Knowledge and rent spillovers through government-sponsored R&D consortia

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Motivation

- Much attention to R&D consortia as an effective means of promoting innovation

- Important opportunities for SMEs

- Direct knowledge spillovers (consortia members) and indirect rent spillovers (customers) through R&D consortia

- Underestimation of spillover effects of R&D consortia by ignoring rent spillovers

- Promotion of science- and evidence-based science and technology policy in Japan since 2011

Aims of this paper

- To examine knowledge spillover effects by R&D consortia and rent spillover effects on customer firms of the consortia members through business transactions

- Focus on a major support program for R&D consortia in Japan, the "Consortium R&D Project for Regional Revitalization" (CRDP)

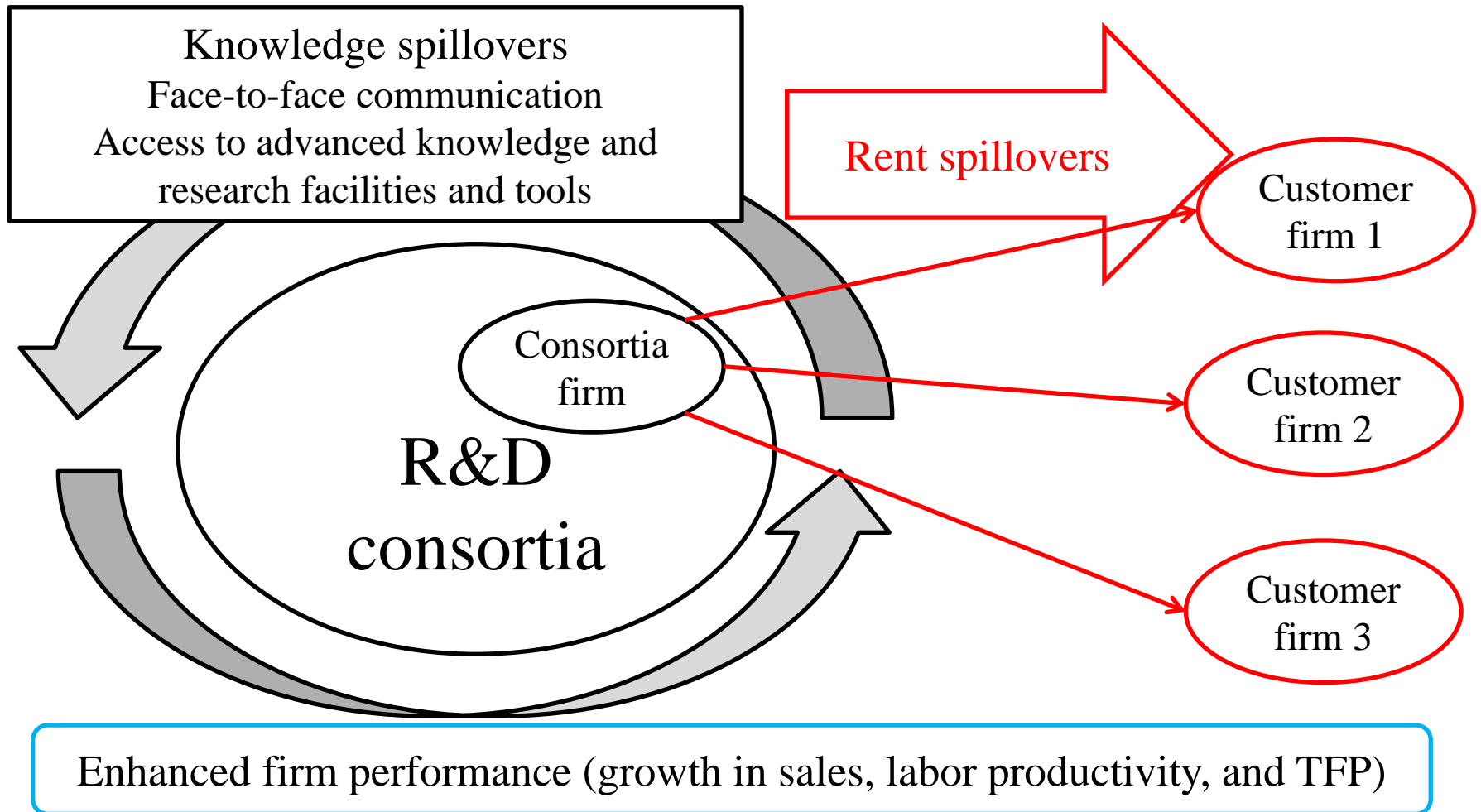- Comparison of spillover effects between SMEs and large firms

Conceptual framework (1)

- Two types of spillovers (Griliches, 1979)

- Knowledge spillovers
  - positive externality: transferred to others *without market transactions*
  - knowledge as a public good

- Rent spillovers
  - Shift rents from innovators to the users (customers) *through market transactions*
  - Unable to set appropriate prices due to competition and bargaining power inferiority

Conceptual framework (2)

- R&D consortia:

   Collaborative R&D projects formed by private firms, universities, and public research institutes

- Benefits of R&D consortia

  - Solve market failure by internalizing knowledge spillovers (Spence, 1984; Teece, 1986; Griliches, 1992)

  - Reduce inherent uncertainty of R&D (Malmberg et al., 1996)

  - Provide access to advanced scientific knowledge through intensive knowledge spillovers from other members (David et al., 2000)

Conceptual framework (3)

Knowledge spillovers
Face-to-face communication
Access to advanced knowledge and
research facilities and tools

Rent spillovers

Customer firm 1

Customer firm 2

Customer firm 3

Consortia firm

R&D consortia

Enhanced firm performance (growth in sales, labor productivity, and TFP)

Previous empirical studies

- Determinants and effects of firm's participation in R&D consortia (George et al., 2002; Mohnen and Hoareau, 2003; Motohashi, 2005; Vergeleurs and Cassiman, 2005)

- Effects of public R&D support for R&D consortia on the performance of subsidized firms (Irwin and Klenow, 1996; Branstetter and Sakakibara, 1998; Bayona-Saez and Garcia-Marco., 2010)

- Few empirical studies take rent spillovers through business transactions into consideration in examining spillover effects through R&D consortia (Klette et al., 2000)

- Knowledge spillovers from customers to suppliers in Japan (Suzuki, 1993; Branstetter, 2002) or from foreign transplants to local suppliers by foreign direct investment (Motohashi and Yuan, 2010; Barrios et al., 2011)

Contributions of this paper

- Examines both knowledge spillovers within R&D consortia and rent spillovers on major customer firms of the consortia members through business transactions

- Compares spillover effects between SMEs and large firms

- Controls for sample selection bias by employing propensity score matching

- Provides support for the science- and evidence-based science and technology policy

Empirical strategy (1)

- Possible differences between the treated and the control firms due to sample selection bias: We should estimate the average values of performance that the treated firms would have shown if they had not been treated (counterfactual situation).

- We use propensity score matching (PSM) to examine the improvement of firm productivity through R&D consortia.

- PSM can balance observed differences between the treated and the control firms; the matched samples have the same propensity of assignment to treatment.

Empirical strategy (2)

- Investigate the determinants of participation in R&D consortia by binary probit regression using *ex ante* firm characteristics

- Calculate the probability of a firm to participate in R&D consortia

- Each participant is matched with a control firm (non-participant) endowed with a similar propensity score of participation in R&D consortia

- Compare *ex post* firm performance of the matched groups to estimate the Average Treatment Effect on the Treated (ATT)

- Apply the same procedure to the matching and comparison between customers of the participants and others (control group)

Empirical strategy (3)

First step: Specification of a probit model

- Variables which would affect firm performance (Guo and Fraser, 2009)

- Firm capability: age, size (employees), R&D intensity, ROA

- Growth potential: sales growth, labor productivity growth, TFP growth

- Industry dummies and prefectural dummies

Empirical strategy (4)

Second step: Matching and performance comparison

- Compare *ex post* firm performance of the matched groups to calculate the ATT

- Use three matching algorithms for robustness check:
  1) One-to-one nearest neighbor matching,
  2) Nearest available Mahalanobis metric matching within calipers, and
  3) Kernel matching

- Compare between the sub-samples of SMEs and large firms (with more than 300 employees)

Data (1): Overview of the CRDP

Program initiator	Ministry of Economy, Trade and Industry (METI)
Concept	CRDP aims at creating new products, processes and businesses for regional economic revitalization, by promoting university-industry-government collaboration.
Target group	University-industry-government R&D consortia that include at least a university and a firm
Grant size	50－150 million yen
Support period	Two years
Program goal	At least 30% of the supported consortia achieve commercialization within three years after the support period.

Data (2): Sampling

- A list of 1,550 firms which participated in the 666 R&D consortia supported by the CRDP between 2004 and 2008

- **584** manufacturers (participants) that could be matched with the COSMOS database of TDB (financial and organizational information for the fiscal years from 2000 to 2009)

- Business transaction data with the three largest customer firms as of 2007 for each of the 584 manufacturers

- **485** customer firms in the manufacturing sector, among 1,210 customer firms of the 584 manufacturers

Data (3): Summary of sample characteristics CRDP participants and non-participants

	CRDP Participants: Treated			Non-participants			Wilcoxon rank-sum test
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	
Firm age	584	46.748	21.935	39,467	32.845	16.698	***
Employees (100 persons)	526	15.157	46.935	28,622	0.882	2.802	***
R&D ratio to sales	412	0.017	0.035	23,314	0.003	0.057	***
ROA	526	0.026	0.066	28,622	0.018	0.201	***
Sales growth	507	0.049	0.526	23,236	0.075	2.963	***
Labor productivity growth	492	0.394	2.174	22,101	0.792	19.924	***
TFP growth	492	0.331	2.141	22,101	0.742	21.836	***

Data (4): Summary of sample characteristics: Customers and non-customers

	Customers: Treated			Non-customers			Wilcoxon rank-sum test
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	
Firm age	485	52.973	21.452	39467	32.845	16.698	***
Employees (100 persons)	440	23.316	54.903	28622	0.882	2.802	***
R&D ratio to sales	355	0.020	0.032	23310	0.002	0.019	***
ROA	440	0.032	0.046	28619	0.019	0.102	***
Sales growth	422	0.017	0.127	23236	0.075	2.963	**
Labor productivity growth	414	0.275	1.296	22101	0.792	19.924	***
TFP growth	414	0.200	1.027	22101	0.742	21.836	*

Results of probit regression

	(1) Treated: Participants		(2) Treated: Customers	
	Marginal effect	Robust S.E.	Marginal effect	Robust S.E.
Firm age	0.0003***	0.0000	0.0003***	0.0000
Employees (100 persons)	0.0010***	0.0001	0.0008***	0.0001
R&D ratio to sales	0.0650***	0.0185	0.0414***	0.0132
ROA	0.0171*	0.0101	0.0192**	0.0078
Sales growth	−0.0000	0.0000	0.0000	0.0001
Labor productivity growth	0.0001	0.0001	0.0002**	0.0001
TFP growth	−0.0001	0.0001	−0.0004	0.0003
industry dummy	yes		yes	
regional dummy	yes		yes	
N	18,766		17,209	

Test of the matching accuracy (example)

| Treated: Participants | Nearest available Mahalanobis metric matching within calipers | | | one-to-one nearest neighbor matching | | | Kernel matching | | |
| | Mean value | | | Mean value | | | Mean value | | |
Variable	Treated	Control	p value	Treated	Control	p value	Treated	Control	p value
Firm age	49.356	49.089	0.882	49.651	48.720	0.555	50.424	43.042	0.000
Employees (100 persons)	6.742	5.900	0.256	11.280	9.405	0.237	20.341	10.867	0.004
R&D ratio to sales	0.010	0.009	0.781	0.017	0.027	0.189	0.017	0.041	0.027
ROA	0.029	0.030	0.849	0.028	0.019	0.215	0.026	0.008	0.025
Sales growth	0.019	0.011	0.303	0.025	0.013	0.222	0.023	0.045	0.622
Labor productivity growth	0.202	0.161	0.507	0.377	0.473	0.626	0.375	0.451	0.892
TFP growth	0.152	0.124	0.629	0.305	0.311	0.967	0.306	0.411	0.856

Post-matching results: Participants in the CRDP

Nearest available Mahalanobis metric matching within calipers	(1) entire sample		(2) SMEs		(3) large firms	
	ATT	S.E.	ATT	S.E.	ATT	S.E.
Sales growth						
2007	0.032**	0.012	0.034*	0.019	0.017	0.016
2008	0.026**	0.012	0.038**	0.019	−0.002	0.014
Labor productivity growth						
2007	0.073**	0.030	0.077*	0.044	0.059	0.043
2008	0.032*	0.018	0.140**	0.070	−0.038	0.043
TFP growth						
2007	0.086***	0.028	0.060*	0.039	0.023	0.106
2008	0.052*	0.027	0.098**	0.038	−0.008	0.045

Post-matching results:
Customers of consortia firms

Nearest available Mahalanobis metric matching within calipers	(1) entire sample		(2) SMEs		(3) large firms	
	ATT	S.E.	ATT	S.E.	ATT	S.E.
Sales growth						
2007	0.038**	0.016	0.024	0.037	0.022**	0.010
2008	0.031**	0.015	0.036*	0.021	0.021*	0.013
Labor productivity growth						
2007	0.076**	0.027	−0.118	0.102	0.047*	0.030
2008	0.027	0.031	−0.002	0.098	0.055*	0.035
TFP growth						
2007	0.074***	0.023	0.003	0.082	0.052*	0.034
2008	0.030	0.029	0.090	0.092	0.040**	0.017

Additional analyses (1)

- Customer's bargaining power (measured by relative size): positive effect

- Transactions with multiple consortia firms: no effect
  .
- Rent spillovers on the second tier (220 top customers of the 485 first-tier customers): no effect

Table 10: Estimation results of the ATT regarding bargaining power and multiple transactions

	customers with strong bargaining power vs. customers with weak bargaining power		customers with multiple transactions vs. customers with a single transaction	
	ATT	S.E.	ATT	S.E.
Sales growth				
2007	0.071***	0.023	0.042*	0.026
2008	0.032*	0.019	−0.020	0.016
Labor productivity growth				
2007	0.113**	0.056	−0.016	0.065
2008	0.031	0.048	−0.101	0.072
TFP growth				
2007	0.111**	0.053	−0.064	0.060
2008	0.051	0.049	−0.081	0.078

Note 1: Level of significance: ***1%, **5%, *10%.

Table 11: Estimation results of the ATT regarding second-tier rent spillover effects

	second-tier rent spillover effects on the top customer of 485 customers	
	ATT	S.E.
Sales growth		
2007	0.038*	0.023
2008	−0.005	0.012
Labor productivity growth		
2007	0.488	0.433
2008	−0.157	0.116
TFP growth		
2007	0.456	0.467
2008	−0.192	0.216

Note 1: Level of significance: *10%.

Additional analyses (2)

- Cost-benefit analysis using data of 273 R&D consortia for which information on the performance of all member firms are available

- Focus on consortia SMEs and their large customers in 2007 and 2008

- Total grant size for two years: 20,984 million yen

- Impact of CRDP for consortia firms (SME): 7,110 M

- Impact of CRDP for their customers: 162,101 M

- Overall spillover effects substantial as compared to its budget: cost-effective if considering benefits of customers

Table 12: Estimates of the impact of the CRDP (million yen)

PANEL A: SMEs participants	Value added		
	2007	2008	Total
(1) Observed average value per firm	331	318	648
(2) Counterfactual average value per firm	307	271	578
(3) Average impact of the CRDP per firm ((1)−(2))	24	46	70
(4) Numbers of sample firms	104	100	—
(5) Total impact of the CRDP ((3)×(4))	2477	4633	7110

PANEL B: Large customers	Value added		
	2007	2008	Total
(1) Observed average value per firm	15484	15219	30703
(2) Counterfactual average value per firm	14779	14360	29139
(3) Average impact of the CRDP per firm ((1)−(2))	704	859	1563
(4) Numbers of sample firms	107	101	—
(5) Total impact of the CRDP ((3)×(4))	75369	86732	162101

Conclusions

- Major results:
  - Knowledge spillover effect is limited to SMEs
  - Extensive rent spillover effects towards downstream manufacturing sectors, esp. for large customers

- Policy implications:
  - Underestimation of the effectiveness of government-sponsored R&D consortia by ignoring rent spillovers
  - Take into account rent spillover effects in the selection of research proposals and the evaluation of supported projects
  - Promote R&D consortia involving SMEs to increase overall spillover effects on related industries