Chapter 8

The Innovation Impact of Knowledge Exchanges within and across Connected Firms

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CHAPTER 8

The Innovation Impact of Knowledge Exchanges within and across Connected Firms*

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This paper examines whether firms consider adopting cross-functional teams as a device of transforming external information to innovation or upgrading. While addressing the difference between firms with cross-functional teams and without teams, we examine the effects of complementarities between internal and external resources on product innovation and product-level creative destruction, using survey data from manufacturers in Indonesia, the Philippines, Thailand, and Vietnam. The firms with cross-functional teams are more likely to have higher impacts of exchanging engineers on product innovation and destruction. We use the interaction terms between teams and exchanging engineers as an instrumental variable for acquiring information on the past failure experience of other firms, explaining the higher level of product innovation and product-level creative destruction. Product innovation and destruction need a wider sharing of outside knowledge within a firm.

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1. Introduction

This paper investigates the dynamic process of the achievement of product innovation, product destruction, and product churning through studying the impact of interactions between internal and external resources on firms in developing economies. External resources have been known to play an important role in explaining the firm-level upgrading because the forward and backward production linkages between customer and supplier generate positive information externalities. In terms of firm-level performance, we do not know much about both the importance of impacts of external resources and the interactions between internal and external resources. It is especially important to ask how organizational choices within a firm interact with external linkages toward the "adaptive organizations" in the age of market turbulence and uncertainty for developing economies.

However this might be qualitatively important, the effect of organizational choices and external linkages on product innovation has not been fully examined. The dynamic process of the industry upgrading may be affected by not only the internal resources, such as formation of teams, QC circles, or investment in R&D, but also by information exchanging with upstream and downstream firms in the connected world. Our empirical question here is to ask how important a role is played by adopting cross-functional teams when the firm exchanges information with downstream or upstream firms through engineers, in terms both of product innovation and of product-level creative destruction. To answer this question, we need to identify which types of customer-supplier relationships would interact with adopting cross-functional teams within a firm. After presenting the innovation impact of interaction between adopting teams and engineers, we show which types of information would create some benefit for product innovation and creative destruction. In particular, since the interaction of internal and external resources yields a higher accessibility of information on the past failure experience of other firms, the past failure experience of other firms could explain product innovation and firm-level creative destruction.

The most relevant theoretical framework is Dessein and Santos (2006), which examines how adopting team production and investment in improvement of communication technologies weakens the trade-off between local adaptation and coordination (the benefit of centralization). Thus, the findings of Dessein and Santos (2006) suggest that adopting team production lowers the coordination costs by using local information that outside engineers diffuse into the firm and which dispatched engineers to outside firms have.

The other relevant literature is in the field of social learning and development. Conley and Udry (2010) shows the presence of social leaning in the context of pineapple farming in Ghana by mapping the inter-household network in a village. To do so, they relate the input fertilizer use of the information neighbor with own fertilizer use. In particular, the past failure experience of connected farmers explains the changes in input fertilizer use on growing pineapples, although of unknown technology. That paper applies the same method to input choices for another crop, also of known technology, to indicate an absence of social learning effects. On the other hand, the most relevant empirical studies are in economics of organization, including Ichniowski, Shaw, and Prennushi (1997), Bresnahan, Brynjolfsson, and Hitt (2002), Hamilton, Nickerson, and Owan (2003), Bartel, Ichniowski, and Shaw (2007) and Bloom and Van Reenen (2007). These empirical studies research the cause and consequences of the introduction of new management practices in several settings, and they find significant complementarities between different types of management practices. Unlike this paper's interest in establishment-level comparisons of product innovation and the combination of internal resources and external linkages, previous studies tended to concentrate on the impacts of adoption of new internal management practices on the improvement of firm-level productivity.

If the engineer exchanges with customer and supplier or acquiring feedbacks from production partners were very important, the dynamic process of industry upgrading becomes closely related to sales and procurement. Especially, geographic features of industry upgrading have not been fully studied in economics of agglomeration such as Fujita and Thisse (1996, 2002) and fragmentation literature like Ando and Kimura (2009) and Kimura (2006, 2008, and 2009). Even though firms' strategy of knowledge exchanges with upstream and downstream firms is restricted in each region, it is natural that the dynamics aspects of the decision of product innovation and creative destruction would vary according to a firm's organizational choices. Examples include adoption of cross-functional teams or formation of a QC circle, and so on.

The purpose of this paper is to examine the impacts of interaction of internal choices of knowledge sharing (internal sharing) and knowledge exchange with external partners (external sharing) on firm-level innovation. This paper proposes a new mechanism linking these two types of information sharing and product destruction as well as product creation in developing economies. It investigates the testable implications using survey data gathered from almost 800 manufacturing firms in Indonesia, Thailand, and Vietnam. We collected firm-level evidence on introducing a new product, decision of discontinuing, changes in the number of product lineups, internal and external resources of information sharing, and the respondent firms' own characteristics combining mail surveys and field interviews. Based on these insider variables, we implement a simple econometric analysis. East Asia is our particular focus because it is a major production site for not only local firms but also for multinationals. The most striking difference between East Asian and other developing economies is in the volume of intra-industry trade and combination of spot market and long-term transactions. The huge volume of intra-industry trade and long-term transactions between customer and supplier in East Asia brings a new way of understanding the agglomeration benefit of product creation and destruction.

This work concentrates on detecting the complementary impact of adopting cross-functional teams and exchanging engineers on product innovation and creative destruction, controlling the kind of main products and the number of products. There have been few empirical research papers that precisely capture the dynamic process of creative destruction with a focus on the interaction between teams within a firm and local information or feedback which supplier and customer bring. There is also a lack of quantitative evidence. Field survey-based datasets provide new findings lacking in previous studies on industrial organization and innovation in developing economies. Moreover, most of the previous studies do not focus on the determinants of knowledge production function.

The empirical result of this paper is quite intuitive. First, the firms which adopt department-wide cross-functional teams tend to have a higher elasticity of knowledge exchanges with upstream and downstream firms on product innovation and product destruction. This suggests that adopting cross-functional teams stimulates the transformation of external knowledge flows to introducing a new good as well as withdrawing an existing good. Thus, it is safe to say that information sharing across teams enhances the likelihood of product churning (reshuffling new products with old ones). Second, since interacting internal and external information sharing has delivered an experience of failure of other firms, then learning an experience of failure from other firms has a positive and significant impact on product innovation and creative destruction. Finally, these results are not supported when we use a QC circle in each department as information sharing within a firm instead of cross-functional teams.

Section 2 provides a brief literature review. Section 3 presents a simple theoretical framework for empirical analysis. Section 4 describes the data which we originally collected for this study. The results are presented in Section 5. Section 6 concludes the paper.

2. Related Literature

We have three fields of related literature. First, the related literature is on the theory of knowledge creation through mutual learning. The theoretical background of this paper explains a model of learning and knowledge creation through face-to-face communication among different types of agents as described by Berliant and Fujita (2008, 2009), Fujita (2007), and Berliant, *et al.* (2006). The central concern of these models is how diversity of knowledge among members could affect the decision on collaboration and its outcome. Their fundamental modeling approach has been applied to the question of how the cultural backgrounds of members affects the city system

(Ottaviano and Prarolo 2009). In that sense, diversity of knowledge among firms and exchange of knowledge between firms could have aggregate implications like the city system as well as agglomerations of firms. Goyal (2007) and Jackson (2008) showed the measuring and theoretical framework of information diffusion through a network. However, it has been difficult to capture and quantify the information flow between agents ─ one of the growing fields in development, labor, and industrial organization ─ specifically, the study of network impact on productivity growth. The following identified some factors that contribute to such difficulty, such as the Conley and Udry (2010) study in development economics which associated the input use of informational neighbors for pineapple farmers in Ghana, as well as their geographic neighbors as affecting growth. Another is the Bandiera, Barankay, and Rasul (2009) study in labor economics where the social and workplace level connections among fruit pickers affect the changing payment system on productivity.

Second, this paper is related to international technology transfer. Productivity growth could differ between firms depending on the types of production or intellectual linkages that they have. It is also true that productivity effects changes on entry or exit, especially when the hub-firm is located central to the production network. Given this situation, the dense network in East Asia could provide new insight on the causes and consequences of information diffusion among local firms. This paper aims to study the innovation impacts of mutual knowledge exchanges among inter-connected firms in the field of industrial development. This paper is also related to the field of international technology diffusion and international knowledge production. Keller (2000) gave an overview of the cause and consequences of technology diffusion across countries. Kerr (2008, 2010) and Kerr and Lincoln (2010) studied the role of ethnic scientific communities on technology diffusion to match ethnic scientist names with individual patent records. Therefore, information exchanges between demand and technologies spill over within the (international) production chain. Information exchanges are not always in "encoded" form (Polanyi 1966, 1967). Communication between firms and their partners is not well-facilitated when demand and technologies become complicated. The same is true with knowledge production in academia. First, team production achieves more cited research than individuals do (Wuchty, Jones, and Uzzi, 2007) across all fields of natural science, social science, and arts-humanities. Second, teamwork in science is done by not only multi-university collaborations but also by stratified groups (Jones, Wuchty, and Uzzi, 2008). Rosenblat and Mobius (2004) studied the impacts of rising Internet usage on international collaboration within a similar field.

Third, this paper is related to organizational economics and industrial organization in networked economy. Bloom and van Reenen (2007) emphasize that differences in management practices play a crucial role in productivity dispersion within a country and across countries. Bloom, *et al.* (2011) also provides the experimental evidence of modern management practices on productivity upgrading among Indian textile factories. Findings showed that treated factories achieve not only product upgrading but also more profitability than control factories do. It is difficult to identify the impact of adoption of modern management practices as well as changing managerial abilities of managers. This was subjected to further testing focus on the background of top management. Hortacsu and Syverson (2009) suggested the importance of intangible inputs like managerial oversight within the firm to show that vertical ownership is not often used to facilitate transfers of goods in the production chain. They concluded that the central motivation of owning production chains is the more efficient transfer of knowledge of production and information on markets. This motivation is closely related to the concept of "adaptive organization," such as Dessein and Santos (2006) theoretically analyzes on the complementarities between the level of adaptation to a changing environment, coordination, and the extent of specialization. Production chains within firms help a firm to collect information on the market and use it for production and vice versa. Therefore, since managerial abilities have centralized local information, these abilities play a key role as a technology of product and process innovations within the firm.

3. Theoretical Framework

We present a hypothesis to explain the dynamic process of industrial upgrading based on customer-supplier relationships interacting with internal resources. To do this, we would like to present an intuitive view following Dessein and Santos (2006) that explains why improvements in communication technologies can reduce the trade-off between adaptation and coordination.

Consider two different manufacturers in terms of investment in improving communication technologies across departments in a firm: That is, one manufacturer invests in improving communication technologies to share the information within a firm while the other manufacturer does not invest. We assume that local information in manufacturing lines is provided by exchanging engineers between customer and supplier. If this is true, the manufacturers investing on improvements in communication technologies are likely to enhance the impact of external linkages on product innovation. This framework derives the hypothesis that, if internal and external resources could be a complement in developing economies such as Indonesia, the Philippines, Thailand, and Vietnam, then such assemblers in these countries will tend to achieve product innovation. The implication of this example is related to the finding of Asanuma (1989).

The central proposition of this paper is related to Conley and Udry (2010), which presents the presence of social leaning in the context of pineapple farming in Ghana by drawing an inter-household network in a village. They find that the past failure experience of the information neighborhood has affected the decision of input use rather than the past success experience of the information neighbor. We add the implication of Conley and Udry (2010) to our framework.

In short, this framework suggests the following two implications: (1) the marginal benefit of exchanging engineers on product innovation and destruction is higher for firms which adopt cross-functional teams across departments, than for firms which do not adopt such internal activities, and (2) sharing information of the past failure experience of other firms has a significant impact on product innovation.

In summary, we can derive the following testable hypothesis based on this framework.

Hypothesis 1: *The probability of product innovation and product destruction for firms which have adopted cross-functional teams and exchanged engineers with their partners is higher than for firms which have not adopted cross-functional teams.*

Hypothesis 2: *The failure experiences of other firms could diffuse into a firm through exchanging engineers with the connected supplier and customer. The probability of product innovation and product destruction for firms which learn about the failure experience of other firms through adopting cross-functional teams and exchanging engineers with their partners is higher than with firms which have not learned about the failure experience of other firms.*

These hypotheses are empirically tested in Section 4 and their robustness is also checked.

4. Data

4.1. Sampling

Based on in-depth interviews with 794 firms, we constructed innovation, external linkages, internal linkages, and other firm-specific variables in four countries: Indonesia (JABODETABEK area), the Philippines (CARABARZON area), Thailand (Greater Bangkok area), and Vietnam (Hanoi and Ho Chi Minh City). We define product innovation, including the change in package/appearance design, introduction of a new good based on existing technology, and introduction of a new good based on new technology. We also define process innovation, including the introduction of new goods, buying new machines, process improvement, organizational changes, finding a new market, and finding a new source of procurement.

4.2. Product Innovation, Creative Destruction, and Main Explanatory Variables

In our survey, we asked about a new variable, such as an effective knowledge sharing system for the introduction of a new product and quality control. To achieve product innovation and process innovation, each firm utilizes information on external linkages and combines it with internal knowledge in the firm. The key point is the tool of knowledge sharing within the firm. We have three types of new variables on knowledge sharing with in the firm: (1) a QC circle which diffuses production-related information by word of mouth within the small groups/communities, (2) a cross-functional team across departments, and (3) department-wide IT connections. These three types of knowledge sharing systems will start from the research department to the engineering/production site to human resources, and from the department of market research to logistics/distribution. Especially for the cross-functional team, we asked as to which departments are involved in a cross-functional team that the survey respondent organizes to achieve introduction of a new product and quality control. Another interesting feature of the survey this year is that we asked whether the establishment shares information on the cases/experiences of success/failure of itself or other firms. Sharing the success/failure information could be valuable if the firm faces market turbulence to deal with disequilibria. Since some bottlenecks usually exist in the market or workplace, the manager’s response would normally reflect the existence of misallocations or maladjustments in the distribution of resources. We hypothesize that an internal knowledge sharing system drives the product and process innovation.

Table 1 presents the summary statistics of the innovation variables. The sample firms consist of 41.2% of firms that achieved significant change in packaging or appearance design, 58.3% of firms that achieved significant improvement of an existing product, 42.4% of firms that experienced development of a totally new product based on the existing technologies, and 24.9% of firms that experienced development of a totally new product based on the new technologies. Table 1 also shows the summary statistics of product churning. The sample firms consist of 21.9% of firms that discontinued a product, fewer than 10% of firms that decreased their number of products, 32.9% of firms that did not change their number of product types, and 57.8% of firms that increased the number of product types. On the other hand, 74% of firms dispatched their in-house engineers to main upstream and downstream firms or accepted engineers from main upstream and downstream firms. A cross-functional team across departments within a firm was adopted by 10% of firms while 52.5% of firms established a QC circle within a department.

Table 1: Summary Statistics of Product Innovation and Main Explanatory Variables

	No. Obs	Mean	Std. Dev.
Product innovation			
Significant change in packaging or appearance design	781	0.412	0.493
Significant improvement of an existing product	787	0.583	0.493
Development of a totally new product based on the existing technologies	787	0.424	0.495
Development of a totally new product based on the new technologies	782	0.249	0.433
Shipping new product			
Existing market where your establishment is operating	695	0.888	0.316
New market to your establishment	686	0.618	0.486
Product churning			
Discontinue a product	789	0.219	0.414
The number of product types decreased between 2009 and 2010	790	0.092	0.290
The number of product types is the same between 2009 and 2010	790	0.329	0.470
The number of product types increased between 2009 and 2010	790	0.578	0.494
Information sharing on experiences of success and failure			
Success of own establishment	794	0.675	0.469
Failure of own establishment	794	0.228	0.420
Success of other firms	794	0.263	0.441
Failure of other firms	794	0.178	0.382

Table 1 *(continued)*			
Main regressors			
Adopting cross-functional team for introduction of a new product	794	0.101	0.301
Exchanges of engineer with main upstream or downstream firms	794	0.743	0.437
Cross-functional Team*Exchanges of engineers	794	0.083	0.276
QC circle	794	0.529	0.499
QC circle*Exchanges of engineers	794	0.417	0.493

Source: ERIA Establishment Survey 2010.

Table 1 also presents the establishment's activities of information sharing on experiences of success and failure of their own and other firms. It is relatively more easy to obtain the information of past experience of success of own establishment than the information of past experience of success of other firms: That is, 67.5% of firms share the information of past experience of success of own establishment while 26.3% of firms access the information of past experience of success of other firms. On the other hand, it is relatively difficult to share the information of past experience of failure of own establishment and other firms: That is, even though 22.8% of firms share the information of past experience of failure of own establishment, only 17.8% of firms can access the information of past experience of failure of other firms.

4.3. Firm Characteristics

The sample industries come from manufacturing. Average age is 16.4 years. Since there are younger and older firms, the standard deviation of age among the sample is high. Of the total number surveyed, approximately 63.2% are local firms, 23.1% are multinational enterprises, and the remaining 13.7% are joint-venture firms. A firm is classified by 11 categories of establishment size. Although firm size distributes across small (1-19 persons), medium (100 persons), and very large (2000 persons and more), our survey collected the information about small and medium-sized firms from 20 to

299 persons. A firm is also classified by 17 categories of manufacturing industry. Except for the "not classified" sample, firms in metal products, electronics, components, machinery, and automobile manufacturing and auto parts and components dominate the sample firms.

The main product is classified by raw materials, raw material processing, components and parts, and final products. Half of the sample (49.3% of firms) produces the final product. Components and parts are the main product of 30.2% of firms. The remaining firms engage in raw material processing and selling raw materials. The number of product types is also dispersed. Single-product firms make up only 13.5% of the sample, while the peak is 11 or more types of product, 38.5% of firms.

Table 2: Summary Statistics of Firm Characteristics

	No. Obs	Mean	Std. Dev.
Firm age	770	16.440	13.411
Location			
The Philippines	794	0.297	0.457
Indonesia	794	0.185	0.389
Thailand	794	0.131	0.338
Hanoi	794	0.195	0.397
Ho Chi Minh City	794	0.191	0.394
Capital structure			
100% locally owned	793	0.632	0.483
100% foreign owned	793	0.231	0.422
Joint venture	793	0.137	0.345
Establishment size			
1-19 persons	790	0.058	0.234
20-49 persons	790	0.171	0.377
50-99 persons	790	0.151	0.358
100-199 persons	790	0.190	0.392
200-299 persons	790	0.109	0.312
300-399 persons	790	0.075	0.263
400-499 persons	790	0.041	0.197
500-999 persons	790	0.104	0.305
1000-1499 persons	790	0.035	0.185
1500-1999 persons	790	0.018	0.132
2000 and above	790	0.049	0.217
Industry			
Food, beverage, tobacco	760	0.091	0.287
Textiles	760	0.047	0.213
Apparel, leather	760	0.046	0.210
Wood, wood products	760	0.011	0.102

Table 2 (*continued*)	**No. Obs**	**Mean**	**Std.Dev.**
Paper, paper products, printing	760	0.030	0.171
Coal, petroleum products	760	0.005	0.072
Chemicals, chemical products	760	0.033	0.178
Plastic, rubber products	760	0.097	0.297
Other non-metallic mineral products	760	0.026	0.160
Iron, steel	760	0.039	0.195
Non-ferrous metals	760	0.003	0.051
Metal products	760	0.130	0.337
Machinery, equipment, tools	760	0.087	0.282
Computers, computer parts	760	0.013	0.114
Other electronics, components	760	0.113	0.317
Precision instrument	760	0.018	0.135
Automobile, auto parts	760	0.047	0.213
Other transportation equipments and parts	760	0.026	0.160
Other	760	0.136	0.343
Main product			
Raw materials	785	0.043	0.204
Raw material processing	785	0.162	0.368
Components and parts	785	0.302	0.459
Final products	785	0.493	0.500
The number of product types			
Single	780	0.135	0.342
2 to 5	780	0.286	0.452
6 to 10	780	0.195	0.396
11 or more	780	0.385	0.487
The ratio of R&D expenditure to sales			
No expenditure	772	0.545	0.498
Less than 0.5%	772	0.196	0.397
0.5 to 0.99%	772	0.131	0.337
1% and more	772	0.128	0.335
The date of starting R&D activities			
Not yet	776	0.521	0.500
Before 1990	776	0.084	0.277
1990-1994	776	0.039	0.193
1995-1999	776	0.080	0.271
2000-2004	776	0.093	0.290
2005 and later	776	0.184	0.388

Source: ERIA Establishment Survey 2010.

The other important firm characteristic is the R&D activities. More than half of sample firms do not expend on R&D activities. About 20% of firms have an R&D expenditure ratio of less than 0.5% of total sales. Firms with an R&D expenditure ratio of less than 1% of total sales account for 13.1% of the sample. Firms with an R&D expenditure ratio of more than 1% of total sales constitute 12.8% of the sample.

4.4. Preliminary Findings

What are the mechanisms underlying the dynamic process of product innovation and creative destruction in terms of utilizing internal and external resources? First we discuss the distribution of the propensity to achieve product innovation and product churning by information sharing activities within and across firms: That is, exchanging engineers with their production partners upstream or downstream and adopting cross-functional teams across departments. Second we show the distribution of the propensity to achieve innovation for firms holding two types of information sharing activities.

Table 3 shows that the probability of achieving product innovation is higher for firms exchanging engineers with their main production partners than for firms that do not exchange engineers with their main production partners. In particular, the probability of achieving product churning is also higher for firms exchanging engineers with their main production partners. They aggressively discontinue a product and introduce a new product. Thus, the probability that the number of products has not been changed is lower for such firms (28.4% of firms) than for firms that do not exchange engineers with their main production partners (45.8% of firms). In sum, firms exchanging knowledge through dispatching or accepting engineers are likely to achieve both product innovation and creative destruction. The propensity of both decreasing and increasing the number of product lineups is higher for firms dispatching or accepting engineers with their partners. Such firms are also likely to access the information of past experience of failure of other firms.

In turn, firms adopting cross-functional teams are likely to achieve product innovation. They are also likely to discontinue a product and increase the number of product lineups. Firms adopting cross-functional teams across departments are likely to share the information on their own past experience of success and failure. It is worth saying that such firms are also likely to share the information of past experience of failure of other firms.

Thus, firms interacting with these two types of information sharing within and across firms are more likely to achieve product innovation, discontinue a product, and increase the number of product lineups than are firms without holding two types of information sharing. In addition, firms interacting on two types of information sharing activities within and across firms are likely to share the past experience of failure of other firms. We assume that information on the past failure experience of other firms could play an important role in achieving product innovation and product churning. We check whether these arguments are justified under controlling differences in many aspects of firm characteristics in the remaining section.

Table 3: Probability of Product Innovation by Exchanges of Engineers and Adopting Cross-Functional Team

	Exchanges of engineer with main upstream or downstream firms		Adopting cross-functional team for introduction of a new product		Exchanges*Team	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
Product innovation						
Significant change in packaging or appearance design	0.440	**0.332**	**0.650**	**0.385**	0.667	0.389
Significant improvement of an existing product	0.650	**0.391**	**0.625**	**0.579**	0.667	0.576
Development of a totally new product based on the existing technologies	0.471	**0.291**	**0.588**	**0.406**	0.606	0.408
Development of a totally new product based on the new technologies	0.280	0.160	0.463	0.225	0.470	0.229
Shipping new product						
Existing market where your establishment is operating	0.886	0.895	0.972	0.878	0.967	0.880
New market to your establishment	0.611	0.644	0.592	0.621	0.574	0.622
Product churning						
Discontinue a product	0.227	0.196	0.338	0.206	0.364	0.206
The number of product types decreased between 2009 and 2010	0.109	0.044	0.075	0.094	0.091	0.093
The number of product types is same between 2009 and 2010	0.284	0.458	0.300	0.332	0.288	0.333
The number of product types increased between 2009 and 2010	0.606	0.498	0.625	0.573	0.621	0.575
Information sharing on experiences of success and failure						
Success of own establishment	0.664	0.706	0.863	0.654	0.879	0.657
Failure of own establishment	0.244	0.181	0.250	0.225	0.288	0.223
Success of other firms	0.300	0.157	0.238	0.266	0.258	0.264
Failure of other firms	0.222	0.049	0.200	0.175	0.227	0.173

Source: ERIA Establishment Survey 2010.

5. Results

5.1. Baseline Results

Table 4 shows the regression results of how adopting cross-functional teams enhances the innovation impacts of exchanging engineers with upstream suppliers or downstream customers. The dependent variable is the binomial choice of several types of product innovation: (1) significant change in package and appearance design, (2) improvement of existing product, (3) introducing a new product based on existing technologies to the firm, and (4) introducing a new product based on new technologies to the firm. In addition, the simple sum of these several types of product innovation is used as a likelihood of firm-level product innovation. The main explanatory variable is the interaction terms between adopting cross-functional teams within a firm and exchanging engineers across firms. The firm's basic characteristics shown in Table 2 are used as control variables. Columns 1 to 4 of Table 2 show the marginal effect of Probit estimates: the interaction effects of department-wide cross-functional teams and engineer exchanges on product innovation. Column 1 of Table 2 suggests that the coefficient for interaction terms between knowledge sharing within and across firms is 0.309 with a robust standard error of 0.074. This result suggests that a firm that adopts cross-functional teams and dispatching/accepting engineers, on average, changes in packaging and designing with a higher probability than firms that have not interacted with internal and external resources. This result is robust even after controlling for additional explanatory variables, in particular, exchanging engineers. This result suggests that if firms dispatch their in-house engineers to upstream and downstream firms or accept engineers from upstream and downstream firms, then those firms could receive more benefit from adopting cross-functional teams in terms of changing packaging, design, and appearance. Investment in communication technologies across departments within a firm enhances the impact of external linkages on product innovation.

Column 2 of Table 4 suggests that the coefficient for interaction terms between knowledge sharing within and across firms is 0.176 with a robust standard error of 0.063. This result means that adopting cross-functional teams and dispatching/accepting engineers, on average, significantly improves existing products with a higher probability compared with firms that have not interacted with internal and external resources. Column 3 of Table 4 suggests that the coefficient for interaction terms between knowledge sharing within and across firms is 0.206 with a robust standard error of 0.079. This result means that adopting cross-functional teams and dispatching/accepting engineers, on average, introduces a new product based on existing technologies with a higher probability compared with firms that have not interacted with internal and external resources. Column 4 of Table 4 indicates that the coefficient for interaction terms between knowledge sharing within and across firms is 0.199 with a robust standard error of 0.077. This result means that adopting cross-functional teams and dispatching/accepting engineers, on average, introduces a new product based on new technologies with a higher probability compared with firms that have not interacted with internal and external resources. Finally, Column 5 of Table 4 presents the results of the Ordered Logit model. The interaction term has a statistically significant impact to explain the likelihood of firm-level product innovation. Firms with interacting internal and external resources are more likely to increase the four types of product innovation.

In summary, given the situation of exchanging engineers across production partners, adopting cross-functional teams within a firm would increase the impact of knowledge flows from exchanging engineers on several types of product innovation.

Table 4: Effects of Interaction of Adopting Cross-functional Teams and Exchange of Engineers on Product Innovation

	(1)	(2)	(3)	(4)	(5)
	Probit (Marginal Effects)				Ordered Logit
	Dependent variables: Product innovation				
	Significant change in packaging or appearance design	Significant improvement of an existing product	Development of a totally new product based on the existing technologies	Development of a totally new product based on the new technologies	The sum of product innovation
Team*Exchanges	**0.309****	**0.176****	**0.206****	**0.199****	**1.215****
	[0.074]	**[0.063]**	**[0.079]**	**[0.077]**	**[0.347]**
Exchanges of engineers	0.051	0.077	0.164**	0.125**	0.655**
	[0.058]	[0.058]	[0.054]	[0.037]	[0.239]
Firm age	0.002	-0.001	0.002	-0.001	0.001
	[0.002]	[0.002]	[0.002]	[0.001]	[0.006]
Indonesia	-0.06	-0.058	-0.013	0.001	-0.097
	[0.075]	[0.081]	[0.076]	[0.061]	[0.339]
Thailand	0.229**	0.249**	0.226**	0.145+	1.212**
	[0.078]	[0.053]	[0.078]	[0.078]	[0.291]
Hanoi	0.109	0.237**	0.221**	0.003	0.742*
	[0.078]	[0.062]	[0.077]	[0.060]	[0.304]
Ho Chi Minh City	0.094	0.338**	-0.053	-0.098*	0.434+
	[0.075]	[0.050]	[0.075]	[0.049]	[0.258]
100% foreign owned	0.053	-0.011	0.022	-0.022	0.098
	[0.053]	[0.056]	[0.055]	[0.042]	[0.191]
Joint venture	0.083	-0.033	0.097	0.093	0.344
	[0.066]	[0.068]	[0.065]	[0.059]	[0.262]
20-49 persons	0.15	0.048	0.094	0.048	0.15
	[0.099]	[0.086]	[0.097]	[0.093]	[0.308]
50-99 persons	0.177+	0.099	0.089	0.089	0.365
	[0.098]	[0.083]	[0.098]	[0.099]	[0.304]
100-199 persons	0.203*	0.145+	0.109	0.188+	0.636*
	[0.095]	[0.080]	[0.094]	[0.102]	[0.293]
200-299 persons	0.235*	0.204**	0.294**	0.306*	1.071**
	[0.104]	[0.078]	[0.097]	[0.122]	[0.326]
300-399 persons	0.132	-0.016	0.077	0.09	0.228
	[0.118]	[0.105]	[0.111]	[0.117]	[0.342]
400-499 persons	0.198	0.046	0.187	0.244	0.511
	[0.127]	[0.121]	[0.130]	[0.149]	[0.489]
500-999 persons	0.277**	0.161+	0.086	0.114	0.656*
	[0.103]	[0.089]	[0.109]	[0.117]	[0.331]
1000-1499 persons	0.319**	0.172+	0.066	0.262+	0.834
	[0.123]	[0.103]	[0.141]	[0.158]	[0.531]
1500-1999 persons	0.292+	0.214+	0.238	0.272	0.946
	[0.160]	[0.124]	[0.171]	[0.193]	[0.622]
2000 and above	0.291*	0.172	0.146	0.352*	0.888+
	[0.139]	[0.121]	[0.146]	[0.164]	[0.473]
Raw material processing	-0.084	-0.121	-0.021	-0.143*	-0.49
	[0.111]	[0.123]	[0.115]	[0.060]	[0.499]
Components and parts	-0.094	0.036	0.032	-0.116	-0.054
	[0.109]	[0.114]	[0.113]	[0.076]	[0.467]
Final products	0.002	0.044	0.042	-0.133	0.007
	[0.107]	[0.109]	[0.106]	[0.084]	[0.454]

Table 4 *(Continued)*					
	(1)	(2)	(3)	(4)	(5)
2 to 5	0.058	-0.039	0.056	0.074	0.247
	[0.073]	[0.069]	[0.071]	[0.064]	[0.279]
6 to 10	0.125	0.129+	0.185*	0.076	0.704*
	[0.082]	[0.071]	[0.079]	[0.074]	[0.305]
11 or more	0.051	0.045	0.065	0.107+	0.438
	[0.072]	[0.066]	[0.071]	[0.063]	[0.282]
Less than 0.5%	0.019	0.066	0.145+	0.024	0.352
	[0.075]	[0.076]	[0.078]	[0.065]	[0.270]
0.5 to 0.99%	0.178*	0.123	0.237**	0.191*	0.844*
	[0.090]	[0.085]	[0.089]	[0.093]	[0.332]
1% and more	0.038	0.163*	0.134	0.177+	0.591+
	[0.092]	[0.079]	[0.095]	[0.097]	[0.337]
Before 1990	-0.03	0.098	-0.093	-0.116*	-0.304
	[0.097]	[0.095]	[0.092]	[0.051]	[0.331]
1990-1994	0.017	0.247**	-0.161	-0.029	0.294
	[0.137]	[0.080]	[0.112]	[0.095]	[0.598]
1995-1999	0.122	0.026	0.067	0.093	0.391
	[0.093]	[0.094]	[0.093]	[0.083]	[0.353]
2000-2004	0.038	-0.008	-0.112	-0.071	-0.275
	[0.093]	[0.097]	[0.087]	[0.064]	[0.349]
2005 and later	0.01	-0.074	-0.162*	-0.126*	-0.475
	[0.083]	[0.089]	[0.078]	[0.052]	[0.297]
Observations	687	694	695	686	691

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Source: ERIA Establishment Survey 2010.

Next, we turn to product destruction and the number of product lineups. Table 5 shows how adopting cross-functional teams changes the impacts of exchanging engineers on the decision of discontinuing a product and decreasing or increasing the number of products. Column 1 of Table 5 suggests that a cross-functional team increases the impact of external linkages on discontinuing a product. Column 2 of Table 5 shows no significant evidence that a cross-functional team changes the impact of external linkages on decreasing the number of total product lineups. Adopting cross-functional teams decreases the impact of external linkages on a firm's decision that the number of products is unchanged (Column 3 of Table 5). Column 4 of Table 5 also shows there is no evidence that a cross-functional team changes the impact of external linkages on increasing the number of total product lineups. In sum, both

Table 4 and Table 5 show that interaction between teams within a firm and linkages across firms stimulates both product innovation and destruction. Even though the interaction could affect this firm-level "creative destruction," it does not change the number of product types.

Table 5: Effects of Interaction of Adopting Teams and Exchanging Engineers on Product Churning

	(1)	(2)	(3)	(4)
	Probit (Marginal Effects)			
	Dependent variables: Product churning			
	Discontinue a product	The number of product types decreased	The number of product types is same	The number of product types increased
Team*Exchanges	**0.212****	0.058	**-0.139***	0.103
	[0.081]	[0.054]	**[0.057]**	[0.073]
Exchanges of engineers	0.008	0.053**	-0.042	-0.008
	[0.043]	[0.020]	[0.055]	[0.059]
Firm age	0.002+	0	0.004**	-0.005**
	[0.001]	[0.001]	[0.001]	[0.002]
Indonesia	0.378**	0.024	-0.240**	0.284**
	[0.082]	[0.048]	[0.043]	[0.057]
Thailand	0.043	0.049	-0.153**	0.132+
	[0.075]	[0.053]	[0.055]	[0.072]
Hanoi	0.289**	0.024	-0.215**	0.195**
	[0.082]	[0.042]	[0.055]	[0.070]
Ho Chi Minh City	0.041	0.217**	-0.359**	0.213**
	[0.065]	[0.069]	[0.037]	[0.065]
100% foreign owned	0.145**	0.02	-0.043	0.011
	[0.048]	[0.025]	[0.050]	[0.054]
Joint venture	0.07	-0.024	0.094	-0.062
	[0.054]	[0.026]	[0.066]	[0.067]
20-49 persons	0.099	-0.018	-0.026	0.068
	[0.111]	[0.032]	[0.083]	[0.094]
50-99 persons	0.187	-0.013	-0.034	0.086
	[0.126]	[0.034]	[0.083]	[0.092]
100-199 persons	0.07	-0.045+	-0.084	0.196*
	[0.102]	[0.026]	[0.080]	[0.084]
200-299 persons	0.016	-0.051*	-0.021	0.142
	[0.098]	[0.020]	[0.095]	[0.095]
300-399 persons	0.207	-0.047*	-0.136+	0.236**
	[0.139]	[0.021]	[0.080]	[0.084]
400-499 persons	0.22	-0.015	-0.05	0.084
	[0.165]	[0.041]	[0.116]	[0.122]
500-999 persons	0.08	-0.060**	-0.026	0.187+
	[0.118]	[0.018]	[0.102]	[0.096]
1000-1499 persons	0.345*	-0.017	-0.108	0.167
	[0.167]	[0.047]	[0.111]	[0.120]
1500-1999 persons	0.064	-0.007	-0.222*	0.290*
	[0.156]	[0.075]	[0.097]	[0.114]

Table 10. *(Continued)*

	(1)	(2)	(3)	(4)
2000 and above	-0.004		-0.102	0.284**
	[0.118]		[0.116]	[0.099]
Raw material processing	-0.122**	0.073	0.01	-0.114
	[0.046]	[0.073]	[0.099]	[0.108]
Components and parts	-0.185**	-0.046	0.034	0.027
	[0.055]	[0.037]	[0.095]	[0.104]
Final products	-0.099	-0.037	0.017	0.014
	[0.070]	[0.046]	[0.087]	[0.098]
2 to 5	-0.014	0.008	-0.144*	0.172*
	[0.048]	[0.032]	[0.057]	[0.069]
6 to 10	0.015	0.004	-0.179**	0.228**
	[0.056]	[0.034]	[0.059]	[0.071]
11 or more	0.036	-0.014	-0.167**	0.216**
	[0.051]	[0.030]	[0.060]	[0.070]
Less than 0.5%	-0.097*	-0.060**	0.047	0.098
	[0.044]	[0.019]	[0.078]	[0.072]
0.5 to 0.99%	-0.077	-0.073**	0.259**	-0.067
	[0.052]	[0.016]	[0.099]	[0.090]
1% and more	0.032	-0.042+	-0.025	0.148+
	[0.072]	[0.023]	[0.095]	[0.086]
Before 1990	-0.117*	0.136	-0.227**	0.123
	[0.046]	[0.092]	[0.056]	[0.096]
1990-1994	0.029	0.137	-0.233**	0.171
	[0.102]	[0.121]	[0.059]	[0.108]
1995-1999	0.171+	0.065	-0.227**	0.185*
	[0.091]	[0.067]	[0.056]	[0.080]
2000-2004	0.038	0.008	-0.160*	0.156+
	[0.077]	[0.048]	[0.067]	[0.083]
2005 and later	0.189*	0.073	-0.108	-0.004
	[0.087]	[0.054]	[0.073]	[0.083]
Observations	697	660	700	696

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Source: ERIA Establishment Survey 2010.

5.2. Internal and External Resources Deliver the Past Experience of Failure of Other Firms

We turn to the question of which types of information that cross-functional teams within a firm and exchanging engineers across firms stimulate for sharing. Baseline results present that internal resources increase the impact of external resources on product innovation and destruction. Baseline results suggest a complementary relationship between these resources within and across firms. It is natural to ask about the types of information that internal and external resources deriver and diffuse. Our goal in this estimation is to understand which types of past experience of own and other firms correlate with interactions of adopting cross-functional teams and dispatching engineers to other firms or accepting engineers from other firms. Table 6 summarizes how adoption of cross-functional teams enhances the impact of exchanging engineers on acquiring the information of past success and failure. Columns 1 and 2 of Table 6 show that the interaction terms between cross-functional teams within a firm and exchanging engineers across firms have positive and significant impacts on sharing the information of past success and failure of the own establishment. The most important finding is in comparing Columns 3 and 4 of Table 6. Adopting cross-functional teams does not increase the impact of external linkages across firms on sharing the information of the past success of other firms (Column 3). On the other hand, teams within a firm increase the impact of external linkages across firms on sharing the past failure experience of other firms (Column 4). Since external linkages have delivered the information of the past success and failure of other firms, these results indicate that firms with cross-functional teams and external linkages through dispatching and accepting engineers are likely to share the past failure experience of other firms. These internal and external resources are found to be a better predictor of sharing the past failure experience of other firms than of sharing the past success experience of other firms.

Table 6: Effects of Interaction of Adopting Teams and Exchanging Engineers on Information Sharing of Past Success and Failure

	(1)	(2)	(3)	(4)
	Probit (Marginal Effects)			
	Dependent variables: Information sharing on experiences of success and failure			
	Success of own establishment	Failure of own establishment	Success of other firms	Failure of other firms
Team*Exchanges	**0.243****	**0.121+**	-0.012	**0.174***
	[0.041]	**[0.073]**	[0.064]	**[0.075]**
Exchanges of engineers	-0.06	0.06	0.107*	0.085**
	[0.050]	[0.041]	[0.043]	[0.032]
Firm age	0.002	-0.001	-0.001	-0.001
	[0.002]	[0.001]	[0.001]	[0.001]
Indonesia	-0.254**	-0.085+	0.077	-0.04
	[0.077]	[0.050]	[0.076]	[0.049]
Thailand	0.04	0.142+	0.043	0.200*
	[0.071]	[0.074]	[0.072]	[0.083]
Hanoi	0.006	-0.104*	-0.190**	0.119
	[0.071]	[0.050]	[0.047]	[0.074]
Ho Chi Minh City	-0.137+	0.191**	0.313**	0.526**
	[0.074]	[0.072]	[0.074]	[0.080]
100% foreign owned	-0.029	0.008	0.025	-0.009
	[0.048]	[0.044]	[0.045]	[0.033]
Joint venture	0.021	0.011	-0.074	0.032
	[0.059]	[0.052]	[0.053]	[0.045]
20-49 persons	0.003	0.063	-0.085	-0.045
	[0.089]	[0.082]	[0.068]	[0.053]
50-99 persons	0.118	0.144	-0.084	0.037
	[0.075]	[0.089]	[0.067]	[0.071]
100-199 persons	0.11	-0.026	-0.07	0.004
	[0.077]	[0.069]	[0.069]	[0.060]
200-299 persons	-0.003	0.052	-0.074	-0.057
	[0.097]	[0.089]	[0.072]	[0.049]
300-399 persons	0.042	0.068	-0.082	0
	[0.096]	[0.097]	[0.074]	[0.070]
400-499 persons	0.107	-0.065	-0.140*	0.055
	[0.102]	[0.081]	[0.071]	[0.089]
500-999 persons	0.099	-0.064	-0.025	-0.067
	[0.086]	[0.069]	[0.083]	[0.045]
1000-1499 persons	-0.09	-0.04	0.059	-0.108**
	[0.135]	[0.106]	[0.126]	[0.034]
1500-1999 persons	-0.125	-0.106	-0.05	0.016
	[0.174]	[0.121]	[0.128]	[0.133]
2000 and above	0.023	-0.096	-0.044	-0.021
	[0.134]	[0.083]	[0.114]	[0.080]

Table 6 *(continued)*

	(1)	(2)	(3)	(4)
Raw material processing	0	0.15	0.059	0.005
	[0.104]	[0.117]	[0.100]	[0.078]
Components and parts	-0.053	0.006	0.115	0.055
	[0.105]	[0.092]	[0.098]	[0.080]
Final products	-0.118	0.104	0.083	0.072
	[0.095]	[0.084]	[0.086]	[0.069]
2 to 5	-0.04	-0.025	0.064	-0.052
	[0.066]	[0.054]	[0.065]	[0.040]
6 to 10	0.073	0.026	0.046	-0.111**
	[0.069]	[0.065]	[0.076]	[0.032]
11 or more	-0.045	0.012	0.016	-0.100*
	[0.066]	[0.056]	[0.062]	[0.042]
Less than 0.5%	0.058	-0.073	-0.079	0.157*
	[0.068]	[0.050]	[0.056]	[0.066]
0.5 to 0.99%	0.078	-0.134**	-0.04	0.190*
	[0.072]	[0.045]	[0.070]	[0.091]
1% and more	0.068	-0.124*	0.036	-0.007
	[0.077]	[0.049]	[0.084]	[0.061]
Before 1990	-0.056	0.108	0.133	-0.016
	[0.095]	[0.093]	[0.102]	[0.058]
1990-1994	-0.214	-0.012	0.189	-0.05
	[0.139]	[0.111]	[0.144]	[0.058]
1995-1999	-0.058	0.032	0.167+	-0.079*
	[0.090]	[0.083]	[0.096]	[0.034]
2000-2004	0.073	0.047	-0.046	-0.005
	[0.080]	[0.081]	[0.076]	[0.056]
2005 and later	-0.014	0.021	0.019	-0.090**
	[0.078]	[0.068]	[0.073]	[0.034]
Observations	702	696	702	692

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Source: ERIA Establishment Survey 2010.

5.3. Sharing Past Failure Experience of Other Firms Correlated with Firm-Level Creative Destruction

In this subsection, we verify the impacts of sharing the past failure experience of other firms on product innovation, product destruction, and product churning: that is, firm-level creative destruction. If firms could utilize other firms' past failure experience in the market, sharing the information would help to shape their innovation strategy. We assume that the past failure experience of other firms comes from the main production partners. Keeping long-term relationships with existing suppliers and partners is efficient not only for accumulating relationship-specific assets but also for collecting the past failure experience of other firms among connected firms. This type of information usually does not diffuse publicly compared to the past success experience. Thus, connected firms, for example, firms that dispatch engineers to their production partners or accept engineers from their production partners, could receive more benefit than firms that do not connect. This creates product differentiation, churning, and firm-level product destruction as the sum of product creation and destruction.

In addition, we make the assumption that firm-level creative destruction needs the adoption of cross-functional teams within a firm as well as the diffusion of information across firms. We use interaction term between adopting cross-functional teams within a firm and exchanging engineers with upstream suppliers and downstream customers as an instrumental variable for the main explanatory variable: sharing the past failure experience of other firms. We expect that firms interacting with these internal and external resources could examine the past failure experience of other firms, and that they would introduce a new product and discontinue an existing product. Thus, this leads to product reallocation and firm-level creative destruction.

Table 7 examines this idea, showing the IV estimates of the impact of the past failure experience of other firms on product innovation. Column 1 of Table 7 presents IV-Probit estimates for firms sharing other firms' past experience of failure. The effect of sharing other firms' failure experience within a firm on changes in packaging and appearance design is significantly positive. Column 2 of Table 7 shows that the sharing other firms' past failure experience within a firm has a positive and significant impact on improving existing products. Column 3 of Table 7 also shows the positive and significant impact of sharing other firms' past failure experience within a firm on introducing a new product based on existing technologies at the firm. In addition, sharing other firms' past failure experience also significantly explains the introduction of a new product based on new technologies (Column 4 of Table 7). This suggests that sharing the past failure experience of other firms could affect the choice of new technologies. Column 5 of Table 7 presents that firms which share the past failure experience of other firms are likely to have a higher innovation tendency.

Table 7: Effects of Information Sharing of Past Failure of Other Firms on Product Innovation

	(1)	(2)	(3)	(4)	(5)
	IV-Probit				IV-Regression
	Dependent variables: Product innovation				
	Significant change in packaging or appearance design	Significant improvement of an existing product	Development of a totally new product based on the existing technologies	Development of a totally new product based on the new technologies	The sum of product innovation
Failure of other firms	**2.235****	**2.187****	**2.716****	**2.799****	**6.285***
	[0.687]	**[0.629]**	**[0.262]**	**[0.206]**	**[2.657]**
Firm age	0.004	0	0.003	0	0.004
	[0.004]	[0.004]	[0.003]	[0.004]	[0.008]
Indonesia	-0.087	-0.045	0.074	-0.044	0.125
	[0.202]	[0.196]	[0.159]	[0.042]	[0.381]
Thailand	0.07	0.114*	0.116*	0.107+	0.129
	[0.254]	[0.274]	[0.055]	[0.180]	[0.459]
Hanoi	-0.114	0.042	0.071	-0.218	0.005
	[0.157]	[0.215]	[0.157]	[0.041]	[0.336]
Ho Chi Minh City	-1.009**	-0.323	0.440**	0.444**	-2.767*
	[0.371]	[0.050]	[0.193]	[0.050]	[1.301]
100% foreign owned	0.106	-0.006	0.046	-0.005	0.083
	[0.123]	[0.127]	[0.036]	[0.036]	[0.259]
Joint venture	0.059	0.041	0.04	0.043	0.027
	[0.167]	[0.163]	[0.040]	[0.144]	[0.324]
20-49 persons	0.374	-0.034	-0.032	-0.044	0.578
	[0.231]	[0.197]	[0.064]	[0.218]	[0.452]
50-99 persons	0.253	0.123	0.032	0.018	0.239
	[0.258]	[0.068]	[0.206]	[0.071]	[0.451]
100-199 persons	0.377	0.001	0.136	0.276	0.543
	[0.251]	[0.067]	[0.194]	[0.229]	[0.438]
200-299 persons	0.681*	0.648*	0.619*	-0.092	1.523**
	[0.271]	[0.258]	[0.076]	[0.078]	[0.567]
300-399 persons	0.253	0	0.105	-0.01	0.28
	[0.287]	[0.079]	[0.079]	[0.254]	[0.517]
400-499 persons	0.223	0.079	0.036	0.069	0.13
	[0.354]	[0.088]	[0.089]	[0.317]	[0.645]

Table 7 *(continued)*

	(1)	(2)	(3)	(4)	(5)
500-999 persons	0.759**	0.550*	-0.083	-0.093	1.168*
	[0.274]	[0.259]	[0.078]	[0.080]	[0.567]
1000-1499 persons	0.897**	-0.137+	0.433	0.719*	1.482*
	[0.324]	[0.287]	[0.085]	[0.087]	[0.709]
1500-1999 persons	0.567	0.46	0.002	-0.006	0.879
	[0.474]	[0.515]	[0.116]	[0.117]	[0.971]
2000 and above	0.628	0.426	-0.026	0.535	1.006
	[0.436]	[0.094]	[0.093]	[0.344]	[0.677]
Raw material processing	-0.232	-0.306	0.045	0.044	-0.393
	[0.290]	[0.064]	[0.064]	[0.064]	[0.550]
Components and parts	-0.248	0.054	0.058	0.054	-0.224
	[0.279]	[0.258]	[0.063]	[0.222]	[0.525]
Final products	-0.133	0.07	-0.145	-0.403+	-0.323
	[0.277]	[0.059]	[0.059]	[0.216]	[0.528]
2 to 5	0.212	0.009	-0.034	0.208	0.359
	[0.167]	[0.168]	[0.151]	[0.159]	[0.345]
6 to 10	0.544**	0.533**	0.565**	-0.120*	1.200*
	[0.191]	[0.050]	[0.050]	[0.050]	[0.489]
11 or more	0.300+	-0.071+	0.290+	0.383*	0.690+
	[0.168]	[0.042]	[0.042]	[0.158]	[0.378]
Less than 0.5%	-0.255	-0.166	0.139*	-0.326+	-0.549
	[0.222]	[0.054]	[0.055]	[0.187]	[0.533]
0.5 to 0.99%	-0.025	0.162**	-0.135	-0.138	-0.205
	[0.323]	[0.291]	[0.260]	[0.062]	[0.630]
1% and more	0.018	0.279	0.024	0.201	0.362
	[0.232]	[0.062]	[0.215]	[0.063]	[0.469]
Before 1990	-0.015	-0.003	-0.005	0.008	-0.231
	[0.254]	[0.071]	[0.072]	[0.072]	[0.528]
1990-1994	0.184	0.711*	-0.017	-0.056	0.333
	[0.313]	[0.335]	[0.304]	[0.084]	[0.664]
1995-1999	0.493*	0.287	-0.09	0.374+	0.871+
	[0.233]	[0.218]	[0.061]	[0.060]	[0.515]
2000-2004	0.124	-0.007	-0.012	-0.096	-0.15
	[0.243]	[0.240]	[0.221]	[0.068]	[0.513]
2005 and later	0.337	0.145	0.133	-0.110+	0.349
	[0.227]	[0.231]	[0.218]	[0.211]	[0.508]
Constant	-1.019*	0.055	-1.094**	-1.492**	-0.039
	[0.409]	[0.423]	[0.094]	[0.096]	[0.793]
rho	0.068	-1.093**	0.046	-0.634+	-0.039
	[0.094]	[0.032]	[0.032]	[0.375]	[0.793]
/athrho	-0.829+	-0.880*	-0.805*	0.062	-0.039
	[0.461]	[0.092]	[0.364]	[0.032]	[0.793]
/lnsigma	-1.094**	-0.631+	-1.339**	-1.091**	-0.039
	[0.032]	[0.349]	[0.354]	[0.344]	[0.793]
Log Psuedo Likelihood	-646.67823	-600.57226	-644.35715	-547.80439	
Wald test of exogeneity (/athrho = 0): chi2(1)	3.24	4.33	13.55	15.82	
Observations	687	694	695	686	691

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Source: ERIA Establishment Survey 2010.

Sharing the other firms' past failure information also explains product destruction. Table 8 shows IV-Probit regression results for discontinuing a product and the number of product lineups. Even though Column 1 of Table 8 does not show that the coefficient of sharing on discontinuing a product is positive and significant, Column 2 of Table 8 presents that sharing other firms' past failure experience has a significant effect on decreasing the number of product lineups. This suggests that sharing the past failure experience of other firms could affect the narrowing of product varieties and the concentration of product lineups advantageously. Column 3 of Table 8 partially supports this: That is, the probability that the number of products is unchanged is lower for firms that share the past failure experience of other firms.

Table 8: Effects of Information Sharing of Past Failure of Other Firms on Product Churning

	(1)	(2)	(3)	(4)
	IV-Probit			
	Dependent variables: Product churning			
	Discontinue a product	The number of product types decreased	The number of product types is same	The number of product types increased
Failure of other firms	1.476	**2.627****	**-1.685+**	0.336
	[1.097]	**[0.301]**	**[0.918]**	[1.500]
Firm age	0	0.002	0.009+	0
	[0.004]	[0.001]	[0.001]	[0.001]
Indonesia	0.929**	-0.039	-0.728**	0.799**
	[0.258]	[0.043]	[0.041]	[0.042]
Thailand	0.113*	0.123*	0.116*	0.116*
	[0.054]	[0.211]	[0.055]	[0.055]
Hanoi	0.472	0.051	0.042	0.042
	[0.292]	[0.042]	[0.041]	[0.041]
Ho Chi Minh City	-0.739	0.436**	-0.24	0.440**
	[0.050]	[0.373]	[0.740]	[0.768]
100% foreign owned	-0.007	0.003	-0.01	0.03
	[0.178]	[0.130]	[0.036]	[0.137]
Joint venture	0.159	0.037	0.031	-0.161
	[0.040]	[0.041]	[0.169]	[0.172]
20-49 persons	0.379	0.057	-0.033	0.181
	[0.306]	[0.069]	[0.227]	[0.248]
50-99 persons	0.476	-0.097	0.033	0.201
	[0.353]	[0.244]	[0.241]	[0.256]
100-199 persons	0.253	-0.021	0.002	0.520*
	[0.067]	[0.071]	[0.246]	[0.067]

Table 8 *(continued)*

	(1)	(2)	(3)	(4)
200-299 persons	-0.083	-0.107	-0.23	-0.084
	[0.321]	[0.278]	[0.270]	[0.076]
300-399 persons	0.59	-0.213	-0.351	0.663*
	[0.360]	[0.287]	[0.080]	[0.291]
400-499 persons	0.079	-0.129	0.076	0.077
	[0.469]	[0.091]	[0.088]	[0.088]
500-999 persons	-0.085	-0.057	-0.085	-0.085
	[0.326]	[0.081]	[0.267]	[0.077]
1000-1499 persons	-0.136+	0.309	-0.135	0.502
	[0.083]	[0.327]	[0.084]	[0.084]
1500-1999 persons	0.224	0.032	0.001	0.900+
	[0.468]	[0.119]	[0.115]	[0.115]
2000 and above	0.044		-0.29	0.860*
	[0.411]		[0.093]	[0.417]
Raw material processing	0.042	0.045	0.04	-0.282
	[0.064]	[0.066]	[0.063]	[0.065]
Components and parts	-0.761*	-0.319	0.127	0.034
	[0.308]	[0.253]	[0.062]	[0.063]
Final products	-0.409	-0.332	0.051	0.049
	[0.259]	[0.061]	[0.058]	[0.262]
2 to 5	0.014	-0.037	-0.399*	-0.026
	[0.044]	[0.045]	[0.044]	[0.188]
6 to 10	-0.119*	0.331+	-0.110*	-0.110*
	[0.050]	[0.195]	[0.197]	[0.050]
11 or more	-0.071+	-0.084+	-0.063	-0.062
	[0.042]	[0.183]	[0.185]	[0.042]
Less than 0.5%	0.134*	-0.690**	0.334	0.212
	[0.054]	[0.055]	[0.214]	[0.054]
0.5 to 0.99%	-0.514+	0.157*	0.808**	-0.205
	[0.266]	[0.256]	[0.061]	[0.317]
1% and more	0.083	-0.34	0.018	0.019
	[0.061]	[0.063]	[0.061]	[0.061]
Before 1990	-0.003	0.385	-0.003	-0.004
	[0.343]	[0.283]	[0.324]	[0.267]
1990-1994	0.226	-0.04	-0.843*	-0.062
	[0.359]	[0.357]	[0.083]	[0.328]
1995-1999	0.649**	-0.093	-0.863**	0.566*
	[0.060]	[0.061]	[0.060]	[0.248]
2000-2004	0.125	0.064	-0.447+	-0.005
	[0.263]	[0.068]	[0.067]	[0.241]
2005 and later	0.711**	-0.134*	-0.114+	-0.114+
	[0.242]	[0.061]	[0.060]	[0.256]
Constant	-0.635	-1.379**	0.705	-1.091**
	[0.093]	[0.408]	[0.351]	[0.032]
rho	-1.095**	-0.799*	-1.094**	-0.166
	[0.032]	[0.096]	[0.091]	[0.092]
/athrho	-1.091*	-1.091**	0.600+	0.068
	[0.510]	[0.358]	[0.457]	[0.514]
/lnsigma	0.055	0.054	0.067	-1.000*
	[0.442]	[0.033]	[0.032]	[0.390]
Log Psuedo Likelihood	-522.52994	-394.1857	-585.14657	-634.28984
Wald test of exogeneity (/athrho = 0): chi2(1)	1.55	11.41	2.37	0.1
Observations	697	660	700	696

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.
Source: ERIA Establishment Survey 2010.

In sum, the empirical results of Tables 7 and 8 suggest that sharing other firms' past failure experience stimulates product innovation as well as product destruction. As a result, it decreases the number of product lineups. Even though such firms are likely to reduce product lineups, they seem to reallocate and concentrate the resources within the firm to a new product.

5.4. Robustness Check: Adopting QC Circle Does Not Explain Product Innovation

We move to a robustness check as to the effect of interaction terms of adopting cross-functional teams and exchanging engineers on the propensity to product innovation across firms. Now we examine whether or not product innovation needs interaction between adopting cross-functional teams and exchanging engineers. If product innovation has required different kinds of information across departments, that is, department-wide information, then there has to be implementation of some internal activities in order to integrate the local information into one. This might exaggerate the benefits of knowledge exchanges with production partners. That is the main story of this paper. But there should be an alternative explanation that firms investing in other types of internal activities could also exaggerate the impacts of knowledge exchanges with their production partners. For example, a firm's local knowledge sharing within a department, such as adopting a QC circle, could affect product innovation. If this has been true, then it is difficult to say whether cross-functional teams enhance the impacts of external linkages on product innovation. To check the robustness of the argument of this paper, we replace adopting cross-functional teams into adopting a QC circle in baseline regressions. We expect that the coefficient of interaction terms between a QC circle and exchanging engineers is insignificant. No columns of Table 9, except for Column 1, present that a QC circle does enhance product innovation. Column 1 of Table 9 only shows the positive and significant impacts of interactions between adopting a QC circle and exchanging engineers on changes in packaging and appearance design. Table 10 also shows there is no evidence that a QC circle enhances the impact of exchanging engineers on discontinuing a product and the number of product lineups. In sum, if we replace the proxy of information sharing across departments into the proxy of information sharing within a department, then such local knowledge sharing could not affect product innovation. Thus, these results suggest that product innovation requires an integration of different types of knowledge across departments. The robustness of the argument of this paper is upheld.

Table 9: Effects of Adopting QC Circles on Product Innovation

	(1)	(2)	(3)	(4)	(5)
	Probit (Marginal Effects)				Ordered Logit
	Dependent variables: Product innovation				
	Significant change in packaging or appearance design	Significant improvement of an existing product	Development of a totally new product based on the existing technologies	Development of a totally new product based on the new technologies	The sum of product innovation
Circle*Exchanges	**0.219***	0.135	-0.047	0.047	0.474
	[0.100]	[0.113]	[0.109]	[0.085]	[0.447]
Exchanges of engineers	-0.11	-0.015	0.238*	0.116	0.433
	[0.123]	[0.116]	[0.099]	[0.077]	[0.480]
Firm age	0.002	-0.002	0.002	-0.001	0.001
	[0.002]	[0.002]	[0.002]	[0.001]	[0.006]
Indonesia	-0.09	-0.075	-0.038	-0.022	-0.2
	[0.073]	[0.081]	[0.074]	[0.058]	[0.333]
Thailand	0.188*	0.233**	0.183*	0.104	1.056**
	[0.079]	[0.056]	[0.078]	[0.073]	[0.290]
Hanoi	-0.017	0.178**	0.147*	-0.064	0.299
	[0.070]	[0.062]	[0.072]	[0.047]	[0.281]
Ho Chi Minh City	-0.003	0.303**	-0.118+	-0.143**	0.088
	[0.069]	[0.051]	[0.067]	[0.041]	[0.246]
100% foreign owned	0.054	-0.006	0.021	-0.025	0.121
	[0.053]	[0.056]	[0.055]	[0.041]	[0.191]

Table 9 *(continued)*

	(1)	(2)	(3)	(4)	(5)
Joint venture	0.083	-0.025	0.098	0.092	0.343
	[0.064]	[0.067]	[0.065]	[0.059]	[0.261]
20-49 persons	0.161	0.059	0.093	0.05	0.192
	[0.101]	[0.085]	[0.098]	[0.095]	[0.317]
50-99 persons	0.176+	0.101	0.083	0.089	0.355
	[0.100]	[0.082]	[0.098]	[0.101]	[0.308]
100-199 persons	0.199*	0.148+	0.113	0.191+	0.629*
	[0.097]	[0.080]	[0.095]	[0.105]	[0.300]
200-299 persons	0.268**	0.223**	0.309**	0.333**	1.182**
	[0.103]	[0.074]	[0.095]	[0.125]	[0.337]
300-399 persons	0.15	-0.003	0.08	0.097	0.271
	[0.118]	[0.105]	[0.111]	[0.120]	[0.337]
400-499 persons	0.211+	0.061	0.201	0.259+	0.531
	[0.127]	[0.120]	[0.129]	[0.151]	[0.482]
500-999 persons	0.314**	0.185*	0.102	0.139	0.783*
	[0.100]	[0.085]	[0.108]	[0.121]	[0.336]
1000-1499 persons	0.339**	0.184+	0.07	0.280+	0.829
	[0.121]	[0.099]	[0.142]	[0.162]	[0.521]
1500-1999 persons	0.291+	0.207+	0.252	0.283	0.986+
	[0.159]	[0.124]	[0.165]	[0.190]	[0.549]
2000 and above	0.309*	0.184	0.153	0.364*	0.955+
	[0.135]	[0.118]	[0.144]	[0.164]	[0.495]
Raw material processing	-0.066	-0.114	-0.021	-0.136*	-0.478
	[0.112]	[0.124]	[0.115]	[0.062]	[0.507]
Components and parts	-0.065	0.048	0.036	-0.103	-0.011
	[0.110]	[0.114]	[0.114]	[0.077]	[0.480]
Final products	0.019	0.053	0.041	-0.123	0.03
	[0.106]	[0.109]	[0.107]	[0.084]	[0.467]
2 to 5	0.074	-0.031	0.057	0.078	0.285
	[0.072]	[0.069]	[0.072]	[0.065]	[0.287]
6 to 10	0.144+	0.141*	0.198*	0.086	0.740*
	[0.081]	[0.070]	[0.079]	[0.074]	[0.311]
11 or more	0.073	0.058	0.079	0.118+	0.506+
	[0.071]	[0.066]	[0.071]	[0.064]	[0.290]
Less than 0.5%	0.036	0.073	0.146+	0.031	0.388
	[0.075]	[0.076]	[0.078]	[0.065]	[0.269]
0.5 to 0.99%	0.202*	0.132	0.250**	0.207*	0.934**
	[0.090]	[0.084]	[0.089]	[0.094]	[0.331]
1% and more	0.049	0.163*	0.135	0.177+	0.639+
	[0.092]	[0.079]	[0.095]	[0.095]	[0.334]
Before 1990	-0.032	0.102	-0.075	-0.107*	-0.262
	[0.098]	[0.096]	[0.094]	[0.054]	[0.334]
1990-1994	0.018	0.248**	-0.151	-0.025	0.298
	[0.132]	[0.079]	[0.113]	[0.095]	[0.564]
1995-1999	0.14	0.042	0.092	0.111	0.495
	[0.091]	[0.092]	[0.093]	[0.084]	[0.353]
2000-2004	0.034	-0.005	-0.098	-0.066	-0.258
	[0.092]	[0.096]	[0.088]	[0.064]	[0.345]
2005 and later	0.007	-0.071	-0.153+	-0.123*	-0.479
	[0.084]	[0.090]	[0.079]	[0.053]	[0.298]
Observations	687	694	695	686	691

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Source: ERIA Establishment Survey 2010.

Table 10: The Effects of Adopting QC Circles on Product Churning

	(1)	(2)	(3)	(4)
	Probit (Marginal Effects)			
	Dependent variables: Product churning			
	Discontinue a product	The number of product types decreased	The number of product types is same	The number of product types increased
Circle*Exchanges	-0.082	-0.057	-0.055	0.122
	[0.095]	[0.062]	[0.103]	[0.103]
Exchanges of engineers	0.103	0.085**	-0.018	-0.101
	[0.072]	[0.030]	[0.107]	[0.107]
Firm age	0.002+	0	0.004**	-0.005**
	[0.001]	[0.001]	[0.001]	[0.002]
Indonesia	0.337**	0.012	-0.231**	0.280**
	[0.080]	[0.042]	[0.044]	[0.057]
Thailand	0	0.034	-0.135*	0.124+
	[0.066]	[0.048]	[0.057]	[0.072]
Hanoi	0.193**	0.007	-0.170**	0.158*
	[0.068]	[0.034]	[0.056]	[0.067]
Ho Chi Minh City	-0.028	0.181**	-0.335**	0.189**
	[0.054]	[0.059]	[0.037]	[0.062]
100% foreign owned	0.142**	0.017	-0.043	0.012
	[0.048]	[0.024]	[0.050]	[0.053]
Joint venture	0.071	-0.027	0.09	-0.059
	[0.053]	[0.024]	[0.066]	[0.068]
20-49 persons	0.111	-0.023	-0.03	0.076
	[0.114]	[0.031]	[0.083]	[0.094]
50-99 persons	0.19	-0.017	-0.034	0.091
	[0.127]	[0.033]	[0.083]	[0.092]
100-199 persons	0.088	-0.044+	-0.088	0.197*
	[0.107]	[0.026]	[0.080]	[0.085]
200-299 persons	0.049	-0.050*	-0.04	0.155+
	[0.109]	[0.020]	[0.093]	[0.094]
300-399 persons	0.222	-0.048*	-0.139+	0.242**
	[0.144]	[0.020]	[0.079]	[0.083]
400-499 persons	0.255	-0.012	-0.064	0.089
	[0.170]	[0.044]	[0.113]	[0.121]
500-999 persons	0.111	-0.060**	-0.046	0.202*
	[0.125]	[0.018]	[0.100]	[0.094]
1000-1499 persons	0.366*	-0.018	-0.119	0.176
	[0.171]	[0.046]	[0.109]	[0.120]
1500-1999 persons	0.082	-0.002	-0.225*	0.293**
	[0.165]	[0.079]	[0.093]	[0.112]
2000 and above	0.004		-0.107	0.291**
	[0.121]		[0.116]	[0.098]
Raw material processing	-0.123**	0.072	0.005	-0.107
	[0.046]	[0.072]	[0.100]	[0.110]
Components and parts	-0.184**	-0.047	0.026	0.039
	[0.055]	[0.037]	[0.096]	[0.105]
Final products	-0.101	-0.039	0.013	0.023
	[0.070]	[0.045]	[0.089]	[0.099]
2 to 5	-0.013	0.009	-0.149**	0.180**
	[0.048]	[0.032]	[0.057]	[0.068]
6 to 10	0.027	0.008	-0.186**	0.232**
	[0.057]	[0.035]	[0.058]	[0.070]

Table 10 *(continued)*

	(1)	(2)	(3)	(4)
11 or more	0.046	-0.011	-0.178**	0.224**
	[0.050]	[0.030]	[0.060]	[0.069]
Less than 0.5%	-0.100*	-0.062**	0.045	0.104
	[0.044]	[0.018]	[0.078]	[0.072]
0.5 to 0.99%	-0.074	-0.072**	0.256**	-0.059
	[0.054]	[0.016]	[0.099]	[0.090]
1% and more	0.034	-0.044+	-0.018	0.147+
	[0.073]	[0.022]	[0.096]	[0.086]
Before 1990	-0.106*	0.153	-0.232**	0.119
	[0.052]	[0.097]	[0.056]	[0.097]
1990-1994	0.051	0.152	-0.235**	0.168
	[0.113]	[0.130]	[0.060]	[0.110]
1995-1999	0.202*	0.078	-0.240**	0.191*
	[0.093]	[0.070]	[0.053]	[0.079]
2000-2004	0.046	0.012	-0.165*	0.155+
	[0.079]	[0.049]	[0.066]	[0.083]
2005 and later	0.200*	0.08	-0.117	-0.005
	[0.089]	[0.056]	[0.072]	[0.083]
Observations	697	660	700	696

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Source: ERIA Establishment Survey 2010.

6. Conclusion

Adopting cross-functional teams affects product innovation and destruction through input-output linkages. Firms exchanging engineers with their customers could affect the positive impacts on product innovation if the firms adopted a knowledge sharing scheme across departments such as cross-functional teams. We summarize our main results as follows.

First, adopting cross-functional teams within a firm can stimulate the product innovation impacts of knowledge exchanges through engineers with upstream and downstream firms. This is supported by several types of product innovation, from very simple product upgrading such as changing the package design to more advanced one-development of a totally new product based on new technologies. Second, adopting cross-functional teams within a firm can raise the product destruction impacts of knowledge exchanges through engineers with connected firms. Thus, interactive internal and external information sharing has a positive impact on creative destruction. Third, since interactive internal and external information sharing has delivered the experience of failure of other firms, then learning an experience of failure from other firms has a positive and significant impact on product innovation and creative destruction. Finally, these results are not supported when we use a QC circle in each department as information sharing within a firm instead of cross-functional teams.

These findings are basically consistent with the theory of organizational economics, Dessein and Santos (2006) for example, that proves investment in communication technologies could weaken the trade-off between adaptation to the local information and specialization. The empirical result in this paper is consistent with the theory that investment in teams across departments has lowered the coordination costs. The empirical result of the innovation impacts of the past failure experience of other firms is also consistent with the finding from the diffusion of a new agricultural technology in Ghana by Conley and Udry (2010). Thus, sharing the past experience of failure could be a mother of future innovation and industrial upgrading through the organizational learning. The empirical result suggests that interaction between adopting cross-functional teams and exchanging engineers strongly correlates with sharing other firms' past failure experience.

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