
Asymmetry of Inbound and Outbound Open Innovation*

What are the Determinants of the Efficacy of Open Innovation?

June 16, 2009

Beyond the Dawn of Innovation (BDI) Conference, Finland

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*This research was financially supported by Kakenhi #19530390

Agenda

- Research Background
 - Research Questions
 - Framework
 - Data
 - Analysis
 - Conclusion
 - Limitations and Future Research
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Research Background

- “Open Innovation”
 - “Open Innovation (OI) is the use of purposive *inflows* and *outflows* of knowledge to accelerate internal innovation and to extend the external uses of innovation, respectively.” [Chesbrough 2006]
 - Inbound OI
 - Outbound OI

 - “Closed innovation”
 - “In closed innovation, a company generates, develops, and commercializes its own ideas.” [Chesbrough 2003]

 - Eroding factors of closed innovation: shifts in the research environment
 - Increasingly mobile trained workers
 - Enormous increase in venture capital
 - More capable universities and other institutions
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Limitations of Research on “Open Innovation”

- Research methodology
 - Case studies
 - Embedded Linux [Henkel 2006]
 - Open-source software [West et al. 2006]
 - Consumer electronics: sound amplification [Christensen et al. 2005]
 - Interview to non high-tech companies [Chesbrough and Crowther 2006]
 - Survey
 - Laursen and Salter (2006)
 - They examined the relationship between the openness in information search and research & development (R&D) performance. Not OI performance.
 - Most of the past research works are based on case studies or interviews.
 - “No large-scale survey has yet been designed to specifically analyze open innovation.” [West et al. 2006, p.302]
- Research Focus
 - Most of the past research works focused into inbound OI.
- Theory
 - No theoretical framework has been developed.

Research Questions

- The occurrence of open innovation (OI)
 - Is OI a rare phenomenon?
 - Is OI concentrated only in the high-tech sector?
 - Is OI beneficial for large firms or small firms?

 - Is OI a new concept/phenomenon?
 - Is close-open paradigm dichotomy effective?
 - What are differences between the performances of OI and R&D as a whole?

 - Is managing both inbound and outbound OI practically possible?
 - Are they in the same dimension?
 - What are the determinants of inbound and outbound OI?
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Central Process of Open Innovation

- To harness open innovation, a formal system/window for *searching and acquiring external knowledge and providing internal knowledge* is necessary.
 - H1: The institutionalization of the *acquisition/provision system* of technology is positively related to the performance of (H1-1) inbound OI and (H1-2) outbound OI.
- Inbound Open innovation is expected to improve R&D performance.
 - Hypothesis 2: The performance of inbound OI is positively related to the performance of R&D.
 - Hypothesis 3: The performance of R&D is positively related to the performance of outbound OI.

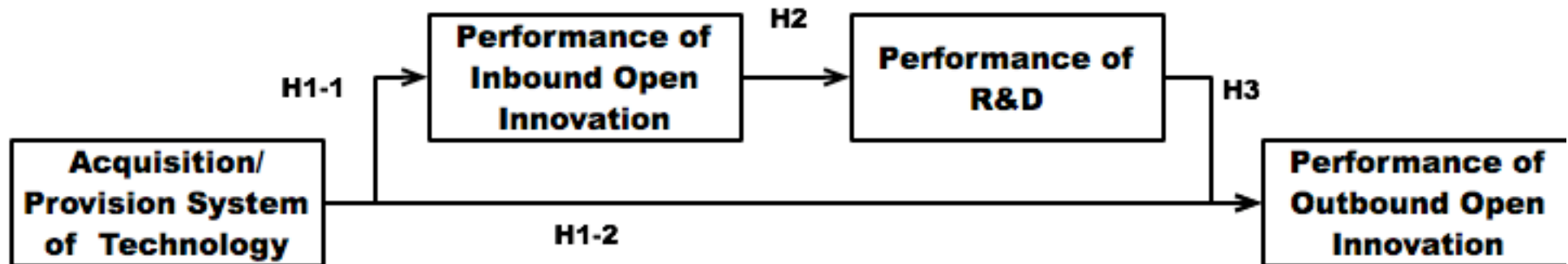
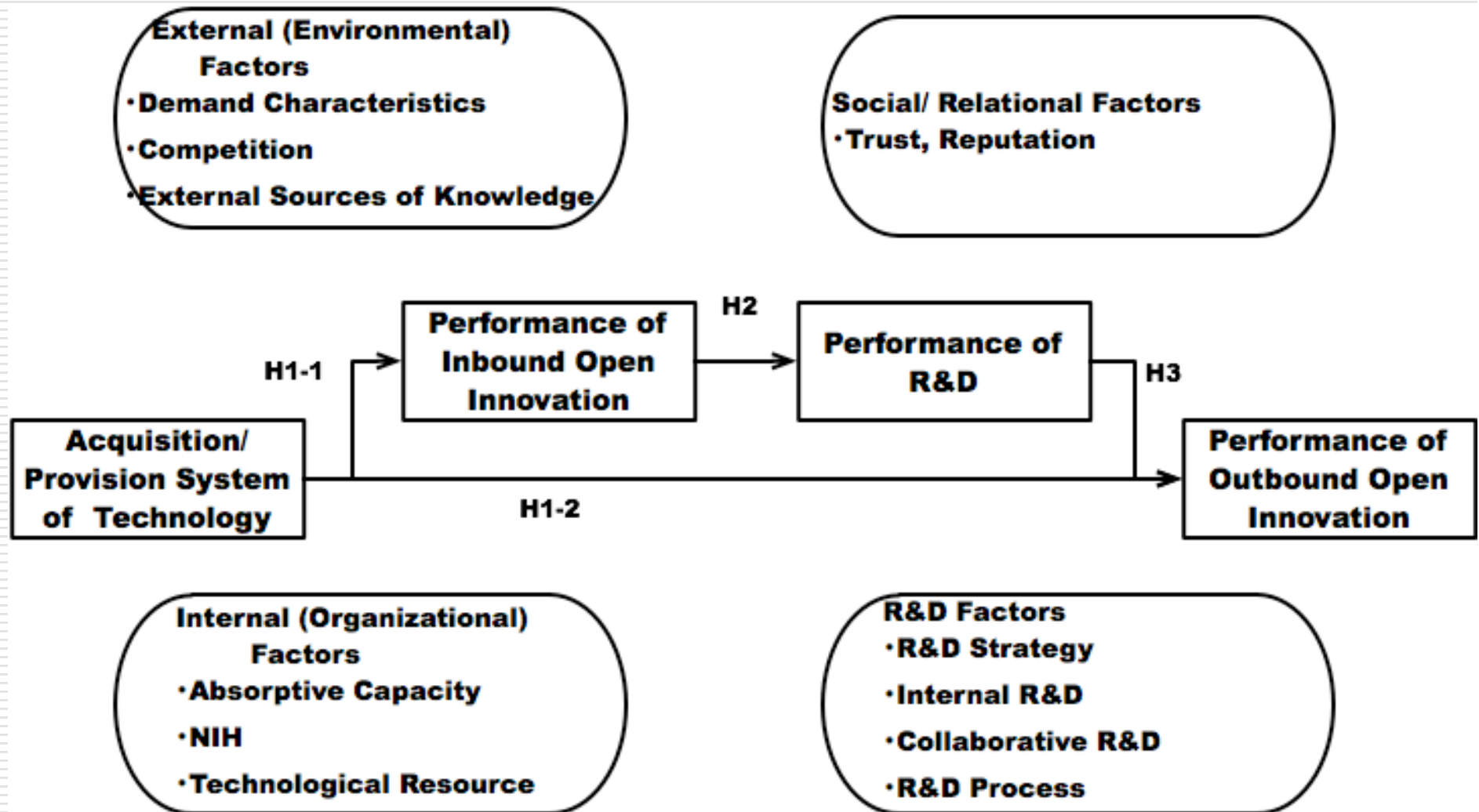


Figure: Central Process of Open Innovation

Framework



Factors and Variables that Affect the Open Innovation Process

- External (environmental) factors
 - Competition
 - Demand variation
 - Availability of external sources of knowledge
 - (+) Venture capital [Chesbrough 2003]
 - (+) Technological start-ups [Chesbrough 2003]
 - (+) Universities [Chesbrough 2003]
 - (+) Users [von Hippel 1988, 2005]
 - (+) *Keiretsu*: Research subsidies
 - Technology/product characteristics
 - Effectiveness of patent protection
 - (+) Technology change [Chesbrough 2003]
 - Customizability of products
 - Importance of R&D
-

Factors and Variables that Affect the Open Innovation Process

- Internal (organizational) factors
 - (+) Absorptive capacity [Cohen and Levinthal 1990]
 - (–) Resistance to external technology/knowledge: the “not invented here” (NIH) syndrome [Katz and Allen 1982]
 - (+) Technological resources
-

Factors and Variables that Affect the Open Innovation Process

- R&D related factors
 - R&D strategy
 - (+) R&D: Marketing Integration [Song and Parry 1992, 1997]
 - R&D diversity
 - Core technology development
 - Platform strategy [Nobeoka and Cusmano 1997]
 - Whether the R&D is patent oriented or black box oriented
 - Whether the firm Utilization/Protective of own technology?
 - Overseas R&D
 - Characteristics of the R&D process
 - Freedom of internal R&D
 - Information sharing/mutual support
 - Cross functional team [Clarke and Fujimoto 1991]
 - Heavyweight project leader [Clarke and Fujimoto 1991]
 - Formalized R&D Process
 - Stage-gate process [Cooper 1986]
 - Front-loading [Thomke 2003]
-

Factors and Variables that Affect the Open Innovation Process

- R&D activity
 - Internal R&D and Collaborative R&D
 - Basic research, applied research, product development, and process research
 - Collaborative R&D Partners
 - Domestic universities
 - Foreign universities
 - Research institutes
 - Rivals [von Hippel 1988]
 - Customers [von Hippel 1988]
 - Suppliers [von Hippel 1988, Nishiguch 1994]
 - Subsidiaries
 - Parent company
 - License-in
 - Acquisition of technology start-ups
 - Other factors
-

Factors and Variables that Affect the Open Innovation Process

- Social relational factors
 - (+) Trust in the firm [Sako 1988]
 - (+) Technological reputation of the firm
-

Data

- Method
 - Mail survey of Japanese manufacturers.
 - Some questionnaire items were developed to measure each construct.
 - The Likert-type five-point scale was employed.
 - Sampling frame
 - Manufacturers listed in the Japanese stock exchange market and having an R&D laboratory.
 - Date
 - Two-wave survey in November 2007 and November 2008.
 - Response
 - 2007: 122/450 (Response rate = 27.1%)
 - 2008: 132/419 (Response rate = 32.0%)
 - N = 254 firms
-

Data

- “No response bias” was not found
 - It was confirmed that there was no difference between the firms that responded and those that did not, in terms of sales and the distribution of industrial classification.

 - No significant difference between the 2007 and 2008 samples.
 - A total of 254 samples were pooled for analysis.
-

Scale Development

- The constructs were measured with subjective judgment scales.
 - For each construct, some questionnaire items were developed and measured with 5-point Likert scale. The reliability of the scales was confirmed with Cronbach's alpha.
 - Examples
 - Performance of inbound OI (Cronbach's alpha = 0.793)
 - *Introduction of external technology has accelerated the firm's R&D speed.*
 - *Introduction of external technology has enabled the development of innovative products in the firm.*
 - *The products of the firm that incorporate external technology have succeeded in the market.*
 - Performance of outbound OI (Cronbach's alpha = 0.780)
 - *The firm's technology is licensed to other firms, which enables them to develop innovative products.*
 - *The products of other firms that have licensed the firm's technology have succeeded in the market.*
 - *The firm's revenue from licensing has increased.*
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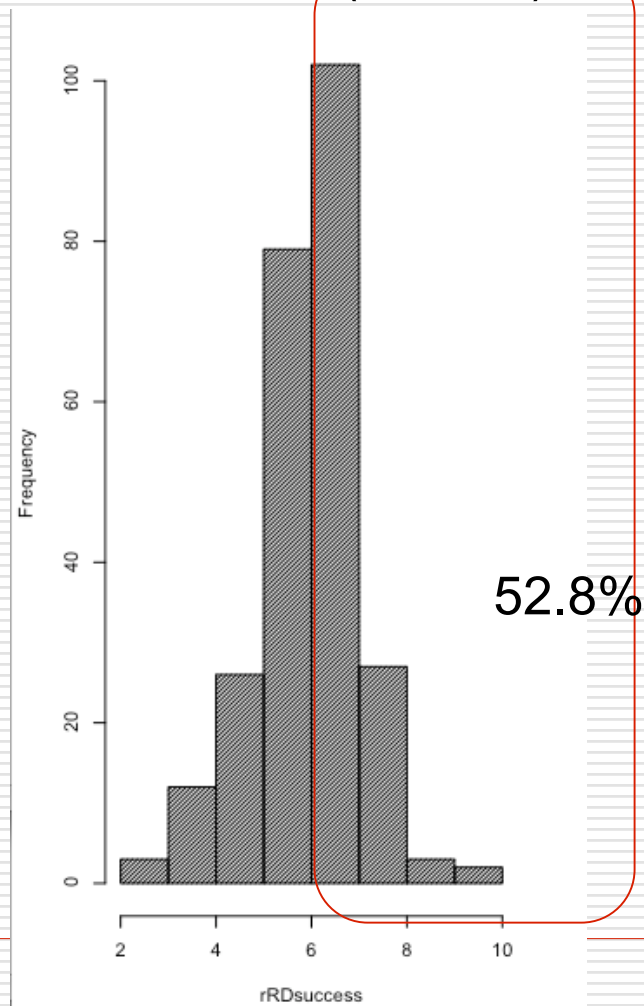
Scale Development

- Technology acquisition/provision window (Cronbach's alpha = 0.591)
 - *The firm has a formal window/system for accepting technological proposals from other firms.*
 - *The firm has a formal window/system for supplying our technology to other firms.*

 - Relative performance of R&D (Cronbach's alpha = 0.598)
 - *The firm's R&D efficiency is better than that of its competitors.*
 - *Most of the firm's R&D output is commercialized.*
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Figure: Histogram of the Relative Performance of R&D

Mean = 6.44 (2 items)



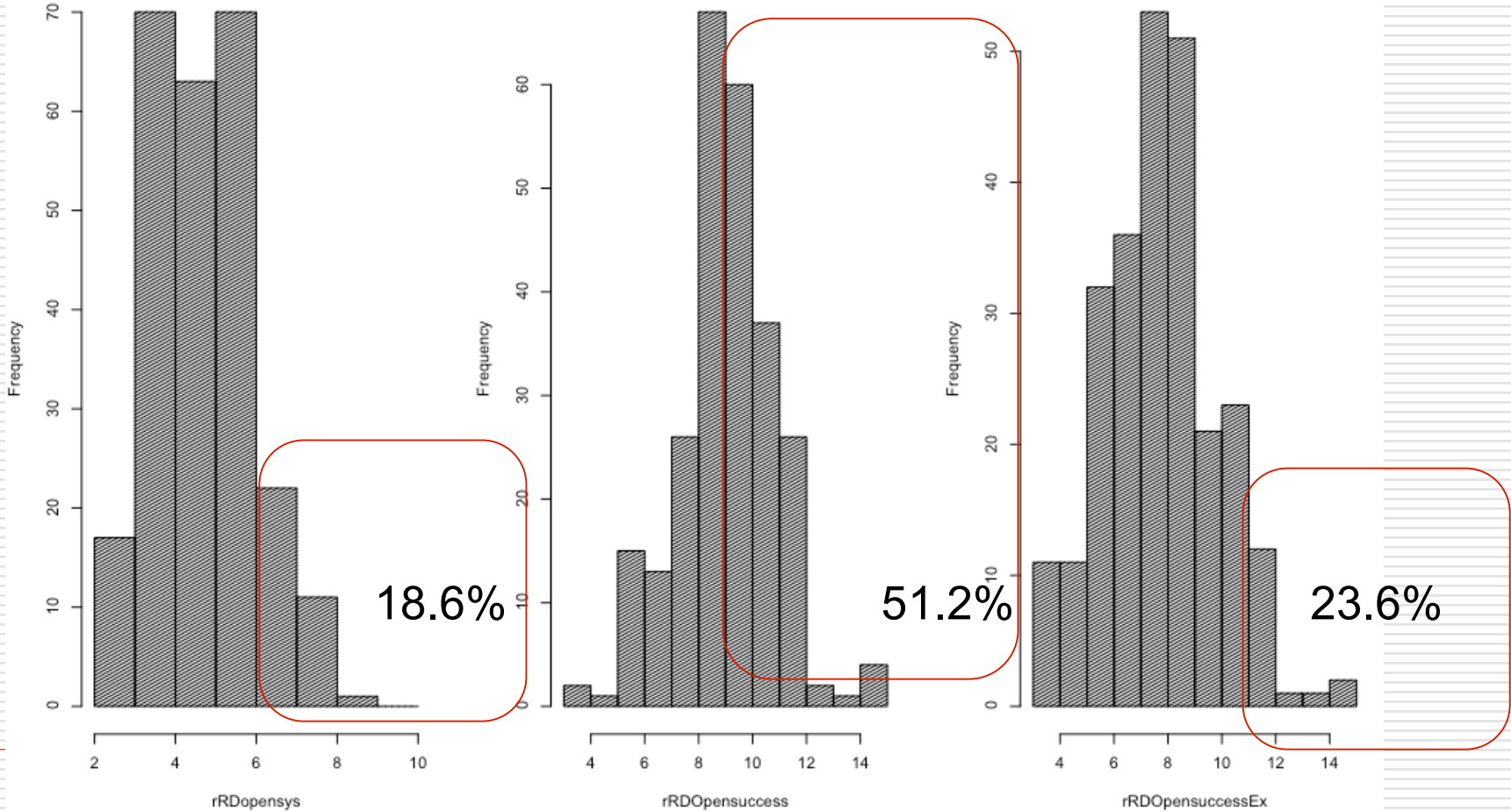
Is OI a rare phenomenon?

Figure: Histogram of the Key Figures

Acquisition/Provision
Mean = 6.44 (2 items)

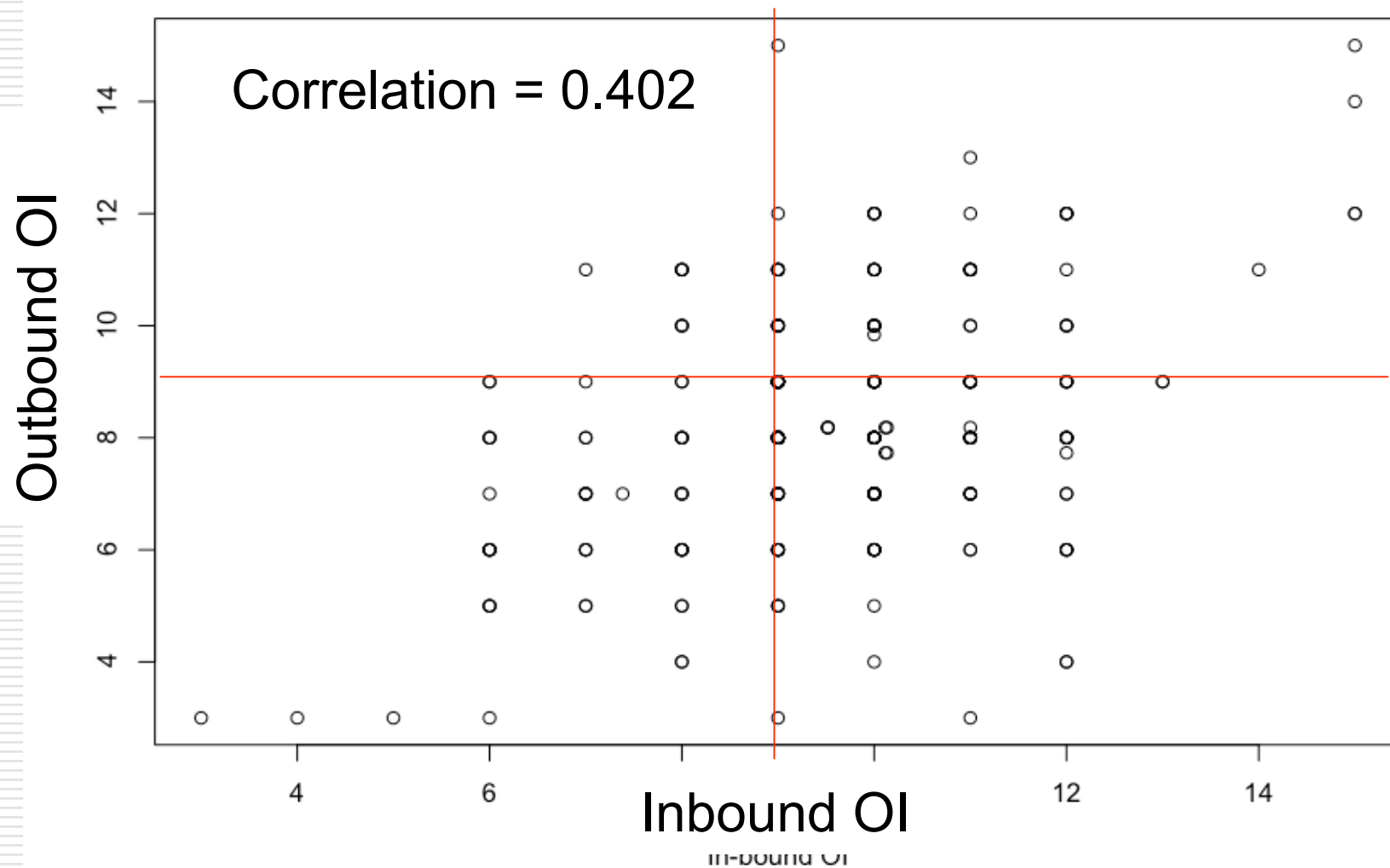
Inbound OI
Mean = 9.52

Outbound OI
Mean = 8.18



Are inbound and outbound OI in the same dimension?

Figure: Relationship Between Inbound and Outbound Open Innovation Performance



Analysis

- *What are the determinants of inbound and outbound OI?*
 - Since the theory on open Innovation is not well developed, we followed an exploratory analysis approach to find the determinants of the following.
 - Institutionalization of scanning/provision window
 - Performance of inbound OI
 - Performance of outbound OI
 - Relative R&D performance
 - Regression analysis and stepwise regression analysis.
 - The following control variables were introduced.
 - Market Share
 - Firm Size: $\log(\text{Sales})$
 - Industry dummy
 - Food, Chemical, Pharmaceutical, Electronics, Automobiles, etc.
 - Year of survey dummy
-

What are the determinants of inbound and outbound OI?

Figure: Results of Stepwise Regression Analysis (OI)

- Three dependent variables are explained by different variables, except,
 - (+) Absorptive capacity
 - (-) Market share
 - They are determined by different variables.

		Acqui/ Provision		In-bound OI		Out-bound OI	
		Est.	t-value	Est.	t-value	Est.	t-value
Intercept		-1.24	-1.31	2.27	2.01 **	1.27	1.23
Acquisition/Provision window				0.23	3.22 ***	0.42	4.51 ***
Competition		-0.09	-1.61	0.10	1.45		
Demand variation		-0.11	-2.36 **	0.13	2.20 **		
Technological Environment	Effectiveness of Patent			-0.15	-2.16 **		
	Technology Change	0.19	3.27 ***	-0.11	-1.44		
	Customizability	0.08	1.82 *	-0.09	-1.58		
External Knowledge	Importance of R&D			-0.09	-1.92 *		
	Venture and Entrepreneurship			0.15	2.21 **		
	Universities	-0.08	-1.79 *			0.11	1.65
Organization/Capability	Research Subsidiaries	0.15	1.73 *	0.24	2.27 **	-0.23	-1.65
	Users						
R&D Strategy	NIH	0.16	2.65 ***	0.34	4.63 ***	0.30	3.11 ***
	Absorptive Capacity	0.35	4.49 ***	0.29	2.79 ***		
R&D Process	Technological Resources			0.16	2.18 **		
	R&D-Marketing Integrity	0.09	2.38 **				
	R&D diversification	0.16	1.82 *	-0.33	-3.19 ***	0.28	2.07 **
	Development Core Tech.			0.23	2.98 ***		
	Platform strategy	0.11	1.36			-0.19	-1.38
R&D Process	Patent or Blackbox					0.23	1.75 *
	Utilization or Protective						
	Overseas R&D						
	Freedom of Internal R&D						
	Information Sharing& Mutual support	0.14	3.35 ***				
Relational	Cross Functional Team			0.11	2.44 **		
	Heavyweight Project Leader	0.11	2.71 ***				
	Formalized R&D Process	0.14	1.88 *				
	Stage-gate Process			0.32	4.31 ***		
In-house R&D	Trust in a Firm	0.13	2.39 **				
	Technical Reputation	-0.08	-2.02 **				
Collaborative R&D	Basic Research					0.18	2.31 **
	Applied Research			0.08	1.40		
Collaborative R&D Partners	New Product Development/Design	-0.27	-1.64	0.60	2.82 ***	-0.46	-1.57
	Production and Process	-0.33	-1.50	1.06	3.45 ***		
		0.49	2.75 ***				
Market Share	Domestic Universities						
	Foreign Universities	-0.23	-1.50	0.30	1.63	0.42	1.70 *
	Research Institutes	0.25	1.52	0.39	1.86 *		
	Rivals						
	Customers			0.30	1.46	0.56	2.23 **
	Suppliers					-0.80	-1.61
	Subsidiaries						
	Parent company						
	license seeking	0.29	1.64				
	Acquisition of Technology Company					1.11	1.49
Firm Size: log(Sales)	Other	-0.08	-1.46	-0.19	-2.88 ***	-0.14	-1.61
		0.07	1.44	-0.14	-2.05 **		
Industry	Food			-0.48	-1.97 **	-0.47	-1.59
	Chemical	-0.27	-1.74 *				
	Pharmaceuticals			0.48	1.87 *	0.89	3.00 ***
	Electronics			0.57	2.52 **	0.76	2.53 **
	Automobiles						
	Machinery	-0.44	-2.16 **				
Other manufacturers	Steel						
				0.31	1.41		
2008 Dummy							
R2		0.441		0.601		0.424	
Adjsted R2		0.382		0.552		0.378	

Pink and blue cells: Positively and negatively significant for 15% level at least.

What are the determinants of inbound and outbound OI?

Figure Determinants of Inbound and Outbound Open Innovation
(t-value for each explanatory variable)

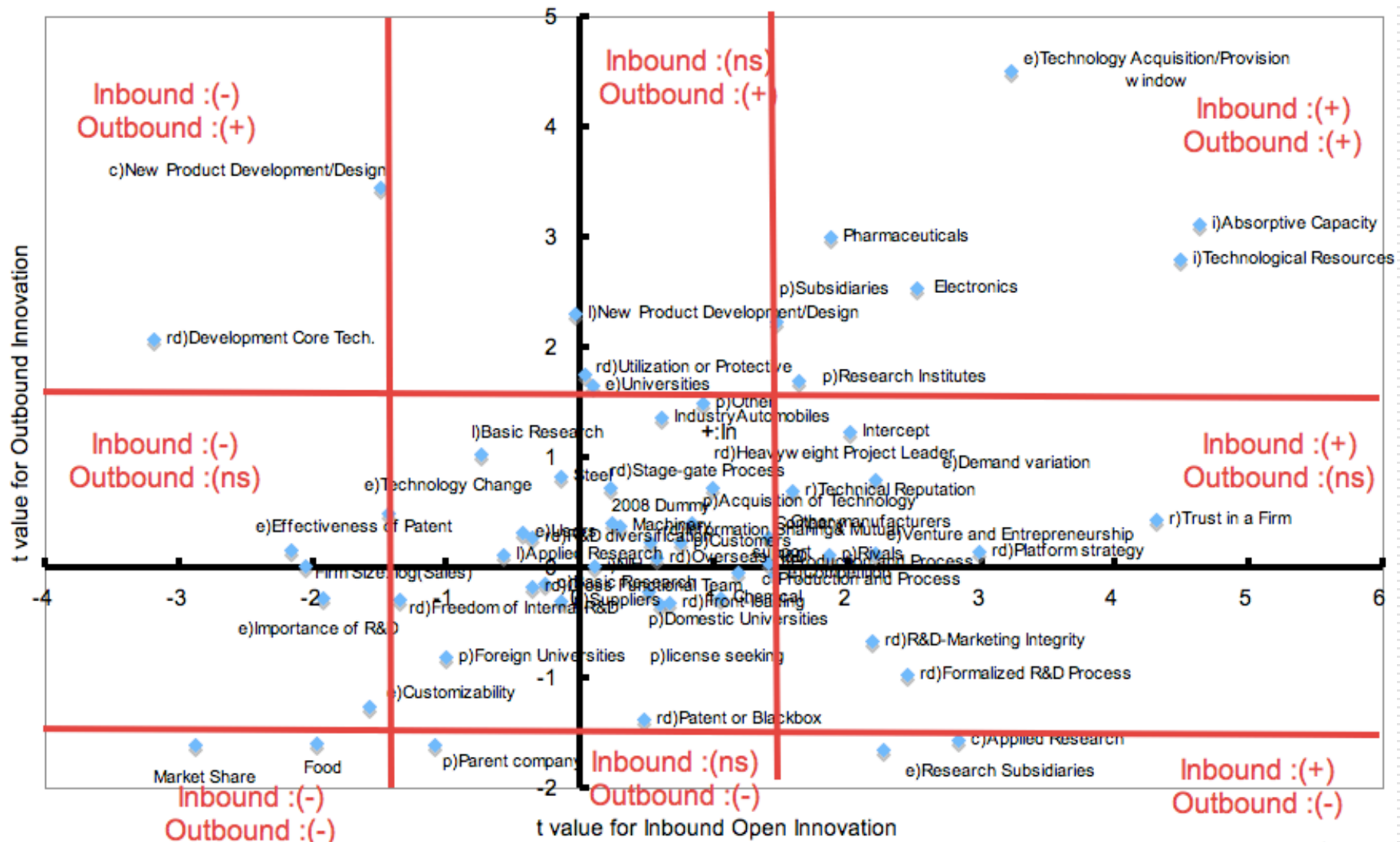


Figure: Results of Stepwise Regression Analysis (OI)

- Is “close”-”open” dichotomy effective?
 - Collaborative research with subsidiaries has positive sign for both inbound and outbound OI.
 - Semi-Open Innovation?

		Scan/ Provision		In-bound OI		Out-bound OI	
		Est.	t-value	Est.	t-value	Est.	t-value
Intercept		-1.24	-1.31	2.27	2.01 **	1.27	1.23
Technology Scanning/Acquire/Provision window				0.23	3.22 ***	0.42	4.51 ***
Competition		-0.09	-1.61	0.10	1.45		
Demand variation		-0.11	-2.36 **	0.13	2.20 **		
Technological Environment	Effectiveness of Patent			-0.15	-2.16 **		
	Technology Change	0.19	3.27 ***	-0.11	-1.44		
	Customizability	0.08	1.82 *	-0.09	-1.58		
	Importance of R&D			-0.09	-1.92 *		
External Knowledge	Venture and Entrepreneurship			0.15	2.21 **		
	Universities	-0.08	-1.79 *			0.11	1.65
Organization/Capability	Research Subsidiaries	0.15	1.73 *	0.24	2.27 **	-0.23	-1.65
	Users						
R&D Strategy	NIH			0.16	2.18 **		
	Absorptive Capacity	0.16	2.65 ***	0.34	4.63 ***	0.30	3.11 ***
R&D Process	Technological Resources			0.35	4.49 ***	0.29	2.79 ***
	R&D-Marketing Integrity			0.16	2.18 **		
	R&D diversification	0.09	2.38 **				
	Development Core Tech.	0.16	1.82 *	-0.33	-3.19 ***	0.28	2.07 **
	Platform strategy			0.23	2.98 ***		
	Patent or Blackbox	0.11	1.36			-0.19	-1.38
Relational	Utilization or Protective					0.23	1.75 *
	Overseas R&D						
	Freedom of Internal R&D						
	Information Sharing& Mutual support	0.14	3.35 ***				
	Cross Functional Team						
In-house R&D	Heavyweight Project Leader	0.11	2.71 ***	0.11	2.44 **		
	Formalized R&D Process	0.14	1.88 *				
Collaborative R&D	Stage-gate Process						
	Front-loading			0.32	4.31 ***		
Collaborative R&D Partners	Trust in a Firm	0.13	2.39 **				
	Technical Reputation	-0.08	-2.02 **				
Collaborative R&D	Basic Research					0.18	2.31 **
	Applied Research			0.08	1.40		
	New Product Development/Design						
Collaborative R&D Partners	Production and Process	-0.27	-1.64	0.60	2.82 ***	-0.46	-1.57
	Basic Research			-0.33	-1.50	1.06	3.45 ***
Industry	Production and Process	0.49	2.75 ***				
	Domestic Universities						
	Foreign Universities	-0.23	-1.50	0.30	1.63	0.42	1.70 *
	Research Institutes	0.25	1.52	0.39	1.86 *		
	Rivals						
	Customers						
	Suppliers			0.30	1.46	0.56	2.23 **
	Subsidiaries					-0.80	-1.61
	Parent company	0.29	1.64				
	license seeking						
Acquisition of Technology Company					1.11	1.49	
Other							
Market Share		-0.08	-1.46	-0.19	-2.88 ***	-0.14	-1.61
Firm Size: log(Sales)		0.07	1.44	-0.14	-2.05 **		
Industry	Food			-0.48	-1.97 **	-0.47	-1.59
	Chemical	-0.27	-1.74 *				
	Pharmaceuticals			0.48	1.87 *	0.89	3.00 ***
	Electronics			0.57	2.52 **	0.76	2.53 **
	Automobiles						
	Machinery	-0.44	-2.16 **				
Steel							
Other manufacturers			0.31	1.41			
2008 Dummy							
Adjusted R2		0.382		0.552		0.424	0.378

Pink and blue cells: Positively and negatively significant for 15% level at least

Figure: Results of Stepwise Regression Analysis (OI)

- Is OI mainly concentrated in high-tech sectors?
 - (+) Pharmaceuticals
 - (+) Electronics
 - (-) Food
 - OI is relatively concentrated in high-tech sectors.

- Is OI beneficial for large firms or small firms?
 - (-) Share
 - OI is beneficial for smaller firms.

		Scan/ Provision		In-bound OI		Out-bound OI	
		Est.	t-value	Est.	t-value	Est.	t-value
Intercept		-1.24	-1.31	2.27	2.01 **	1.27	1.23
Technology Scanning/Acquire/Provision window				0.23	3.22 ***	0.42	4.51 ***
Competition		-0.09	-1.61	0.10	1.45		
Demand variation		-0.11	-2.36 **	0.13	2.20 **		
Technological Environment	Effectiveness of Patent			-0.15	-2.16 **		
	Technology Change	0.19	3.27 ***	-0.11	-1.44		
	Customizability	0.08	1.82 *	-0.09	-1.58		
	Importance of R&D			-0.09	-1.92 *		
External Knowledge	Venture and Entrepreneurship			0.15	2.21 **		
	Universities	-0.08	-1.79 *			0.11	1.65
	Research Subsidiaries	0.15	1.73 *	0.24	2.27 **	-0.23	-1.65
Organization/Capability	Users						
	NIH						
R&D Strategy	Absorptive Capacity	0.16	2.65 ***	0.34	4.63 ***	0.30	3.11 ***
	Technological Resources			0.35	4.49 ***	0.29	2.79 ***
	R&D-Marketing Integrity			0.16	2.18 **		
R&D Process	R&D diversification	0.09	2.38 **				
	Development Core Tech.	0.16	1.82 *	-0.33	-3.19 ***	0.28	2.07 **
	Platform strategy			0.23	2.98 ***		
	Patent or Blackbox	0.11	1.36			-0.19	-1.38
	Utilization or Protective					0.23	1.75 *
R&D Process	Overseas R&D						
	Freedom of Internal R&D						
	Information Sharing& Mutual support						
	Cross Functional Team	0.14	3.35 ***				
	Heavyweight Project Leader						
Relational	Formalized R&D Process	0.11	2.71 ***	0.11	2.44 **		
	Stage-gate Process	0.14	1.88 *				
	Front-loading						
In-house R&D	Trust in a Firm			0.32	4.31 ***		
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Collaborative R&D	Basic Research	-0.08	-2.02 **				
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Collaborative R&D Partners	New Product Development/Design			-0.33	-1.50	1.06	3.45 ***
	Production and Process	0.49	2.75 ***				
	Domestic Universities						
	Foreign Universities			0.30	1.63	0.42	1.70 *
	Research Institutes	-0.23	-1.50	0.39	1.86 *		
Market Share	Rivals	0.25	1.52				
	Customers						
	Suppliers						
	Subsidiaries			0.30	1.46	0.56	2.23 **
	Parent company					-0.80	-1.61
	license seeking	0.29	1.64				
	Acquisition of Technology Company						
	Other					1.11	1.49
	Firm Size: log(Sales)	-0.08	-1.46	-0.19	-2.88 ***	-0.14	-1.61
	Industry	0.07	1.44	-0.14	-2.05 **		
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2008 Dummy							
Adjusted R2			0.382		0.552		
						0.424	
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Pink and blue cells: Positively and negatively significant for 15% level at least

What are differences between the performances of OI and R&D as a whole?

Figure. Results of Step-wise Regression Analysis (Inbound OI & R&D)

- The pattern of relative R&D performance is different from other dependent variables.
 - This indicates that the management of OI and R&D as a whole also have different dimensions.
- Additionally,
 - None of the R&D strategy variables are significant. On the contrary, the R&D process variables such as cross function and heavyweight project leader are positive and significant.
 - This reflects other characteristics of Japanese firms, such their process-oriented outlook and lack of strategy.

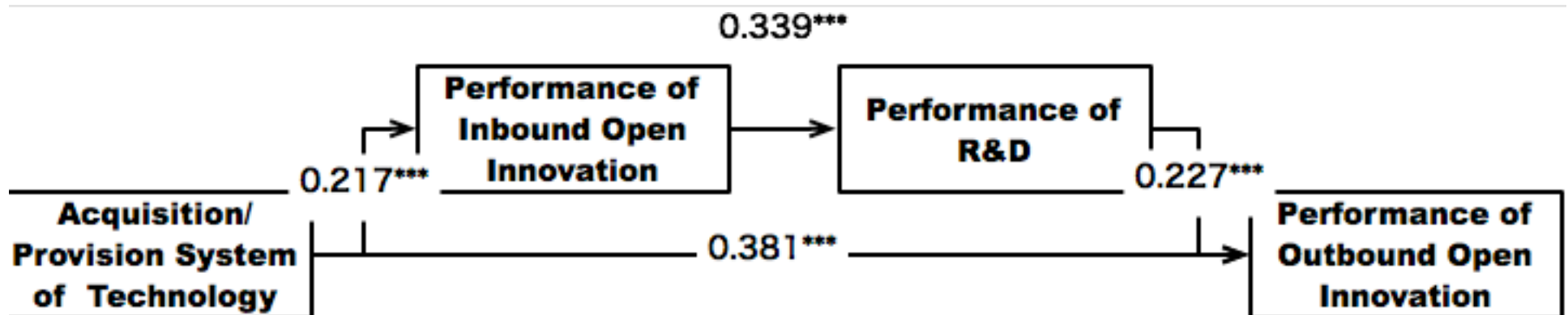
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	Information Sharing& Mutual support				
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Collaborative R&D	Technical Reputation				
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	Applied Research				
	New Product Development/Design	0.08	1.40	-0.08	-1.89 *
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Pink and blue: Positively and negatively significant at least 15% level.

Central Process of Open Innovation

- Hypothesis 1-1&H1-2: The institutionalization of the acquisition/provision system of technology is positively related to the performance of inbound OI and outbound OI.
 - *Supported*
- Hypothesis 2: The performance of inbound OI is positively related to the performance of R&D.
 - *Supported*
- Hypothesis 3: The performance of R&D is positively related to the performance of outbound OI.
 - *Supported*

Figure Estimation Results for Central Process of Open Innovation



Summary

- Occurrence of OI
 - 51.2% of the respondents positively evaluated their performance of inbound OI.
 - 23.6% of the respondents positively evaluated their performance of outbound OI.
 - *Outbound innovation is more difficult to achieve.*
 - 18.6% of the respondents positively evaluated their institutionalization of scanning/acquisition/provision window.
 - This fraction is lower than the evaluation of OI performance. *It indicates that they collaborate informally.*
 - Is OI a rare phenomenon?
 - As indicated by the figures, *OI itself is not rare. However, only 15% of the respondents positively evaluated their inbound and outbound OI.*
-

Summary

- Is OI mainly concentrated in high-tech sectors?
 - The *pharmaceuticals* and *electronics* dummies have positive coefficients and the food dummy has a negative coefficient for inbound and outbound OI performance.
 - *This indicates that OI is relatively concentrated in high-tech sectors.*

 - Is OI beneficial for large firms or small firms?
 - *Market share* has a negative coefficient for inbound and outbound OI performance.
 - *Thus, OI is beneficial for weaker firms.*
-

Summary

- Is managing both inbound and outbound OI really possible?
 - Do they have the same dimension?
 - Their correlation is 0.4, which indicates that they have a distinct dimension.
 - 15% of the firms are successful at both inbound and outbound OI.
 - *Effective management or an advantage arising from the outflow of innovation is difficult to achieve.*
 - What are the determinants of inbound and outbound OI?
 - Acquisition/provision window, absorptive capacity, and technological resources positively affect inbound and outbound OI.
 - Most of the significant variables are different between inbound and outbound OI. This means that there is *asymmetry* between inbound and outbound OI performances.
-

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- What are the differences between the performances of OI and R&D as a whole?
 - Relative R&D and inbound and outbound OI performances are explained by different variables.
 - *This result indicates that OI management requires a different approach from the traditional R&D management.*
-

Contribution

- The first questionnaire survey designed to specifically analyze OI has been conducted.
 - This research work has developed the measurement scales for inbound and outbound OI performances.
 - The similar and different aspects between inbound and outbound OI performances and between R&D and OI performances were presented.
 - Thus, this research work contributes to the understanding of R&D and OI management.
-

Limitations and Future Research

- Exploratory analysis with pooled data.
 - The development and testing of a theoretical model.

 - The concept of open innovation
 - Semi-open innovation
 - In this study's sample, which comprised Japanese manufacturers that have an R&D division, subsidiary has an impact on OI. This indicates that OI is not very open in Japan. Thus, the concept of OI should be modified.
 - “Open or close (Market or organization)” to “market,*intermediate market*, organization ?” is necessary.

 - The research target comprised only Japanese firms.
 - Comparisons with international firms are essential for confirming the generalizability of the findings of this study.
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*Asymmetry of
Inbound and Outbound Open Innovation
What are the Determinants of the Efficacy of Open Innovation?*

June 16, 2009

Beyond the Dawn of Innovation (BDI) Conference, Finland

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