction term between O_s and *inv* is negative and statistically significant in regression (5), implying that the investment efficiency of a SOE could be lower than a FIE and a PE in the later period. And, to test H2, F-test is conducted on the values of $(\beta_1+\beta_3)$ in the later period to determine the investment effect of a SOE on productivity. The values are significantly negative, which means the investments of SOEs were inefficient in the period. The same result is obtained from the robustness test in the next section. Hence, H2 is supported in the later period.

Size effect by ownership is estimated as the coefficients of interaction term between size and ownership dummies, namely, O_s and O_p. The coefficient of *size* is significant and positive, and is robust in all specifications, suggesting that the size of an FE leads to growth in labor productivity. The interaction term between O_p and *size* generates significantly positive estimate in the later period. In other words, the size effect of a PE on productivity is larger than that of an FIE at least in the late 2000s. Therefore, H3 is well supported between PEs and FIEs in the later period. Unlike H3, the coefficient of the

interaction term between O_s and *size* is positive and statistically significant in the later period, which is similar to the interaction term between O_p and size. Thus, H3 is not supported between PEs and SOEs. Similar to PEs, SOEs enjoy positive size effect on labor productivity. Overall, regression results confirm that the positive effects of investment and size are common among ownership types, but the size of effects differs among PEs, FIEs, and SOEs.

<Table 4> Estimation results: effects of size and investment on labor productivity

FE Model	Early Period			Later Period			Whole Period		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Inv	15.39	18.85	19.28	14.45	11.31	1.69	35.38	43.9	34.22
	(4.43)***	(2.82)***	(2.88)***	(4.46)***	(1.79)*	(0.22)	(16.88)***	(9.74)***	(7.56)***
State**Inv*		–3.7	–2.59		–26.03	–16.92		–34.77	–25.44
		(–0.34)	(–0.24)		(-1.95)*	(–1.01)		(–3.96)***	(–2.89)***
Private**Inv*		–5.1	–5.92		6.39	17.13		–7.15	4.2
		(–0.64)	(–0.74)		(0.77)	(2.05)**		(–1.41)	(0.82)
Size	53.1	51.52	53.25	31.46	74.34	30.93	75.93	105.36	75.91
	(17.97)***	(28.61)***	(17.97)***	(9.14)***	(46.37)***	(8.96)***	(45.19)***	(116.74)***	(44.99)***
State**Size*	10.13		10.07	57.78		59.1	27.51		26.57
	(1.33)		(1.30)	(4.05)***		(4.14)***	(5.10)***		(4.92)***
Private* *Size*	–3.31		–3.57	52.58		53.26	38.82		38.96
	(–0.95)		(–1.02)	(14.03)***		(14.15)***	(20.81)***		(20.77)***
Age(t–1)	–7.71	–7.85	–7.71	8.18	8.06	8.1	–6.04	–6.48	–6.01
	(–3.45)***	(–3.52)***	(–3.45)***	(3.54)***	(3.49)***	(3.51)***	(–5.12)***	(–5.50)***	(–5.10)***
Debt ratio(t–1)	–1.68	–1.37	–1.55	–2.31	–0.83	–2.14	–8.33	–10.13	–8.5
	(–0.29)	(–0.24)	(–0.27)	(–0.46)	(–0.17)	(–0.43)	(–2.66)***	(–3.24)***	(–2.72)***
Current ratio(t–1)	–3.45	–3.35	–3.41	1.06	0.99	1.05	0.1	–0.21	0.06
	(–1.94)*	(–1.88)*	(–1.91)*	(0.74)	(0.69)	(0.73)	(0.1)	(–0.22)	(0.06)
Constant	–296.13	–293.44	–295.78	–295.01	–308.9	–295.38	–684.15	–681.42	–684.87
	(–9.85)***	(–9.82)***	(–9.83)***	(–9.62)***	(–10.09)***	(–9.63)***	(–37.39)***	(–37.28)***	(–37.43)***
R2	0.06	0.06	0.06	0.06	0.06	0.06	0.11	0.11	0.11
N	161,534	161,534	161,534	361,997	361,997	361,997	603,148	603,148	603,148
F-value	5.01***	5.01***	5.01***	4.94***	4.94***	4.94***	4.74***	4.74***	4.74***
Hausman Test	142.1***	139.2***	158.5***	121.5***	119.4***	131.5***	98.4***	97.4***	106.3***

Note: 1. The t-value is in parentheses. 2. . ***, **, and * in the cells indicate 1%, 5%, and 10% levels of significance, respectively. 3.Year, industry, and region dummy are included, but the results are not reported

4. Robustness test

$$LP_{i,t} = \beta_0 + \beta_1 \begin{bmatrix} size \\ inv \end{bmatrix} + \beta_2 \begin{bmatrix} size \\ inv \end{bmatrix} T + \beta_3 T + \alpha F_{i,t-1} + \mu_i + \mu_t + \epsilon_{i,t} \quad (2)$$

Equation (1) is transformed into equation (2), which will include time-period dummy T to check for robustness. Key variables *size* and *inv* interact with a time-period dummy to check the changing effects of size and investment on productivity as seen in <Table 5>. Utilizing the interacting term of time and key variables indicates their time varying tendency. The firm samples of PEs, FIEs, and SOEs will be run separately in the regressions.

The results of the estimated coefficients and significances in <Table 5> are in line with those presented in the previous section, which is reassuring. The investment of a firm has positive and significant estimators across regressions except regression (1). The investment effect of a SOE has reduced in the later period with significance across regressions; these of a PE and a FIE also have been down over time but not consistently significant among regressions. The size of a firm is positively related with labor productivity at the 1% significance level across regressions. The size effects of a private and state-owned firm have increased over time, whereas that of a FIE remained stagnant.

<Table 5> Robustness test: effects of size and investment on labor productivity

FE Model	State			Private			Foreign		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Period	–300.09	–16.09	–300.37	–203.98	0.53	–203.09	–15.5	–11.98	–14.67
	(–10.71)***	(–4.9)***	(–10.7)***	(–15.7)***	(0.38)	(–15.7)***	(–0.9)	(–5.6)***	(–0.85)
Inv	7.08	22.24	20.83	34.46	43.54	41.2	28.19	38.02	38.01
	(1.43)	(3.28)***	(3.08)***	(13.60)***	(8.60)***	(8.14)***	(6.43)***	(5.32)***	(5.32)***
Inv* Period		–28.18	–28.57		–11.88	–8.83		–15.43	–15.39
		(–2.93)***	(–2.99)***		(–2.07)**	(–1.54)		(–1.74)*	(–1.54)
Size	73.74	92.75	74.78	83.66	101.04	83.78	87.66	88.03	87.84
	(18.76)***	(26.1)***	(18.9)***	(55.8)***	(98.0)***	(55.8)***	(41.7)***	(50.9)***	(41.7)***
Size* Period	27.26		27.3	20.64		20.58	0.33		0.26
	(10.20)***		(10.21)***	(15.89)***		(15.83)***	(0.2)		(0.16)
Age (t–1)	–4.64	–6.29	–4.37	–7.89	–8.17	–7.88	–47.22	–47.17	–47.16
	(–1.07)	(–1.44)	(–1.01)	(–6.65)***	(–6.88)***	(–6.64)***	(–19.2)***	(–19.2)***	(–19.2)***
Debt Ratio (t–1)	24.8	21.13	24.7	–15.94	–16.27	–15.98	22.09	22.12	22.14
	(2.36)**	(2.00)**	(2.35)**	(–4.33)***	(–4.42)***	(–4.34)***	(3.31)***	(3.31)***	(3.31)***

Constant	–764.01 (–18.43)***	–954.25 (–25.09)***	–776.47 (–18.64)***	–701.15 (–48.21)***	–871.97 (–88.11)***	–702.57 (–48.21)***	–700.91 (–33.31)***	–704.97 (–41.14)***	–703.04 (–33.35)***
R2	0.08	0.07	0.08	0.05	0.05	0.05	0.04	0.04	0.04
N	24,218	24,218	24,218	450,567	450,567	450,567	128,363	128,363	128,363
F-value	5.24***	5.24***	5.24***	4.27***	4.27***	4.27***	6.43***	6.43***	6.43***
Hausman test	121.3***	119.0***	124.5***	91.8***	96.7***	100.3***	77.4***	82.7***	89.7***

Note: 1. The t-value is in parentheses. 2. ***, **, and * in the cells indicate 1%, 5%, and 10% levels of significance, respectively. 3.Year, industry, and region dummy are included, but the results are not reported.

V. Conclusion

Using the 10-year period (2000 - 2009) data of companies in China, this paper first investigated longitudinal changes in the performance based on ownership type. Utilizing labor productivity as performance measure and panel data regression methods, this paper demonstrates the upward trend in the relative performance of PEs. PEs have more powerful growth in terms of labor productivity than the other types of ownership. And, more importantly, two hypotheses were developed to explain this performance change. These hypotheses are dependent on the resource-based view and MNCs theory. Investment and firm size are set as key variables causing the change in labor productivity, and the hypotheses are tested to determine the different effects of investment and firm size based on ownership type.

Statistical and empirical analyses confirm the hypotheses. First, regarding the effect of investment on productivity, PEs have a higher propensity to invest than other ownerships, resulting in the rapid growth of labor productivity of PEs as compared to FIEs and SOEs. Investment trend analysis using t-test confirms that PEs constantly displayed higher investment ratio than other ownership types. Regression results indicate that investment contributed to the growth of labor productivity. No significant difference in investment efficiency is indicated between PEs and FIEs. However, the efficiency of investment of an SOE was lower than PEs and FIEs at least in the later period. Overall, the higher propensity of PEs causes more rapid growth in labor productivity than FIEs and SOEs in China.

The size effect of a firm exists regardless of ownership type. However, the

effect of a PE increased significantly over time as compared with FIEs in the later period as proposed in H3. SOEs also increased in size effect on productivity of SOEs also increased during the same period. Therefore, size effect exists regardless of ownership type but differed among ownership types.

Active investments during the entire period and the size effect from 'economies of growth', particularly during the later period are the main contributors to the increase in productivity of PEs. Consequently, labor productivity of PEs eventually exceeded that of FIEs in 2007. FIEs have no active investment activity and no increase in size effect, which caused stagnation in labor productivity. Finally, although SOEs have enjoyed the growing size effect in the later period and have enjoyed improved productivity since 2000, the improvement appears to have stemmed from government policy that terminated small and inefficient SOEs during the period as showed in <Table 1> and not from economies of growth. This study confirms that SOEs have still suffered from the problem of inefficient investment.

In sum, private ownership exhibited an increasing performance over time compared with other types of ownership. Private firms in China achieved higher growth and improvement in productivity at the same time by exploiting the existing resources well and investing actively for further expansion of the firm's resources, which eventually contribute to the rapid performance growth through an increase in size. The conclusion shows the successful catch-ups of Chinese firms in recent years (Lee, Jee, and Eun, 2011).

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