第 4 章

企業間・組織内知識伝播と産業高度化の関係についての実証研究

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要約：（300 字程度）

インドネシア、フィリピン、タイ、ベトナムの製造業企業に対して行った調査に基づき、産業高度化の源泉を内部資源と外部資源の補完性に求めるような実証研究を行った。内部資源と外部資源、そしてそれらの補完性が企業の生産性に与える影響を実証的に検討する研究はこれまでなされてきたものの、具体的な経路を特定し、かつ企業内部で採用されている経営管理手法の情報を用いて生産性上昇効果を見るような実証研究は少ない。本稿では、大きな生産性上昇効果を生み、産業高度化の一指標と考えられる新製品導入と製品ラインアップの絞り込み、入れ替えに注目し、内部・外部資源の補完性が持つ影響を推定する。その際、外部からのエンジニア受入または外部へのエンジニア派遣を外部からの技術・知識移転とみなし、組織内部における部門横断的チームの導入が、こうした外部からの技術移転効果を組織内部で増幅させる役割を果たすかどうかを検証する。他社の「失敗経験」を組織内部で共有する仕組みが新製品導入、絞り込み、入れ替えを促すことを明らかにした。

キーワード：

補完性、エンジニアの派遣･受入、部門横断的チーム、産業高度化、東南アジア

1. Introduction

One of the most striking aspects of the industrial development of Southeast Asia is the growing interdependence of firms. This interaction between firms has generated not only local demand linkages but also technology transfers through knowledge exchanges with production partners In particular these exchanges have been from downstream multinationals customers to upstream local suppliers. It has been expected that these two factors strengthen demand linkages and improve productivity. They are also known as engines of growth and agglomeration.

Although firms may have similar product lineups and may be located in proximity to one another, even within narrowly defined industries and specific locations there are huge disparities in demand and productivity across existing firms. Hsieh and Klenow (2009) show that, in comparison with the United States, China and India are likely to have longer-tailed distributions of productivity across firms. Thus, the productivity gap between the top 10% and the bottom 10% is over 5-fold greater for firms in China and India. This is not a phenomenon exclusive to developing economies. Syverson (2004) shows that productivity in the ready-mixed concrete industry almost doubles between the top 10% and bottom 10% of firms. Foster et al. (2009) also find similar evidence by using other four-digit manufacturing industries in United States.

In seeking determinants of the gaps in firm performance, three recent papers provide an overview of the theoretical underpinnings and empirical studies. First, Syverson (2010) put forward two main factors for explaining productivity differences, even within narrowly defined industries: internal activities and external channels. Internal activities are composed of management practices, input quality of labor and capital, investment in IT and R&D, learning by doing, introducing new product lineups, and degree of centralization. External channels include knowledge spillovers across firms, natural selection mechanisms of pro-competitive effects, effects of liberalization, deregulation and suitable regulation, and efficient competition-driven markets.

Lentz and Mortensen (2010) focus on the quality of search-matching between heterogeneous labor and firms, and provide a new theoretical view of the relationship between input labor quality, labor reallocation, and productivity and wage differences across firms. Finally, Bloom et al. (2010) focus on differences in management practices within a firm by scoring and interviewing management across firms and countries.

This paper investigates the dynamic process of product innovation, product-level creative destruction, and product replacement by 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 firm-level upgrades because the forward and backward production linkages between customer and supplier generate positive information externalities. We know little about either the impact of external resources or the interactions between internal and external resources in terms of firm-level performance. It is especially important to understand how organizational choices within a firm affect interactions with external entities with regards to “adaptive organizations” in this age of market turbulence and uncertainty for developing economies.

Although possibly important, the effect of organizational choices and external linkages on product innovation has not been fully examined. The dynamic process of industry upgrading may be affected by not only internal resources, such as team formation, quality control circles, and R&D investment, but also information exchange between upstream and downstream firms. The empirical problem is to determine how important the adoption of cross-functional teams is when the firm exchanges information with a downstream or upstream firm in terms of both product innovation and product-level creative destruction. To answer this question we need to identify which types of customer-supplier relationships would lead to the adoption of cross-functional teams within a firm. After showing the impact of interaction between the adoption teams and engineers, we show which types of information would create some benefit with regards to product innovation and creative destruction. In particular, since the interaction of internal and external resources has led to more information about past failures of other firms, this experience could explain product innovation and creative destruction.

The most relevant theoretical framework was reported by Dessein and Santos (2006), who examine how the adoption of team production and investment in 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 through the use of local information that outside engineers, and engineers dispatched to outside firms, bring into the firm.

The other relevant literature is in the field of social learning and development. Conley and Udry (2010) show the presence of social learning in the context of pineapple farming in Ghana by mapping an inter-household network in a village. To do so, they relate information on a neighbor’s fertilizer use with the farmer’s own fertilizer use. In particular, the past failures of connected farmers explain the changes in fertilizer use in growing pineapple. In that paper, the same method is applied to input choices for

another crop, a ‘known technology’, but in the absence of social learning effects.[1] The most relevant empirical studies are in the fields of industrial organization and labor economics, for example, Ichniowski et al. (1997), Bresnahan et al. (2002), Hamilton et al. (2003), Bartel et al. (2007) and Bloom and Van Reenen (2007).[2] These empirical studies look at the causes and consequences of the introduction of new management practices in several settings and find significant complementarities between different types of management practices. In comparison to the present study’s focus on establishment-level comparisons of product innovation and the combination of internal resources and external linkages, previous studies tended to concentrate on the impact of the adoption of new internal management practices on improvements in firm-level productivity.

If the acquisition of feedback from production partners, or engineer exchanges with customers and suppliers, are important, the dynamic process of industry upgrading will be closely related to sales and procurement. Even if a firm’s strategy of knowledge exchange with upstream and downstream firms is restricted in each region, it is natural that the dynamic aspects of product innovation and creative destruction will vary according to the firm’s organizational choices such as the adoption of cross-functional teams and the formation of a quality control circle.[3]

The purpose of the present study is to examine the impact of internal choices regarding knowledge transfer (internal knowledge transfer) and knowledge exchange with

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[1] There is an emerging field that focuses upon knowledge creation through mutual learning: see, for example, 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 affects decisions regarding collaboration and its outcome. The fundamental modeling approach in these studies has been applied to the question how the cultural background of members affects a city system (Ottaviano and Prarolo 2009). In that sense, diversity of knowledge among firms and the exchange of knowledge between firms could have aggregate implications (e.g., in a city system or an agglomeration of firms).

[2] There are many important works in the fields of empirical industrial organization and labor economics that study the relationship between productivity and management practices. 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. (2010) also provide experimental evidence of the effects of modern management practices on raising productivity at Indian textile factories. Their finding showed that the factories improve not only their products but also their profitability in comparison with control factories. It is difficult to identify the impact of adoption of modern management practices as well as the impact of changing managerial abilities of managers. Bandiera et al. (2009)investigated the social and workplace connections among fruit pickers, finding that changing the payment system has an effect on productivity.

[3] Information exchanges are not always in "encoded" form (Polanyi 1966, 1967). Communication between firms and their partners is difficult when demand and technologies are complex. This is the same as knowledge production in academia. First, team production results in more highly cited research than does individual production (Wuchty, Jones, and Uzzi, 2007) across all fields of natural science, social science, and arts-humanities. Second, teamwork in science is implemented through not only multi-university collaborations, but also stratified groups (Jones et al. 2008). Rosenblat and Mobius (2004) studied the impact of the rise of the Internet on international collaboration in similar fields. Hortacsu and Syverson (2009) suggested the importance of intangible inputs such as managerial oversight within the firm to show that vertical ownership is not usually used to facilitate transfers of goods in the production chain. They concluded that the central motivation behind owning production chains is the more efficient transfer of knowledge about production and information about markets.

external partners (external knowledge transfer) on firm-level innovation. This paper proposes a new mechanism linking these two types of information transfer with product creation and creative destruction in developing economies. The testable implications are investigated by using survey data gathered from almost 800 manufacturing firms in Indonesia, Thailand, and Vietnam. Through mail surveys and field interviews, we collected firm-level data on the introduction of new products, the decision to discontinue existing products, changes in the product lineup, internal and external resources for information transfer, and the respondent firms' characteristics. Based on these variables, a simple econometric analysis is carried out.

The reason for our focus on East Asia is that this region is a major production site for not only local firms but also multinational corporations. The most striking difference between East Asian and other developing economies is in the volume of intra-industry trade and the combination of spot markets and long-term transactions. The huge volume of intra-industry trade and long-term transactions between customers and suppliers in East Asia allows for a new approach to understanding the agglomeration benefit of product creation and creative destruction.[4]

This work concentrates on detecting the complementary impact of adopting cross-functional teams and exchanging engineers on product innovation and creative destruction, controlling for the type of main product and the number of products. There have been few empirical research studies 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 from suppliers and customers. There is also a lack of quantitative evidence. Field survey-based datasets provide new findings that were lacking in previous studies on industrial organization and innovation in developing economies. Moreover, most of the previous studies do not focus on the knowledge production function.[5]

The empirical results of this paper are quite intuitive. First, firms that 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-level creative destruction. This suggests that adopting cross-functional teams

[4] Geographic features of industry upgrading in particular have not been fully studied in economics of agglomeration (e.g., Fujita and Thisse (1996, 2002)) or in studies on fragmentation, such as Kimura and Ando (2005) and Kimura (2006, 2008, and 2009).

[5] Studying the knowledge production function includes international technology diffusion and international knowledge production. Keller (2000) gave an overview of the cause and effects of technology diffusion across countries. Kerr (2008, 2010) and Kerr and Lincoln (2010) studied the role of ethnic scientific communities on technology diffusion by matching ethnic scientist name with individual patent records.

stimulates the transformation of external knowledge flows in the introduction of new goods as well as the withdrawal of existing products. Thus, it is safe to say that information transfer across teams enhances the likelihood of product churning (the replacement of old products with new ones). Second, since the interaction of internal and external information transfer has revealed the failure experiences of other firms, there is a positive and significant impact on product innovation and creative destruction. Finally, these results are not supported when a quality control circle in each department is used for information transfer within a firm instead of cross-functional teams. This paper aims to study the innovation impacts of mutual knowledge exchanges among inter-connected firms in the field of industrial development.

Section 2 presents a simple framework and testable hypotheses for empirical analysis. Section 3 describes the data originally collected for this study. Section 4 shows preliminary results. The main results are presented in Section 5. Section 6 concludes the paper.

2. Framework

We present a hypothesis to explain the dynamic process of industrial upgrading based on customer–supplier relationships and interactions with internal resources. To do this, we present the “adaptive organization” view described by Dessein and Santos (2006) which explains why improvements in communication technologies can reduce the trade-off between adaptation and coordination. Dessein and Santos (2006) analyze the complementarities between level of adaptation, coordination, and extent of specialization. Production chains within firms collect information on the market and use it for production and vice versa. Since managers centralize local information, their abilities play a key role in product and process innovations within the firm.

Consider two different manufacturers in terms of investment in communication technologies across departments in a firm. One manufacturer invests in improving communication technologies to disseminate information within the firm while the other manufacturer does not. We assume that local information in manufacturing lines is gained through the exchange of engineers between customer and supplier. If this is true, the manufacturer’s investments in communication technologies are likely to enhance the impact of external linkages on product innovation. From this framework we derive the hypothesis that if internal and external resources could be complements in developing economies such as Indonesia, the Philippines, Thailand, and Vietnam, such assemblers

in these countries will tend to achieve greater product innovation. The implication of this example is related to the finding of Asanuma (1989). We can state the following hypotheses.

Hypothesis 1: The probability of product innovation and creative destruction for firms that have adopted cross-functional teams and exchanged engineers with their partners will be higher than that for firms that have not adopted cross-functional teams.

This framework raises a new question concerning which type of information can stimulate product innovation and creative destruction. We combine our framework with that of Conley and Udry (2010), which examines the presence of social leaning in the context of pineapple farming in Ghana by drawing inter-household network in a village. They find that within the information neighborhood, past failure experiences, rather than past successes, affected the decision to use a certain level of inputs.

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

Hypothesis 2: Failure experiences of other firms could diffuse into a firm through the exchange of engineers with connected suppliers and customers. The probability of product innovation and creative destruction for firms that learn about the failure experiences of other firms through the adoption of cross-functional teams and engineer exchanges with their partners will be higher than that of firms that have not learned about the failure experiences of other firms.

3. Data

A. Sampling

Based on in-depth interviews with 794 firms, we constructed innovation, external linkage, internal linkage, and other firm-specific variables for 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 to include changes in product packaging and appearance, the introduction of a new product based

on existing technology, and the introduction of a new product based on new technology. We also define process innovation to include the introduction of new goods, the purchase of new machines, process improvements, organizational changes, the discovery of a new market, and finding a new source of procurement.

B. Product innovation, destruction, and main explanatory variables

In our survey, we measure a new variable for an effective knowledge transfer system in the introduction of new products and quality control. To achieve product and process innovation, each firm utilizes information from external sources and combines it with knowledge internal to the firm. The key point is the tool of knowledge transfer within the firm. We have three types of new variables for knowledge transfer within the firm: (1) quality control circles which diffuse production-related information by word of mouth within small groups/communities; (2) Cross-functional team across departments; (3) Department-wide IT connections. These three types of knowledge transfer systems will connect the research department to engineering and production sites and to human resources, or the market research department to logistics and distribution. For cross-functional teams, we ask which departments are involved in the cross-functional team that the establishment organizes to introduce new products and conduct quality control. Another interesting feature of this year's survey is a question about whether the establishment disseminates information about the successes or failures of their own establishment or other firms. Dissemination of success or failure information could be valuable if the firms face market turbulence. Since some bottlenecks usually exist in the market or workplace, the manager's responses would normally reflect misallocations or maladjustments in the distribution of resources. We hypothesize that an internal knowledge transfer system drives product and process innovation.

Table 1 presents summary statistics for the innovation variables. The sample shows 41.2% of firms achieving significant change in packaging or appearance design, 58.3% of firms achieving significant improvement of an existing product, 42.4% of firms developing a totally new product based on existing technologies, and 24.9% of firms developing a totally new product based on the new technologies. Table 1 also shows summary statistics for product churning. The sample shows 21.9% of firms discontinue a product, 9.2% of firms decrease the number of products, 32.9% of firm do not change the number of product types, and 57.8% of firm increase the number of product types. On the other hand, 74% of firms dispatch their in-house engineer to main upstream and downstream firms or accept engineers from main upstream and downstream firms.

Cross-functional teams across departments are adopted by 10% of firms while 52.5% of firms establish a quality control circle within a department.

Table 1 also shows the establishment's activities in regard to dissemination of information about experiences of successes and failures of their own and other firms. It is relatively easier to uncover information about the past experiences of success within one's own establishment as opposed to other firms. 67.5% of firms disseminate the information about past experiences of success of their own establishment while 26.3% of firms are party to information about the past successes of other firms. On the other hand, it is relatively difficult to disseminate information about the past failures of one's own establishment and of other firms: 22.8% of firms disseminate information about past failures within their own establishment and only 17.8% of firms are party to the past failure experiences of other firms.

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 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
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.

C. Firm characteristics

The sample industries are all in manufacturing. The average age is 16.4 years. Since there are younger and older firms, the standard deviation of age in 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. Firms are classified into 11 categories of establishment size. Although firm size ranges between small (1-19 persons), medium (100 persons), and very large firms (2000 persons and more), our survey only collects information about small and medium sized firms from 20 to 299 persons. A firm is also classified into 1 of 17 manufacturing categories. Except for the "not classified" sample, firms in metal products, electronics, machinery, and automobile manufacturing and parts dominate the sample.

Products are classified into raw materials, raw material processing, components and parts, and final products. Roughly half of the sample firms (49.3%) produce final products. Components and parts are the main products of 30.2% of firms. The remaining firms engage in processing and selling raw materials. The number of product types is also dispersed. Single product firms are only 13.5% of the sample while the peak is 11 or more types of product for 38.5% of firms.

The other important firm characteristic is R&D activity. Just over half of sample firms have no R&D expenditures. About 20% of firms have a ratio of R&D expenditure to total sales of less than 0.5%. Firms with less than 1% of R&D expenditure to total sales ratio make up 13.1% of the sample. 12.8% of firms have a ratio greater than 1%.

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	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, bevarage, 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
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
Automobille, autoparts	760	0.047	0.213
Other transportation equipments and parts	760	0.026	0.160
Other	760	0.136	0.343

Table 2. Summary Statistics of Firm Characteristics (continued)

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.

4. Preliminary findings

What are the mechanisms underlying the dynamic process of product innovation and creative destruction in terms of the utilization of internal and external resources? First we discuss the distribution of the propensity to achieve product innovation and product churning through information transfer activities within and across firms. These include the exchange of engineers with production partners upstream or downstream and the adoption of cross-functional teams across departments. Second we show the distribution of the propensity to innovate for firms with two types of information transfer activities.

Table 3 shows that the probability of product innovation is higher for firms that exchange engineers with their main production partners than for firms that do not. The probability of product churning is also higher. These firms aggressively discontinue old products and introduce new ones. Thus, the probability that the number of products has not 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 that exchange knowledge through dispatching or accepting engineers are likely to achieve both product innovation and creative destruction. The propensities for both decreasing and increasing the product lineup are higher for firms that dispatch to or accept engineers from their partners. Such firms are also more likely to access information about past experiences of failure of other firms.

In turn, firms that adopt cross-functional teams are more likely to innovate. They are also more likely to discontinue products and expand the product lineup. Firms that adopt cross-functional teams across departments are more likely to be party to information about the past failure or success experiences of their own firms. It is worth noting that such firms are also more likely to be party to information about past experiences of failure of other firms.

Thus, firms that combine these two types of information transfer within and across firms are more likely to innovate, discontinue a product, and expand the lineup than firms that do not. In addition, firms combining these two types of information transfer activities within and across firms are more likely to be party to past failure experiences of other firms. We assume that the information about the past failure experiences of other firms could play an important role in product innovation and product churning. We check whether these arguments are justified by controlling for differences in many aspects of firm characteristics in the remaining sections.

What are the mechanisms underlying the dynamic process of product innovation and creative destruction in terms of the utilization of internal and external resources? First we discuss the distribution of the propensity for product innovation and product churning through information transfer activities within and across firms such as the exchange of engineers with production partners upstream or downstream and the adoption of cross-functional teams across departments. Second we show the distribution of the propensity to innovate for firms that combine two types of information transfer activities.

Table 3 shows that the probability of product innovation is higher for firms that exchange engineers with their main production partners than for firms that do not. The probability of product churning is also higher for firms that exchange engineers. These firms aggressively discontinue old products and introduce new ones. Thus, the probability that the number of products has not changed is lower for these firms (28.4%) than for firms that do not exchange engineers (45.8%). In sum, firms who practice knowledge exchange through dispatching or accepting engineers are more likely to

achieve both product innovation and creative destruction. The propensity both to decrease and to increase the number of products is higher for firms who dispatch engineers to or accept engineers from their partners. Such firms are also likely to have access to information about the past failure experiences of other firms.

In turn, firms who adopt cross-functional teams are more likely to innovate. They are also more likely to discontinue products and to increase the number of products in their lineup. Firms who adopt cross-functional teams across departments are more likely to disseminate information of past successes or failures of their own firms. Such firms are also likely to disseminate information about past failure experiences to other firms.

Thus, firms that combine these two types of information transfer within and across firms are more likely to achieve product innovation, discontinue a product, and increase their product lineup than firms that do not utilize these two types of information transfer. In addition, firms that combine these two types of information transfer activities are likely to be party to the past failure experiences of other firms. We assume that this information could play an important role in product innovation and product churning. We check whether these arguments are justified by controlling for differences in many aspects of firm characteristics in the remaining sections.

Table 3. Probability of Product Innovation through Exchange of Engineers and Adoption of Cross-Functional Teams

	Exchanges of engineer with main upstream or downstream firms		Adopting cross-functional team for introduction of a new product		Exchanges*Team	
Product innovation	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
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
Produt charning						
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

A. Baseline results

Table 4 shows the regression results on how the adoption of cross-functional teams enhances the impact of exchanging engineers with upstream suppliers or downstream customers on innovation. 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) introduction of a new product based on technologies already used by the firm; (4) introduction of a new product based on technologies new to the firm. In addition, the simple sum of these types of product innovation is used to determine the likelihood for firm-level product innovation. The main explanatory variable is the interaction terms between the adoption of cross-functional teams within a firm and the exchange of engineers across firms. The firm's basic characteristics shown in Table 2 are used as controls 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 transfer 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 uses dispatching/accepting of engineers, on average, makes changes in packaging and design with a higher probability than firms that have not combined internal and external resources. This result is robust even after controlling for additional explanatory variables, in particular, the exchange of engineers. This result suggests that if firms dispatch their in-house engineers to upstream and downstream firms or accept engineers from these other firms, then those firms could receive more benefit from adopting cross-functional teams with respect to changes in 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 the interaction terms between knowledge transfer within and across firms is 0.176 with a robust standard error of 0.063. This result suggests that adopting cross-functional teams and dispatching or accepting engineers from a firm's main partners, on average, significantly improves existing products with a higher probability than when firms do not combine internal and external resources. Column 3 of Table 4 suggests that the coefficient for interaction terms between knowledge transfer 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, leads to the introduction of a new product based on existing technologies with a higher probability than when firms do not combine internal and external resources. Column 4 of Table 4 shows that the coefficient for the interaction terms between knowledge transfer 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, increases the introduction of new products based on new technologies with a higher probability than when firms do not practice this combination. Finally, Column 5 of Table 4 presents the result of an ordered logit model. The interaction term is significant in explaining the likelihood of firm-level product innovation. Firms with a combination of internal and external resources are more likely to increase the four types of product innovations.

In summary, given an exchange of engineers across production partners, the adoption of cross-functional teams within a firm would increase the impact of knowledge flows from the exchange on several types of product innovations.

Table 4. The 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	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes
Capital structure	Yes	Yes	Yes	Yes	Yes
Firm size	Yes	Yes	Yes	Yes	Yes
Main products	Yes	Yes	Yes	Yes	Yes
Number of products	Yes	Yes	Yes	Yes	Yes
R&D expenditure-sales ratio	Yes	Yes	Yes	Yes	Yes
R&D experience (year)	Yes	Yes	Yes	Yes	Yes
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 products in the lineup. Table 5 shows how adopting cross-functional teams changes the impact of exchanging engineers on the decision to discontinue a product and decrease or increase the number of products in a firm's lineup. Column 1 of Table 5 suggests that cross-functional teams increase the impact of external linkages on the decision to discontinue products. Column 2 of Table 5 shows no significant evidence that cross-functional teams change the impact of external linkages on decreasing the number of products in a lineup. Adopting cross-functional teams decreases the impact of external linkages on a firm's decision that the number of product is unchanged (Column 3 of Table 5). Column 4 of Table 5 also shows there is no evidence that cross-functional teams change the impact of external linkages on increasing the number of products in the firm's lineup. In sum, both Table 4 and Table 5 show that interaction between teams within a firm and linkages across firms stimulate both product innovation and destruction. Whereas the interaction was significant for firm-level creative destruction, it was insignificant for the number of product types.

Table 5. The Effects of Interaction of Adopting Cross-functional Teams and Exchange of Engineers

	(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	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Capital structure	Yes	Yes	Yes	Yes
Firm size	Yes	Yes	Yes	Yes
Main products	Yes	Yes	Yes	Yes
Number of products	Yes	Yes	Yes	Yes
R&D expenditure-sales ratio	Yes	Yes	Yes	Yes
R&D experience (year)	Yes	Yes	Yes	Yes
Observations	687	694	695	686

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

B. Internal and external resources reveal past experiences of failure of other firms

We turn now to the question of what types of information cross-functional teams and engineer exchanges make available. Baseline results show that internal resources increase the impact of external resources on product innovation and destruction. These results suggest a complementary relationship between these resources within and across firms. It is natural to question what types of information they deliver and diffuse. Our goal in this estimation is to understand which types of past experiences, both of one's own and other firms, correlate with the adoption of cross-functional teams and engineer dispatching or accepting. Table 6 summarizes how the adoption of cross-functional teams enhances the impact of engineer exchanges on the acquisition of information on past success or failure. Columns 1 and 2 of Table 6 show the interactions terms between cross-functional teams within a firm and engineer exchanges across firms have significant positive impacts on the dissemination of information about the past successes and failures of one's own establishment. The most important finding is the comparison of Columns 3 and 4 of Table 6. Adopting cross-functional teams does not increase the impact of external linkages across firms on the dissemination of information about the past successes of other firms (Column 3). On the other hand, teams within a firm increase the impact of external linkages across firms on being party to past failure experiences (Column 4). Since external linkages have delivered information on 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 be party to the past failure experiences of other firms. These internal and external resources are found to be a better predictor of disseminating information on the past failure experiences of other firms.

Table 6. The Effects of Interaction of Adopting Teams and Exchanging Engineers on Disseminating Information on 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	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Capital structure	Yes	Yes	Yes	Yes
Firm size	Yes	Yes	Yes	Yes
Main products	Yes	Yes	Yes	Yes
Number of products	Yes	Yes	Yes	Yes
R&D expenditure-sales ratio	Yes	Yes	Yes	Yes
R&D experience (year)	Yes	Yes	Yes	Yes
Observations	687	694	695	686

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

C. Being party to past failure experiences of other firms correlated with firm-level creative destruction

In this subsection, we verify the impact of being party to the past failure experiences of other firms on product innovation, product destruction, and product churning, in other words, firm-level creative destruction. If firms could utilize other firms' past failure experiences in the market, disseminating this information would help to shape their innovation strategies. We assume that the past failure experiences of other firms come from their main production partners. Maintaining long-term relationships with existing suppliers and partners is effective not only for accumulating relationship-specific assets but also for collecting the experiences of other firms. This type of information usually does not diffuse publicly, unlike past success experiences. Thus connected firms, or those that dispatch or accept engineers from their production partners, could receive more benefit than firms which do not connect. This creates product differentiation, churning, and firm-level creative destruction. In addition, we assume that firm-level creative destruction requires the adoption of cross-functional teams within a firm as well as diffusion of information across firms. We construct a composite of cross-functional team adoption and engineer exchange with upstream suppliers and downstream customers for the main explanatory variable, being party to the past failure experiences of other firms. We expect that firms combining these internal and external resources could examine the past failure experiences 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 shows the IV estimates of the impact of past failure experiences of other firms on product innovation. Column 1 of Table 7 presents IV-Probit estimates for firms party to other firms' past experience of failure. The effect of disseminating information on other firms' failure experiences within a firm on changes in packaging and appearance design is significantly positive. Column 2 of Table 7 shows that this has a significant positive impact on improving existing products. Column 3 of Table 7 also shows the significant positive impact of disseminating information on other firms' past failure experiences within a firm on introducing new products based on technologies already existing within the firm. In addition, being party to other firms' past failure experiences also significantly explains the introduction a new product based on new technologies (Column 4 of Table 7). This suggests that being party to the past failure experiences of other firms could affect the choice of new technologies.

Table 7. The Effects of Being Party to Failure Experiences of Other Firms on Product Innovation (Instrument: Team*Exchange)

	(1)	(2)	(3)	(4)	(5)
	Probit				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
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	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes
Capital structure	Yes	Yes	Yes	Yes	Yes
Firm size	Yes	Yes	Yes	Yes	Yes
Main products	Yes	Yes	Yes	Yes	Yes
Number of products	Yes	Yes	Yes	Yes	Yes
R&D expenditure-sales ratio	Yes	Yes	Yes	Yes	Yes
R&D experience (year)	Yes	Yes	Yes	Yes	Yes
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.

Being party to other firms' past failure information also explains product-level creative destruction. Table 8 shows IV-probit regression results for discontinuing a product and the number of products in the lineup. However, while Column 1 of Table 8 does not show that the significant positive coefficient for the discontinuation of a product, Column 2 of Table 8 shows that being party to other firms' past failure experiences has a significant effect on decreasing the number of products in the firm's lineup. This suggests that being party to the past failure experiences of other firms could cause a narrowing of product varieties and a concentration of product lineups. Column 3 of Table 8 partially supports this. The probability that the number of products is unchanged is lower for firms that are party to the past failure experiences of other firms.

In sum, empirical results of Table 7 and 8 suggest that being party to other firms' past failure experiences stimulates product innovation as well as product creative destruction. As a result, it decreases the number of products in the lineup. However while such firms are likely to reduce the product lineup, they seem to reallocate and concentrate the resources within a firm to a new product.

Table 8. The Effects of Learning Failure Experiences of Other Firms (Instrument: Team*Exchange)

	(1)	(2)	(3)	(4)
	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	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Capital structure	Yes	Yes	Yes	Yes
Firm size	Yes	Yes	Yes	Yes
Main products	Yes	Yes	Yes	Yes
Number of products	Yes	Yes	Yes	Yes
R&D expenditure-sales ratio	Yes	Yes	Yes	Yes
R&D experience (year)	Yes	Yes	Yes	Yes
Observations	687	694	695	686

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 see positive impacts on product innovation if these firms also adopt knowledge transfer schemes across departments such as cross-functional teams. We summarize our main results as follows.

First, adopting cross-functional teams within a firm can affect the impact of knowledge exchanges through engineers with upstream and downstream firms in terms of stimulating product innovation. This is supported by several types of product innovations from very simple product upgrades such as changing package design to more advanced changes such as development of a totally new product based on new technologies. Second, adopting cross-functional teams within a firm can increase the impact of knowledge exchanges through engineers with connected firms on product destruction. Thus combining internal and external information dissemination has a positive impact on creative destruction. Third, since combining internal and external information dissemination can reveal the failure experiences of other firms, this learning has a significant positive impact on product innovation and creative destruction. Finally, these results are not supported when we use a quality circle in each department for disseminating information within a firm instead of cross-functional teams.

These findings are basically consistent with theories of organizational economics such as that of Dessein and Santos (2006), which demonstrates that investment in communication technologies could weaken trade-offs between adaptation to local information and specialization. Empirical results in this paper are consistent with the theory that investment in teams across departments lowers coordination costs. Empirical results of the innovation impacts of the past failure experiences of other firms is also consistent with the findings on the diffusion of new agricultural technology in Ghana by Conley and Udry (2010). Thus, being party to the past experiences of failure could be a catalyst for future innovation and industrial upgrades through organizational learning. Empirical results suggest that combining the adoption of cross-functional teams and engineer exchange strongly correlates with being party to other firms' past failure experiences.

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