

Research on explanatory factors to determine efficiency of water suppliers in Japan using panel data: focusing on the merger effect on DEA efficiency

JAPPM FUTURE LEADERS CONFERENCE 2019

Feb 29, 2020

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Introduction

- Challenges faced by Japanese water industry
 - Deterioration of facilities
 - Decrease in income due to population decline
 - It is necessary to improve efficiency in order to maintain the water industry

- Aims and Assumptions of Concession Law of 2018
 - Aiming to increase efficiency by
 - ① Changing ownership
 - ② Inducing mergers to take advantage of scale economy
 - It is necessary to check these assumptions

Previous research

- Ownership Effect (Abbot and Cohen, 2009)
 - Ownership structure does not affect the efficiency of water supplier
- Scale Economy (Nakayama,2002, Abbot & Cohen, ibid)
 - Scale economy works up to the suppliers operating less than 100 thousand subscribers
 - Merger under the optimal level is desirable, but the ones beyond that should be avoided
 - This analysis used only cross section data and did not compare directly the efficiency change after mergers for each supplier

Purpose of research

1. Calculating the efficiency of all the retail water supplier in Japan for 10 years from 2007 to 2016 using DEA, and examine the general trends of efficiency change for these 10 years
2. Identifying the suppliers which experienced merger during this period and detect the changes in efficiency after merger for each supplier using longitudinal data

Methodological Problem:

Productivity vs. Efficiency

1. Productivity

- defined by output/input
- measured by estimating production functions or cost functions
- It is possible to know whether scale economy works or not from the shape of the functions in the industry
- However, this approach does not assume **inefficiency** of suppliers

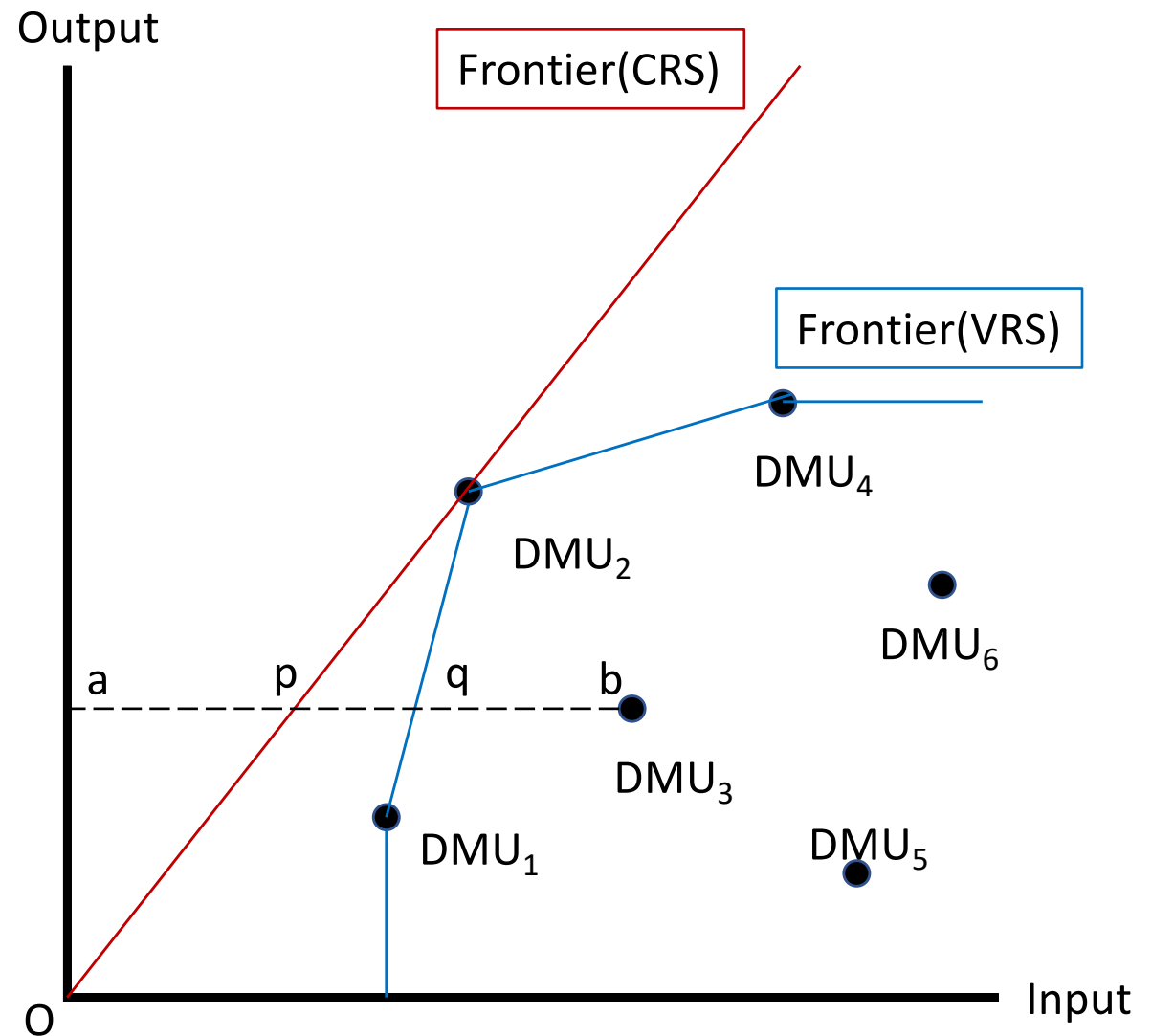
2. Efficiency

- measured by distance from the frontier production function
- Stochastic frontier analysis (SFA) and Data envelopment analysis (DEA) are the commonly used techniques
- SFA does not separate scale efficiency and agency efficiency

Two Concepts of Efficiency in DEA

Fig. 1 DEA The case of 1 input and 1 output

- Determine efficiency values with reference to frontiers composed of the most productive DMUs (decision making units)
- The constant returns to scale model (CRS) and the valuable returns to scale model(VRS)
- CRS: efficiency = ap/ab
VRS: efficiency = aq/ab



Scale Efficiency and Agency Efficiency

- In CRS, efficiency is expressed as the product of VRS efficiency and Scale Efficiency.
- VRS is a model that eliminates the effect of scale on efficiency, so VRS efficiency can be interpreted as Agency Efficiency
- The ratio of the efficiencies of VRS to CRS can be interpreted as scale efficiency

CRS efficiency = Scale efficiency X Agency efficiency

CRS efficiency = a_p/a_b

VRS efficiency (Agency efficiency) = a_q/a_b

Scale efficiency = a_p/a_q

Three Domain of Mergers

- By using VRS, it is possible to divide the production space into three domains:

IRS (increasing return to scale)
CRS (constant return to scale)
DRS (decreasing return to scale)

- Economy of scale is expected to work only for the agencies positioned in IRS domain

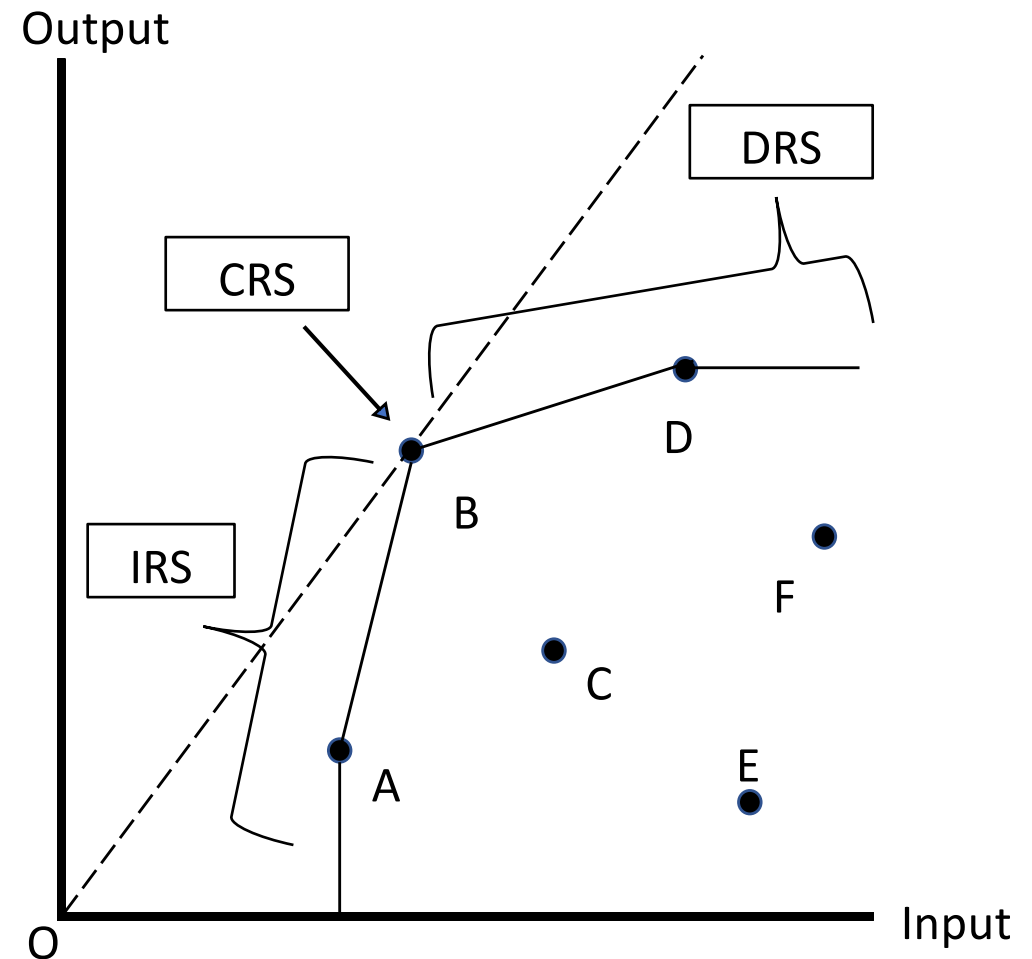


Fig. 2 Three Domains of Mergers

Data and variables

Table 1 The number of retail water suppliers examined

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Number of suppliers	1325	1316	1289	1284	1281	1281	1279	1276	1273	1263

(Data Source: Local Government Enterprise Yearbook for the fiscal year 2007-2016)

Table 2 Variables to measure efficiency

Output Y : annual total volume of water sold (yen)

Input X_1 (labor): the number of workers (person)

X_2 (capital): tangible fixed assets (yen)

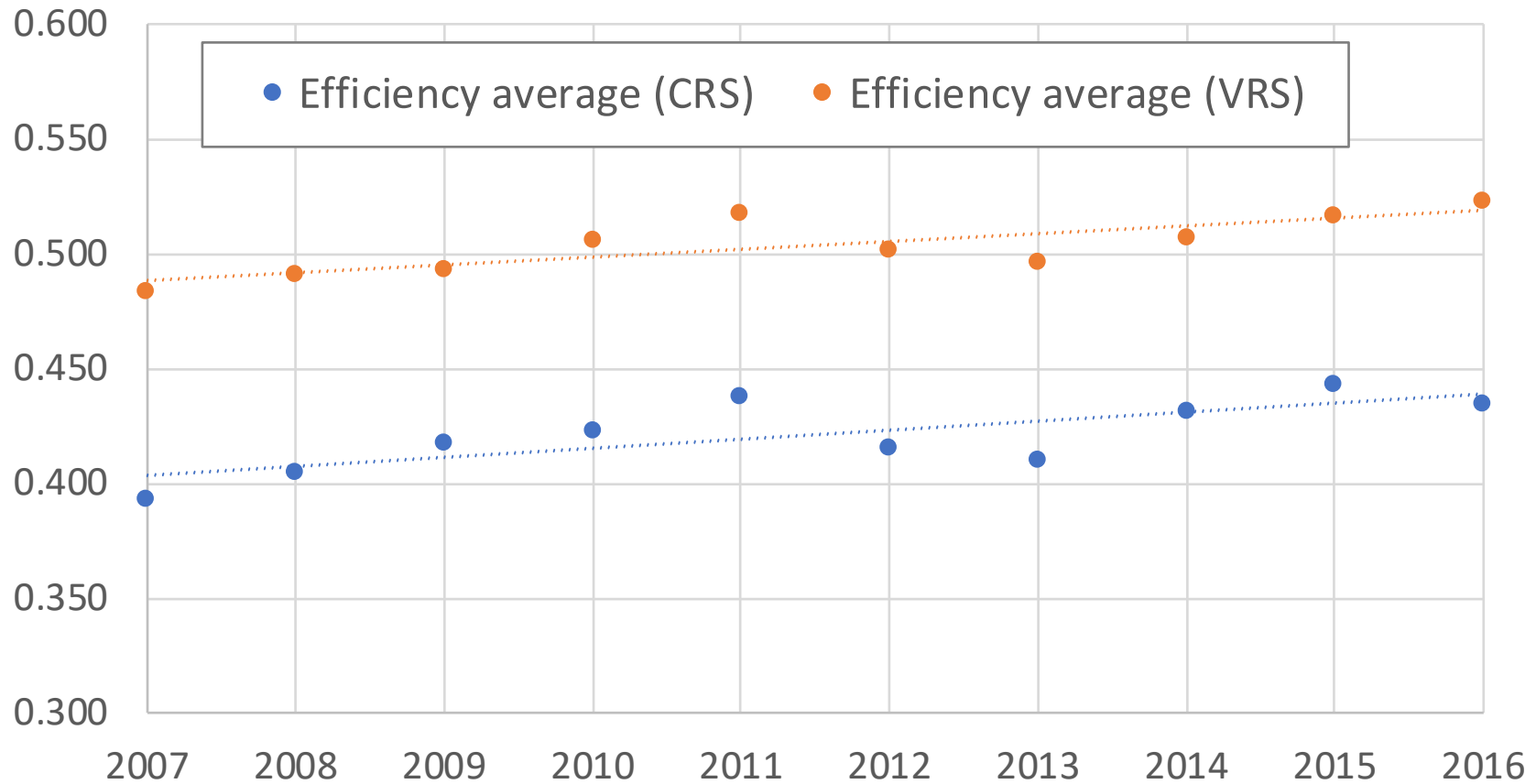
X_3 (other input): sum of variable cost (yen)

Table 3 Annual average of efficiency (2007-2016)

CRS				
Year	Ave.	Std.	Max	Min
2007	0.393	0.143	1	0.059
2008	0.405	0.144	1	0.077
2009	0.418	0.146	1	0.02
2010	0.423	0.147	1	0.067
2011	0.438	0.156	1	0.044
2012	0.416	0.147	1	0.001
2013	0.410	0.148	1	0
2014	0.432	0.149	1	0.001
2015	0.443	0.157	1	0.002
2016	0.434	0.153	1	0.005

VRS				
Year	Ave.	Std.	Max	Min
2007	0.484	0.185	1	0.102
2008	0.491	0.186	1	0.108
2009	0.493	0.184	1	0.107
2010	0.506	0.188	1	0.117
2011	0.517	0.193	1	0.087
2012	0.501	0.190	1	0.07
2013	0.497	0.192	1	0.076
2014	0.508	0.188	1	0.064
2015	0.517	0.193	1	0.092
2016	0.523	0.195	1	0.084

Fig 3 Annual average of efficiency (2007-2016)



Efficiency seems to be increasing year by year

Table 4 Efficiency of Merger Experienced Suppliers

	CRS	VRS
All suppliers	1.018	1.014
After merger experienced	1.153	1.333

There were 48 cases of merger involving 105 suppliers

- the average annual rate of change in the efficiency of all suppliers for 10 years is 1.018(CRS) and 1.104(VRS)
 - the efficiency change one year after merger is 1.153(CRS) and 1.333(VRS)
- positive effects detected on efficiency both for CRS and VRS.

Findings and Discussions (1)

- Both of scale efficiency and agency efficiency worked by merger.
- However, the latter was larger than the former
 - Managerial formalization can be a source of the latter efficiency.
 - the effect of the formalization is larger than technical efficiency improvement.

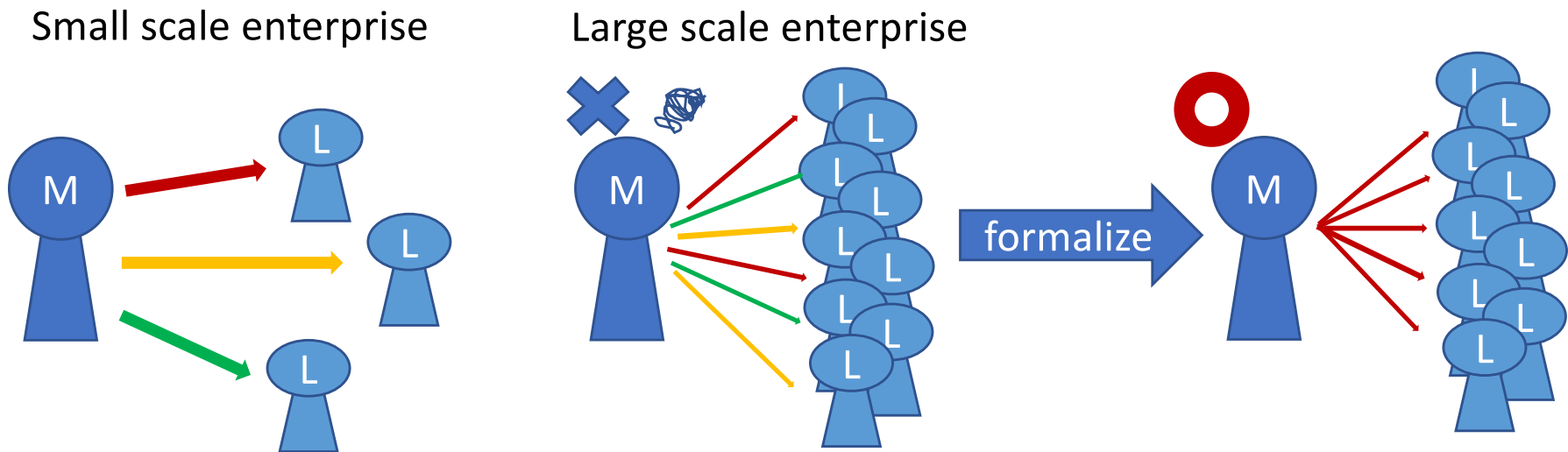


Table 5 Domain Change Patterns by Merger
and Corresponding Efficiency Change Rate

Domain Change Patterns	Number of Suppliers	Efficiency Change Rate after Merger	
		CRS	VRS
IRS-IRS	11	1.179	0.923
IRS-CRS	8	1.094	0.875
IRS-DRS	45	1.256	1.561
DRS-IRS	0		
DRS-CRS	1	0.944	0.921
DRS-DRS	38	1.069	1.302
CRS-IRS	0		
CRS-CRS	0		
CRS-DRS	2	0.640	1.142

Findings and Discussions(2)

- 70 % of merger experience suppliers are positioned in IRS domain
- Actually, CRS efficiencies are larger than 1 for all the mergers in this domain
 - Considering scale efficiency is to be worked in this domain, this result shows most of merger were conducted as rational decisions
- However, not all of VRS efficiencies in this domain are larger than 1
- The largest change of VRS efficiency were observed in the suppliers whose after- merger position were in DRS domain
 - Implying that scale of IRS domains is not large enough for managerial improvement

Conclusion

- A slight positive yearly trend effect was confirmed
- The improvement of the efficiency by merger was higher than the trend effect of the whole water industry
 - > there is economy scale in Japanese water industry, and it is possible to increase efficiency by merger
- The scale efficiency works only for the suppliers in IRS domains. Even so, managerial efficiency is considered to work in DRS domains
 - >the merger in DRS domain is not always decreasing efficiency

Thank you for listening.