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Discovery and Imitation of Export Products and the Role of Existing Exporters in Korean Manufacturing†

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This paper empirically examines what role of existing exporters play in the discovery of new export products and whether there are evidence of spillovers from export discovery. We find that existing exporters are more likely to discover new export products than non-exporters. We also find evidence of export discovery spillovers; export discovery of a product by some plants had an effect of increasing the probability of subsequent export market penetration of the same product by other plants. Export discovery spillovers are found to be stronger among geographically closely located plants. We argue that information spillovers is a part of the story: you learn from your neighboring discoverers about the profitability of potentially exportable products.

Key Word: Export Discovery, Imitation, Export Spillovers
JEL Code: F14, F61, O12

I. Introduction

One of the distinguishing characteristics of countries which have exhibited rapid industrialization and catch-up growth since World War II, such as Korea, is the remarkable growth of manufacturing exports. More noteworthy is the fact that the rapid export growth of Korea has been, upon a casual observation, sustained by the continual introduction of new export products and the subsequent development of new export industries. Hence, understanding how new export products are discovered and how these export discoveries eventually lead to a development of new export industries is likely to be critically important for understanding sustained industrialization and growth.[1]

Utilizing a plant-product dataset in the Korean manufacturing sector, this paper empirically examines initially the types of plants that are more likely to discover new export products and secondly whether there is evidence of spillover from export discovery. In doing so, the study particularly focuses on the role played by existing

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exporters. Foremost, a better understanding of the export discovery process is important *per se,* not only because the continual upgrading of an export product portfolio is key to the economic growth of many developing countries (Hausmann, Hwang, and Rodrik, 2007) but also because learning generated by a firm from the discovery of an export product can potentially spill over to other imitators who subsequently start exporting the same product. This leads to the question of who discovers new export product for the first time in an economy and who imitates the product. Do existing exporters play a leading role in the discovery? The first part of our main empirical analysis attempts to address these issues.

In the second part of our main empirical analysis, we ask whether there is evidence of spillover from export discovery. One key issue in the literature on export spillover is how to identify it. In an effort to do this, to the best of our knowledge, most existing studies examined whether the presence or prevalence of exporting activities in a product market by exporters in close proximity to each other affects the likelihood of subsequent export market penetration by a firm. A positive effect of existing export activity was interpreted as evidence of export spillover.

In this paper, we utilize detailed year-plant-product level information on domestic and export shipments to define export discovery and identify spillover from export discovery. Identifying spillover from export discovery is likely to be important because there should be export discovery in the development process of any export industry. This is one novel feature of this paper. This paper's focus on spillover from export discovery is motivated by Hausmann and Rodrik (2003), who show theoretically that self-discovery of what one is good at producing is key to developing growth in a country. They also show that there is too little self-discovery and too much imitation, as self-discovery is easily imitated. To the best of our knowledge, however, there are few empirical studies which rigorously examine spillover from export discovery.

Before moving ahead, we briefly explain why we expect that existing exporters play a leading role in the discovery of a new export product. First, all other factors being equal, exporters have a cost advantage over non-exporters in export discovery. Suppose that when a firm exports a product for the first time to a market (country), it must incur a fixed firm-specific export market entry cost, a product-specific fixed entry cost, and a market-specific fixed entry cost.[2] When a non-exporter attempts to export a product for the first time in an economy, it must pay all three of these entry costs. However, when an existing exporter attempts to do the same, it does not have to incur again the firm-specific export entry cost, which gives existing exporters a cost advantage over non-exporters in export discovery. Second, related to this, a plant may learn from its own previous exporting experience "what one is good at exporting." Through previous exporting experience of a product, the plant may learn not only about the profitability of exporting that particular product but also about the

[1]There is a vast body of literature on economic growth which shows that the creation of new knowledge and its domestic diffusion is a key process of economic growth for both developed and developing countries. (e.g., Hausmann and Rodrik, 2003; Parente and Prescott, 1994; Grossman and Helpman, 1991a; 1991b). To the extent that the discovery of new export products and the development of new export industries are associated with knowledge creation and diffusion, understanding the former process is likely to be necessary for understanding the process of economic growth.

[2]Our dataset does not have information about the destination market (country) to which a plant-product is exported.

profitability of exporting other related products, including those that have never been exported by any other plant in the economy.[3] Third, existing exporters can be better than non-exporters at discovering new export products due to their superior observable characteristics, such as their higher productivity and larger size. In our empirical analysis below, we will control for the effects of these superior observable characteristics.

We present evidence that existing exporters are more likely to discover new export products than non-exporters. We also find that export discovery of a product by some plants had the effect of increasing the probability of subsequent export market penetration of the same product by other plants. We show some additional evidence that information spillover is a part of the underlying story: you learn from your neighboring discoverers about the profitability of potentially exportable products.

This paper is related to the existing literature in several ways. First, the paper is related to various studies examining firm-level exporting activity, such as those by Clerides, Lach, and Tybout (1998), Bernard and Jensen (2004), Eaton, Kortum, and Kramarz (2004; 2011), and Feenstra and Kee (2008), among others. The paper differs from these studies in that it distinguishes between export discovery and imitative exports during a firm's export market entry by examining the firm's entry into the export market. Second, the paper is related to the literature on export spillover, such as studies by Aitken, Hanson, and Harrison (1997), Alvarez, Faruq, and Lopez (2008), Koenig, Mayneris, and Poncet (2010), and Fernandes and Tang (2014). These studies examined whether the presence or prevalence of exporting activities in a product market by closely located exporters, as mentioned above, affects the likelihood of subsequent export market penetration by a firm.[4] However, these studies do not examine spillover from export discovery as is done in this paper. Third, there is a small but growing body of work on export discovery, including studies most directly related to this paper. Iacovone and Javorcik (2010) present evidence from Mexico that once a firm introduces an export product previously not exported by any other firm, other firms quickly follow. Freund and Pierola (2010) and Artopoulos, Friel, and Hallak (2013) document an important role of export pioneers in the emergence of a new export industry in Peru and Argentina, respectively. However, these studies rely on descriptive analysis or a case-study approach. In contrast, this paper provides systematic econometric evidence of the importance of existing exporters in export discovery, as well as evidence on spillover from export discovery.

Hahn (2018) shows that there is evidence of export discovery spillover in the Korean manufacturing sector while utilizing the same dataset used in this study. This paper also shows evidence of export discovery spillover in addition to some other results, but it differs from Hahn (2018) mainly in that the present paper examines export spillover among geographically closely located plants—i.e., regional export discovery spillover. If export discovery spillover estimated in this paper is information spillover in nature, geographical proximity would matter with regard to

[3]Albornoz *et al.* (2012) and Nguyen (2012) theoretically explain firms' export strategies and dynamics while assuming that a firm's export performance in a market can inform the firm about the performance in other markets. In a similar vein, a firm's exporting experience of a product may inform the firm about the export market performance of other related products.

[4]Swenson (2008) examines the spillover effect from multinational firms on Chinese new exports.

such spillover. In this respect, this paper's results help strengthen the interpretation that the estimated export spillover effect is indeed spillover.

This paper is organized as follows. In the next section, we explain the data and provide some basic facts about export discovery and imitation. In section III, we estimate a multinomial logit model of a plant's choice among export discovery and imitation. In section IV, we estimate a linear probability model of product-level export entry to examine the existence of spillover from export discovery. The final section concludes the paper.

II. Data and Basic Patterns

This study utilizes two datasets. The first consists of unpublished plant-level census data underlying the *Mining and Manufacturing Census* published by Statistics Korea for the period from 1991 to 1998. It is an unbalanced panel dataset and covers all plants with five or more employees in the mining and manufacturing sector. The dataset has information about various plant characteristics, such as production, shipments, production and non-production workers, tangible fixed assets, and R&D expenditures.

The second dataset is an unpublished plant-product-level dataset for the same period, which can be matched to the plant-level dataset through plant identification numbers. A product is identified by an eight-digit product code which is devised by combining the five-digit KSIC (Korea Standard Industrial Classification) code to which the product belongs and the three-digit code based on Statistics Korea's internal product-classification scheme.[5] The product code is consistent over time during the period of the analysis. For each plant-product observation, the values of total shipments (domestic plus export shipments) and export shipments are available. The plant-product dataset covers roughly 70 to 80 percent of plants in the plant-level dataset.[6] The coverage ratio is much higher for total and export shipments. Yearly total shipments and exports from the plant-product dataset account for more than 84.1 percent of shipments and virtually all (99.9 percent) of the exports in the plant-level dataset. Using the information on the plant-product-level total and export shipments, we can identify which plant made a discovery of a new export product for the first time in the economy and which plant began exporting the same product later on.

Table 1 shows the number of plants, products, and the product varieties in the dataset. Here, a product variety is a product produced by a plant. The number of plants in the sample increases from 57,679 in 1991 to a peak of 75,053 in 1996 and then declines to 62,458 in 1998 with the outbreak of the Korean financial crisis.

[5]The product categories are quite narrow. For example, the number of products listed under *television, sound recording and apparatus* (KSIC five-digit code "32300") is 60 in 1997. Among those, there are 16 product categories related to televisions: mono TV receivers, color TV receivers (more than 20 inch), color TV receivers (less than 20 inch), combination TV receivers (color), combination TV receivers (mono), LCD color TVs, multi-vision TVs, projection TV receivers, VCRs, TV tuners (mechanical type), TV tuners (electronic type), laser disc players, VCR &TV receivers, video accompaniment equipment, closed-circuit TVs, and TV components not elsewhere classified. This example gives us a rough sense of what new products are captured in this paper, i.e., major product innovation output.

[6]Only those plants included in the plant-product dataset are included in the sample.

TABLE 1—NUMBERS OF PLANTS, PRODUCTS, AND VARIETIES

Year	Number of Plants		Number of Products		Number of Product-Varieties	
	All	Exporting	All	Exported	All	Exported
1991	57,679	11,018	3,147	2,232	81,453	14,639
1992	58,143	11,433	3,108	2,233	80,355	14,903
1993	68,397	11,345	3,126	2,294	94,313	14,942
1994	69,645	11,045	3,129	2,288	93,568	14,476
1995	73,582	11,056	3,185	2,374	100,172	14,484
1996	75,053	10,634	3,203	2,357	100,812	13,871
1997	71,505	11,160	3,351	2,521	97,065	14,589
1998	62,458	11,755	3,299	2,560	86,215	15,660
Total	536,462	89,446	25,548	18,859	733,953	117,564

Between 14 and 20 percent of plants are engaged in exporting. The number of eight-digit products varies between 3,108 in 1992 and 3,351 in 1997. Between 71 and 78 percent of those products are those exported by some plant. The share of exported products is highest in 1998, when there was a large depreciation of the Korean won. The number of product varieties varies between 80,355 in 1992 and 100,812 in 1996. The share of exported product varieties is between 14 and 19 percent.

Table 2 shows the number of export-discovery products and the number of newly exported product varieties during the sample period. Column A shows the number of exported products, which is from the fourth column of Table 1. It is very interesting to note that the discovery of a new export product is very frequent, which likely reflects the fact that Korea maintained a respectable level of economic growth by relying on export manufacturing. The numbers of yearly export-discovery products, as shown in column B, are between 270 and 495 during the sample period. They account for between 13 and 20 percent of all exported products.

Column C shows the number of export product varieties, which is taken from the sixth column of Table 1. It is surprising to find that more than half of these export product varieties are those which are exported for the first time from the plant's viewpoint (column D, new to the plant). We can further classify these newly exported product varieties into two categories: those that are new to the economy (column E) and those that are new only to the plant (column F). Column E shows that between 7 and 17 percent of newly exported product varieties are newly discovered export

TABLE 2—EXPORT DISCOVERY PRODUCTS AND NEWLY EXPORTED PRODUCT VARIETIES

Year	Exported Product		Exported Product Variety			
	All	Discovery	All	Newly Exported Product Variety		
				(New to the Plant)	(New to the Economy)	(New only to the Plant)
	A	B	C	D = E + F	E	F
1991	2,232		14,639			
1992	2,233	377	14,903	8,337	973	7,364
1993	2,294	414	14,942	9,074	1,073	8,001
1994	2,288	300	14,476	7,473	559	6,914
1995	2,374	342	14,484	7,812	621	7,191
1996	2,357	270	13,871	6,925	467	6,458
1997	2,521	495	14,589	7,812	1,069	6,743
1998	2,560	445	15,660	9,245	1,559	7,686

product varieties, which do not appear to be small numbers.[7] The remaining the newly exported product varieties are first-time exports of a product by a plant which other plants have already begun exporting for the first time in Korea. In short, we observe fairly frequent new exports of products and product varieties from the viewpoint of the economy, as well as fairly frequent imitative exports.

The discussion above shows that there are plants which discover a new export product as well as those which follow and imitate. When a product is newly exported for the first time in the economy by some plants, how quickly and how frequently do other plants imitate it and export the same product? Table 3 provides an answer to this question.

The upper panel of Table 3 shows the mean and median of the number of plants exporting a product which was newly exported from the perspective of the economy in 1992. In 1992, there were 377 new export product discoveries. An average of 2.6 plants simultaneously exported those products in that year. The corresponding median value is one. After one year, the average number of plants increases to 3.4 and the median value increases to two. The imitative exporting continues in later years but appears to slow rapidly. Although the average number of plants exporting a product discovered in 1992 increases to 3.8 in 1998,[8] the median value remains at two. The lower panel in Table 3 shows a case where we focused on 111 products which were exported in 1992 for the first time in the economy and survived in the export market through 1998. We see more clearly that a small number of plants start exporting a product for the first time in the economy and that other plants join in exporting the same product quickly thereafter.

TABLE 3—NUMBER OF PLANTS EXPORTING PRODUCTS DISCOVERED IN 1991

Year	Mean	Median	s.d.	Max	Min	Number of Product
Upper Panel: All 1992 export discovery						
1992	2.6	1	5.0	55	1	377
1993	3.4	2	6.0	54	1	250
1994	3.6	2	5.3	45	1	223
1995	3.4	2	4.7	34	1	237
1996	3.7	2	5.0	43	1	223
1997	3.4	2	4.3	34	1	237
1998	3.8	2	5.0	41	1	228
Lower Panel: 1992 export discovery surviving through 1998						
1992	4.4	2	6.8	45	1	111
1993	5.1	3	7.1	40	1	111
1994	5.0	3	5.9	36	1	111
1995	5.1	3	5.6	34	1	111
1996	5.2	4	5.2	29	1	111
1997	5.3	4	5.5	34	1	111
1998	5.6	4	6.4	41	1	111

[7]The figures in column E are larger than those in column B because two or more plants can start exporting a product for the first time in the economy in the same year.

[8]The increase in the average number of plants in 1998 is likely to reflect again the huge exchange rate depreciation associated with the Korean financial crisis.

TABLE 4—EXPORT DISCOVERY OF PRODUCT VARIETIES: EXPORTERS VS. NON-EXPORTERS

Year	All Plants	Exporters	Non-exporters
	Number of Economy-wide New Export Varieties		
1992	973	595	378
1993	1,073	624	449
1994	559	287	272
1995	621	363	258
1996	467	242	225
1997	1,069	671	398
1998	1,559	846	713
Total	6,321	3,628	2,693
	Per Plant		
1992	0.017	0.054	0.008
1993	0.018	0.055	0.010
1994	0.008	0.025	0.005
1995	0.009	0.033	0.004
1996	0.006	0.022	0.004
1997	0.014	0.063	0.006
1998	0.022	0.076	0.012
Total	0.012	0.041	0.006

Do exporters play a leading role in export discovery? Although we will address this issue more rigorously in the main empirical analysis below, we will provide a simple table here which shows that the answer is likely to be yes. Table 4 shows the number of export discoveries of product variety in year t made by exporters and non-exporters in year t-1. Out of 6,321 product varieties which were discovered during the period of 1991-1998, 3,628 product varieties were discovered by existing exporters. In terms of the number of export discoveries per plant, the role of existing exporters becomes much clearer. Existing exporters discovered 0.041 product varieties per plant while for non-exporters the value of 0.006.

Our plant-level dataset has information about the location of plants at the region level. The original plant dataset has 16 regions at the major city or provincial level. These are Seoul, Busan, Daegu, Incheon, Gwangju, Daejeon, Ulsan, Gyunggi, Gangwon, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyungbuk, Gyungnam, and Jeju. Due to changes of the administrative regions within the sample period, however, we reclassified the regions into 13 regions so that the definition of a region would remain consistent over the years.[9] The number of plants, exporting plants, and workers for each of the 13 regions is provided in the Table A1. Using the regional location information of the plants, we are able to examine whether geographical proximity among plants matters with regard to export discovery spillover.

III. Who Discovers and Who Imitates Export Product Varieties?

As discussed in the previous section, there are fairly frequent new export discoveries of product varieties as well as much more frequent follow-up or imitative exports in the data. This leads to the question of who (or what type of plant) discovers

[9]Gwangju, Daejeon, and Ulsan were integrated with Jeonnam, Chungnam, and Gyungnam, respectively.

new export products and who imitates. Answering this question is important for understanding how Korea added new products to her export product portfolio. More importantly, if export discovery creates new knowledge of "learning what you are good at exporting" and if this new knowledge can potentially spill over to the rest of the economy, as in Hausmann and Rodrik (2003), finding answers to the above question would be important for devising appropriate policies to promote knowledge creation and diffusion.

A. *Empirical Model: Multinomial Logit*

In this section, we estimate a multinomial model and attempt to understand the plant characteristics which determine the choice from among three alternatives of starting to export a product variety which is new to the economy between year $t-1$ and t (export discovery, alternative 2), starting to export a product variety which is new to the plant but not new to the economy (imitation, alternative 3), and doing neither (not starting to export any new product variety, alternative 1). The probability of plant j choosing an alternative i is expressed as

$$(1) \qquad p_{ij} = \Pr(y_j = i) = \begin{cases} \dfrac{1}{1+\exp(X_j\beta_2)+\exp(X_j\beta_3)}, & if\ i=1 \\ \dfrac{\exp(X_j\beta_i)}{1+\exp(X_j\beta_2)+\exp(X_j\beta_3)}, & if\ i=2,3 \end{cases}$$

where y_j is the choice of alternative by plant j, X_j is the row vector of the characteristics of plant j, and β_i denotes the coefficient vector for alternative i. We estimated this model using plant-level data during the period of 1991-1998. We used one-year lagged values of X_j.

As plant characteristics, we consider exporting status (EXPORTER) for all plants above, taking a value of 1 if the plant exported at year $t-1$ and 0 otherwise. As discussed above, a plant's previous exporting status may importantly affect the exporting mode choice because previous exporting gives a plant a cost advantage over non-exporters for reasons related to sunk costs. More importantly, a plant may learn from its own previous exporting experience about "what you are good at exporting." Information or knowledge pertaining to the profitability of exporting a product acquired through its own experience may spill over to other related products, including those that have never been exported by any other plants in the economy.

In the analysis below, we also considered as explanatory variables certain observable plant characteristics. More productive plants can more easily export a new product, new to the plant or new to the economy, because the various sunk costs required to export a new product can be more easily justified by the higher expected operating profit. In order to estimate the (log of) the plant total factor productivity (LNTFP), we applied the methodology by Levinsohn and Petrin (2003) to each of the two-digit industries. The plant size can also affect the export mode choice with imperfections in the financial market. With an imperfect financial market, larger plants are expected to be able to finance more easily various sunk-entry costs or R&D expenditures which may be required to introduce a new product to an export market. Or, a larger plant may, for example, have more foreign contacts and obtain better deals in contracts with foreign distributors.[10] We used the (log of) the number of workers (LNWORKER) as a proxy for the plant size. Plants that are engaged in R&D activities may introduce a new export product more easily if exporting a new product requires a modification of product specifications or the upgrading of product attributes. We used an innovation status dummy variable for plants (INNOVATOR), which takes a value of one if a plant had a positive R&D expenditure in year t-1 and zero otherwise.

We also controlled for other plant characteristics which may determine a plant's choice of exporting a new product. These are plant's plant age (AGE); multiproduct plant dummy variable (MULTI), which takes a value of one if the plant is a multiproduct plant and zero otherwise; the (log of) the capital intensity (LNKI); and the (log of) the non-production worker ratio as a proxy for skill intensity (LNSI). We also included year and KSIC (Korea Standard Industrial Classification) three-digit level industry dummy variables in order to control for year and industry fixed effects.[11]

B. *Estimation Results*

The average marginal effects of the explanatory variables estimated from the multinomial logit model are displayed in Table 5. Here, the baseline is "do neither." The regression results are consistent with our previous expectation that exporting plants are more likely to discover new export products than non-exporters. The estimated average marginal effect of the EXPORTER variable in the discovery equation is significantly positive. Other factors being equal, the probability that an exporting plant will discover new export products is higher than for non-exporters by 0.02. The estimated average marginal effect of the EXPORTER variable in the imitation equation is also significantly positive. This result most likely reflects the point that exporting plants have a cost advantage over non-exporters because they have already paid the firm-specific export market entry cost.

It is important to note that the estimated marginal effect of EXPORTER in the "imitation" equation, which is 0.065, is also highly significant, which is consistent with the explanations provided earlier as to why existing exporters are at an advantage when introducing new export products. It is interesting to observe that the estimated marginal effect of EXPORTER in the imitation equation is much larger than in the discovery equation. We conducted the Wald test to determine if the estimated marginal effect of EXPORTER is statistically significantly larger in the imitation equation than in the discovery equation, and we were able to reject at the 1 percent level the null hypothesis of the equality of the marginal effects between

[10]Alvarez, Faruq, and Lopez (2008).

[11]One may consider estimating equation (1) using a plant fixed effect model. However, we decided not to pursue this approach because we wanted to utilize both cross-plant and over-time variations in the data to estimate the model. In fact, the exporter dummy does not have any variations over time within plant for a large number of plants. That is, for a large number of plants, their export status does not change over time within the sample.

TABLE 5—EXPORT DISCOVERY AND IMITATION: MULTINOMIAL LOGIT

Variables	Discovery	Imitation
EXPORTER	0.020***	0.065***
	(0.001)	(0.001)
LNTFP	0.001*	0.005***
	(0.000)	(0.001)
LNWORKER	0.005***	0.032***
	(0.000)	(0.001)
INNOVATOR	0.003***	0.010***
	(0.001)	(0.001)
AGE	-0.001*	-0.006***
	(0.000)	(0.001)
MULTI	0.006***	0.010***
	(0.000)	(0.001)
LNKI	0.001***	0.005***
	(0.000)	(0.001)
LNSI	0.002***	0.011***
	(0.000)	(0.001)
Year Dummy	Yes	
Industry Dummy	Yes	
Observations	286,371	
Log likelihood	-97991	
Pseudo R^2	0.143	

the two equations. Hence, existing exporters are not only more likely to discover new export products but also even more likely to start imitative exports.[12]

Other plant characteristics, which we used as control variables, also have significant effects on the export mode choice. Larger plants, innovative plants, or multiproduct plants are more likely to discover new export products or start imitative exporting than smaller, non-innovative, or single-product plants, respectively. Plants with higher capital intensity or with higher skill intensity levels are also more likely to discover or imitate. There is some weak evidence that plants that are young or with higher productivity rates are more likely to discover new export products.

All in all, the above result suggests that plants which have previous exporting experience play a leading role in the discovery of new export product varieties. These results are not driven by the observable characteristics of existing exporters which are superior to those of non-exporters, such as higher productivity, a larger size, and a greater tendency to be engaged in R&D. As explained above, existing exporters' leading role in export discovery may be due to, among others factors, their sunk-cost-related cost advantage or export-related learning spillover across products within the plant. Viewed from the perspective of Hausmann and Rodrik (2003), the above results may indicate that existing exporters play a leading role in the creation of new learning, which is "learning what you are good at exporting."

[12]Understanding why existing exporters have a greater advantage over non-exporters when beginning imitative exporting appears to require further scrutiny, which we leave as a future study.

IV. Spillover from Export Discovery

A. *Empirical Strategy*

In this section, we are mainly interested in examining whether plants learn from past export discoveries of products by other plants. To do so, we start by largely following the convention in the existing literature on export spillover, investigating studies by Fernandes and Tang (2014), and we estimate the probability of introducing a new export product variety. While the key explanatory variables in the existing literature are measures of the presence or prevalence of existing exporters or the exporting activity, the key explanatory variable in this study is the measure of export discovery, which will be explained below.

In order to define the dependent variable of the regression, we initially let X_{rjpt} be equal to one if product p by plant j located at region r is exported in year t and zero otherwise.[13] The dependent variable Y_{rjpt} is equal to one if $X_{rjpt}=1$ and $X_{rjpt-1}=0$, and zero if $X_{rjpt}=0$ and $X_{rjpt-1}=0$. That is, the product variety of a plant located in a certain region is a new export product variety if, from the plant's point of view, it is exported in year t and was not exported in the previous year. The probability of introducing a new export product variety by a plant located in region r can then be estimated using the following a linear probability model:

$$Y_{rjpt} = c + Z_{rpt-1}\alpha + V_{jpt-1}\beta + W_{jt-1}\gamma + \delta_{pt} + \delta_{jt} + \delta_{rt} + \varepsilon_{rjpt}. \tag{2}$$

Z_{rpt-1} is a variable or a vector of variables which measures other plants' exporting activities in region r for product p at time $t-1$. As discussed above, one key issue in the literature on export spillover is how to identify export spillover. In most existing studies, export spillover was identified by examining whether the presence or prevalence of existing exporters in a product market and/or in a geographical unit affects the likelihood of the export entry of a firm. We start by following this approach and consider the export dummy variable $XDUM_{rpt-1}$, which takes a value of one if product p was exported at region r in year $t-1$ and zero otherwise. We consider as alternative explanatory variables the export shipments of product p at region r at time $t-1$, $XVOL_{rpt-1}$, or the number of plants which are exporting product p at region r at year $t-1$, $XNUM_{rpt-1}$, because a larger export volume or a larger number of exporters may provide a stronger positive signal about the profitability of exporting product p. The coefficient α captures export spillover or learning from others.

Next, in order to examine whether plants learn from past export discoveries of products by certain other plants, we break down $XDUM_{rpt-1}$ further into two

[13]A plant is always located in only one region.

variables and let Z_{rpt-1} be equal to $[XDISCDUM_{rpt-1}, XCONTDUM_{rpt-1}]$. Here, $XDISCDUM_{rpt-1}$ is a measure of export discovery, which is equal to one if product p is exported for the first time in the region in year $t-1$ and zero otherwise, and $XCONTDUM_{rpt-1}$ is equal to one if product p is exported by any other plant in the region in both year $t-1$ and year $t-2$. If there is export spillover from export discovery, the estimated coefficients on $XDISCDUM_{rpt-1}$ is expected to be positive.

W_{jt-1} is a vector of plant characteristics which include the plant's exporting status $(EXPORTER)$, the (log of) the plant total factor productivity $(LNTFP)$, the (log of) the number of workers $(LNWORKER)$ as a proxy for the plant size, the plant's innovation status dummy variable $(INNOVATOR)$, plant age (AGE), a multiproduct plant dummy variable $(MULTI)$, the (log of) the capital intensity $(LNKI)$, and the (log of) the non-production worker ratio as a proxy for skill intensity $(LNSI)$. These are the same variables used in section III.

V_{jpt-1} is a vector of the plant-product (or plant-variety) characteristics, measuring the importance of the variety j to the plant p at time $t-1$. We considered two such measures, following Iacovone and Javorcik (2010), which are the share of the variety p in the plant's total domestic shipments at year $t-1$ (variety relevance in the domestic market: $VRRELEVD$) and the plant's share of the national domestic shipments of product p (variety domestic market share: $VMSD$). Based on the predictions from recent multiproduct firm trade models, such as Bernard, Redding, and Schott (2011), Mayer, Melitz, and Ottaviano (2014), we expect positive coefficients on these variables.

Meanwhile, it is possible that a positive demand shock in the export market will cause the first export shipment of a given product (export discovery) as well as subsequent export shipments by other plants. Because we are interested in estimating spillover effects from export discovery working across plants on the supply side, e.g., information spillover, we include product $\times$ year fixed effects, δ_{pt}, in all regression specifications in order to control for demand side factors which may affect the probability of introducing a new export product variety by a plant. Here, the product dummy variables used are those for the KSIC five-digit industries. We also include plant $\times$ year fixed effects, δ_{jt}, and region $\times$ year fixed effects, δ_{rt}, in order to control for any unobserved time-varying plant-specific or region-specific factors which determine the introduction of a new export product variety.

In the regressions below, we used lagged values of the explanatory variables above to allow for possible time lags in the export spillover outcomes. The data used are a plant-product-year data for the period of 1991-1998.[14] Because we are estimating the probability of a new export product entry, we confined the analysis with plant-

[14] Because we used one-year lagged values of the explanatory variables in the baseline regressions, the observations for 1991 were not used in the estimation.

product-year observations which have positive domestic shipments but which were not exported in year $t-1$ $(X_{jpt-1}=0)$.

B. *Results*

1. Evidence of Export Spillover

Table 6 shows the estimation results when we used $XDUM$, $XVOL$, and $XNUM$ as the independent variables. Overall, the results are quite consistent with the existence of export spillover arising from the presence or prevalence of existing exports, as reported in previous studies. The coefficients of $XDUM$, $XVOL$, and

TABLE 6—EXPORT SPILLOVER AND PRODUCT-LEVEL EXPORT MARKET ENTRY

Model	[1]	[2]	[3]	[4]	[5]	[6]
XDUM	0.013*** (0.001)	0.010*** (0.002)				
XVOL			0.001*** (0.000)	0.001*** (0.000)		
XNUM					0.002*** (0.000)	0.001*** (0.000)
EXPORTER	0.096*** (0.005)		0.096*** (0.005)		0.096*** (0.005)	
LNTFP	0.010*** (0.002)		0.009*** (0.002)		0.009*** (0.002)	
LNWORKER	0.037*** (0.001)		0.037*** (0.001)		0.037*** (0.001)	
INNOVATOR	0.012*** (0.003)		0.012*** (0.003)		0.012*** (0.003)	
AGE	-0.005*** (0.001)		-0.005*** (0.001)		-0.005*** (0.001)	
MULTI	0.006*** (0.002)		0.006*** (0.002)		0.006*** (0.002)	
LNKI	0.006*** (0.001)		0.006*** (0.001)		0.006*** (0.001)	
LNSI	0.008*** (0.001)		0.008*** (0.001)		0.008*** (0.001)	
VRRELEVD	0.051*** (0.003)	0.029*** (0.002)	0.050*** (0.003)	0.028*** (0.002)	0.050*** (0.003)	0.028*** (0.002)
VMSD	0.101*** (0.009)	0.047*** (0.013)	0.105*** (0.009)	0.048*** (0.013)	0.105*** (0.009)	0.047*** (0.013)
product*year dummy	Y	Y	Y	Y	Y	Y
plant*year dummy	N	Y	N	Y	N	Y
region*year dummy	N	N	N	N	N	N
Observations	221,517	221,517	221,517	221,517	221,517	221,517
R-squared	0.046	0.120	0.047	0.120	0.047	0.120

Note: Numbers in the parenthesis are robust standard errors. Asterisks ***, **, and * indicate that the coefficient is significant at the 1, 5, and 10 percent level. Constants are not reported.

$XNUM$ are all significantly positive with and without control of the plant×year fixed effects or region×year fixed effects.[15]

All of the plant characteristics included, except for AGE, are estimated to be positive and highly significant. Product varieties which have been previously produced for the domestic market only by existing exporters, large plants, innovator plants, multiproduct plants, young plants, and capital- or skill-intensive plants are more likely to be exported for the first time from a plant's viewpoint. Both $VRRELEVD$ and $VMSD$ are estimated to be positive and significant in all regressions, suggesting that product varieties that are important to the plant in the domestic market or have large domestic market shares are more likely to be introduced into the export market.

Table 7, which presents our main empirical results, shows regression results with $XDUM$ replaced with $XDISCDUM$ and $XCONTDUM$. Overall, the results

TABLE 7—SPILLOVER FROM EXPORT DISCOVERY

Model	[1]	[2]	[3]	[4]
XDISCDUM	0.004* (0.002)	0.004** (0.002)	0.011*** (0.003)	0.011*** (0.003)
XCONTDUM	0.016*** (0.002)	0.016*** (0.002)	0.010*** (0.003)	0.010*** (0.003)
EXPORTER	0.096*** (0.005)	0.095*** (0.005)		
LNTFP	0.010*** (0.002)	0.009*** (0.002)		
LNWORKER	0.037*** (0.001)	0.037*** (0.001)		
INNOVATOR	0.012*** (0.003)	0.012*** (0.003)		
AGE	-0.005*** (0.001)	-0.006*** (0.001)		
MULTI	0.006*** (0.002)	0.006*** (0.002)		
LNKI	0.006*** (0.001)	0.006*** (0.001)		
LNSI	0.008*** (0.001)	0.007*** (0.001)		
VRRELEVD	0.051*** (0.003)	0.050*** (0.003)	0.029*** (0.002)	0.029*** (0.002)
VMSD	0.102*** (0.009)	0.103*** (0.009)	0.047*** (0.013)	0.047*** (0.013)
product*year dummy	Y	Y	Y	Y
plant*year dummy	N	N	Y	Y
region*year dummy	N	Y	N	Y
Observations	221,517	221,517	221,517	221,517
R-squared	0.047	0.047	0.120	0.120

Note: Numbers in the parenthesis are robust standard errors. Asterisks ***, **, and * indicate that the coefficient is significant at the 1, 5, and 10 percent level. Constants are not reported.

[15]The additional inclusion of region×year dummy variables scarcely affects the results and is thus not reported.

indicate the existence of export spillover from export discovery. In the first two columns, which show the results without plant×year fixed effects, the coefficients on $XDISCDUM$ are estimated to be positive and significant at the ten and five percent level. However, when we controlled for plant×year fixed effects in the third and fourth columns, the estimated coefficient of $XDISCDUM$ increased and became highly significant at the one percent level. Thus, when a product was exported for the first time (discovered) at the region level by some plants in the prior year, it raises the probability that other plants in the region will start to export the same product in the present year, consistent with the interpretation that one can learn from the export discoveries of one's neighbors. This is most likely the most novel empirical result in this paper.

The coefficient of $XCONTDUM$ is also estimated to be positive and highly significant in all of the regression specifications shown in Table 7, and the size of the estimated coefficient of $XCONTDUM$ is comparable to or larger than the coefficient of $XDISCDUM$. This result suggests that when a product is newly discovered, plants may immediately start imitative exporting or take a wait-and-see approach to determine if the product survives in the export market before they start imitative exporting.

Motivated by the observation that there may be some time lag between export discovery and imitative exporting, we additionally included several lagged variables of $XDISCDUM$ and $XCONTDUM$ in Table 8. Again, we always include product×year dummy variables and run the analyses with and without plant×year or region×year dummy variables. Here, the coefficients of $XDISCDUM(t-1)$ and $XDISCDUM(t-2)$ are estimated to be significantly positive, indicating that it takes approximately one to two years for the initial response of an imitative export to export discovery to take place.

Thus far, we have argued that the positive and significant coefficient of export discovery dummy variable captures export spillover from export discovery. We have also been inclined to argue that the nature of export spillover is likely to be basically information spillover, i.e., learning from neighbors about the profitability of potentially exportable products. If information spillover is actually behind the relationship between initial export discovery by some plants and subsequent exports by some other plants, the spillover effect should be most pronounced in industries where information is especially important. To test this idea, we divided manufacturing industries into "machinery" and "non-machinery" industries and ran separate regressions for each group. The basic premise is that the machinery industries are characterized by higher search costs in relation to the matching between international buyers and sellers, as in the differentiated goods industries in Rauch (1999).[16]

[16]A possible alternative approach may be to use the classification in Rauch (1999) and divide industries into differentiated goods and homogeneous or reference-priced goods industries. Rauch (1999) argues that the search barriers for differentiated goods are higher than those for homogeneous goods during the processes used by international buyers and sellers. However, it was not possible to match eight-digit product code in our dataset, which is based on Statistics Korea's international classification scheme, with SITC Rev. 2, on which Rauch's classification is based. Furthermore, by looking at the names of the industries, we concluded that most differentiated goods industries according to the classification in Rauch largely correspond to the "machinery" industry in this paper. For

TABLE 8—LAGGED SPILLOVER EFFECTS OF EXPORT DISCOVERY

Model	[1]	[2]	[3]	[4]
XDISCDUM(t-1)	0.007*** (0.002)	0.008*** (0.002)	0.015*** (0.003)	0.015*** (0.003)
XDISCDUM(t-2)	0.015*** (0.003)	0.016*** (0.003)	0.013*** (0.004)	0.013*** (0.004)
XDISCDUM(t-3)	0.002 (0.003)	0.001 (0.003)	0.000 (0.004)	0.000 (0.004)
XCONTDUM(t-1)	-0.005** (0.002)	-0.004 (0.002)	-0.004 (0.004)	-0.004 (0.004)
XCONTDUM(t-2)	0.026*** (0.003)	0.028*** (0.003)	0.022*** (0.005)	0.022*** (0.005)
XCONTDUM(t-3)	0.009*** (0.003)	0.010*** (0.003)	0.004 (0.004)	0.004 (0.004)
EXPORTER	0.095*** (0.005)	0.095*** (0.005)		
LNTFP	0.009*** (0.002)	0.009*** (0.002)		
LNWORKER	0.037*** (0.001)	0.037*** (0.001)		
INNOVATOR	0.012*** (0.003)	0.012*** (0.003)		
AGE	-0.005*** (0.001)	-0.006*** (0.001)		
MULTI	0.006*** (0.002)	0.006*** (0.002)		
LNKI	0.006*** (0.001)	0.006*** (0.001)		
LNSI	0.008*** (0.001)	0.008*** (0.001)		
VRRELEVD	0.050*** (0.003)	0.050*** (0.003)	0.028*** (0.002)	0.028*** (0.002)
VMSD	0.104*** (0.009)	0.106*** (0.009)	0.049*** (0.013)	0.049*** (0.013)
product*year dummy	Y	Y	Y	Y
plant*year dummy	N	N	Y	Y
region*year dummy	N	Y	N	Y
Observations	221,517	221,517	221,517	221,517
R-squared	0.047	0.048	0.121	0.121

Note: Numbers in the parenthesis are robust standard errors. Asterisks ***, **, and * indicate that the coefficient is significant at the 1, 5, and 10 percent level. Constants are not reported.

Table 9 shows the regression results. The first column is identical to column [3] of Table 7, while the second and third columns are the regression results for the machinery and non-machinery industries, respectively. The remaining three columns show regression results similar to those of region×year fixed effects. Consistent with our expectation, the estimated effect of export discovery on the introduction of a new export product variety is greater in the machinery industry in this case than in

these reasons, we use the machinery and non-machinery grouping. In this paper, products belonging to the machinery industry are those with KSIC two-digit product codes between 29 and 35, and products belonging to the non-machinery industry encompass all of the other manufacturing products (two-digit product codes between 15 and 28, as well as 36 and 37).

TABLE 9—SUBGROUP ESTIMATION: MACHINERY VS. NON-MACHINERY

Model	All Industries [1]	Machinery [2]	Non-machinery [3]	All Industries [4]	Machinery [5]	Non-machinery [6]
XDISCDUM	0.011*** (0.003)	0.014** (0.006)	0.007* (0.004)	0.011*** (0.003)	0.014** (0.006)	0.007* (0.004)
XCONTDUM	0.010*** (0.003)	0.004 (0.005)	0.010*** (0.003)	0.010*** (0.003)	0.004 (0.005)	0.010*** (0.003)
VRRELEVD	0.029*** (0.002)	0.046*** (0.006)	0.021*** (0.003)	0.029*** (0.002)	0.046*** (0.006)	0.021*** (0.003)
VMSD	0.047*** (0.013)	0.039* (0.022)	0.052*** (0.018)	0.047*** (0.013)	0.039* (0.022)	0.052*** (0.018)
product*year dummy	Y	Y	Y	Y	Y	Y
plant*year dummy	Y	Y	Y	Y	Y	Y
region*year dummy	N	N	N	Y	Y	Y
Observations	221,517	68,383	153,134	221,517	68,383	153,134
R-squared	0.120	0.097	0.143	0.120	0.097	0.143

Note: Numbers in the parenthesis are robust standard errors. Asterisks ***, **, and * indicate that the coefficient is significant at the 1, 5, and 10 percent level. Constants are not reported.

the non-machinery industry. This result strengthens our argument that the estimated positive spillover effects from export discovery indeed reflect information spillover.[17]

2. Additional Analysis

Thus far, we have restricted our analysis to the export spillover occurring at the regional level, implying that the key independent variables in the regression equation (2), $XDISCDUM$ and $XCONTDUM$, were defined and measured at the regional level. As a robustness check, we alternatively defined and measured $XDISCDUM$ and $XCONTDUM$ at the country level, $XDISCDUM\_E$ and $XCONTDUM\_E$, respectively, and ran similar regressions. The dependent variable in the country-level regressions are identical to those in the region-level regressions (i.e., $Y_{jpt} = Y_{rjpt}$), as the introduction of a new export product variety is measured at the plant-product level and a plant is located at only one region. All other control variables in the country-level regressions are identical to those in the region-level regressions. Another reason for running country-level regressions is to facilitate an examination of the spillover effects from country-level export discovery, and by doing this we do not have to limit the geographical scope of export spillover to the regional level.

Table 10 shows the country-level regression results, indicating that these results

[17]However, the estimated coefficient of XCONTDUM is not significant for the machinery industry but is significantly positive for the non-machinery industry. Although we cannot clearly interpret this result, we conjecture that not only the value of new information about foreign buyers or markets but also certain unobserved product characteristics are important for determining the behavior of imitative exporting.

TABLE 10—ECONOMY-WIDE SPILLOVER FROM EXPORT DISCOVERY

Model	All Industries [1]	Machinery [2]	Non-machinery [3]	All Industries [4]	Machinery [5]	Non-machinery [6]
XDUM_E	0.013*** (0.002)	0.016** (0.007)	0.013*** (0.002)			
XDISCDUM_E				0.008** (0.003)	0.018* (0.009)	0.006* (0.003)
XCONTDUM_E				0.014*** (0.002)	0.015** (0.007)	0.015*** (0.002)
VRRELEVD	0.028*** (0.002)	0.045*** (0.006)	0.020*** (0.003)	0.028*** (0.002)	0.045*** (0.006)	0.020*** (0.003)
VMSD	0.051*** (0.013)	0.048** (0.023)	0.056*** (0.018)	0.052*** (0.013)	0.048** (0.023)	0.058*** (0.018)
product*year dummy	Y	Y	Y	Y	Y	Y
plant*year dummy	Y	Y	Y	Y	Y	Y
Observations	221,517	68,383	153,134	221,517	68,383	153,134
R-squared	0.120	0.097	0.143	0.120	0.097	0.143

Note: Numbers in the parenthesis are robust standard errors. Asterisks ***, **, and * indicate that the coefficient is significant at the 1, 5, and 10 percent level. Constants are not reported.

are largely similar to the region-level results. The coefficients of $XDUM\_E$ are estimated to be significantly positive in all industries and in each subgroup of the industries, i.e., machinery and non-machinery. The coefficients of $XDISCDUM\_E$ are positive as well, although their significance is somewhat low, which suggests the existence of country-wide spillover from export discovery. The size of the coefficient of $XDISCDUM\_E$ in regression [4] of Table 10, which is 0.008, is slightly smaller than in the comparable region-level regression [3] in Table 7 (0.011), indicating that geographical proximity matters with regard to spillover from export discovery. The coefficient of $XDISCDUM\_E$ in the machinery industry is again larger than that in the non-machinery industry, which is consistent with the argument that the nature of spillover is likely to be related to information.

Table 11 shows the results with our key independent variables measured at the regional and economy-wide levels. For all industries, both $XDISCDUM$ and $XDISCDUM\_E$ are estimated to be positively significant at the five and ten percent level, respectively, whereas the coefficient of $XDISCDUM$ is approximately 1.5 times larger than that of $XDISCDUM\_E$, indicating that although spillover from export discovery exists at the country level, it is stronger at the regional level. When the model was estimated separately for the machinery and non-machinery industry samples, $XDISCDUM$ was significantly positive only for the machinery sample, consistent with our earlier results. $XDISCDUM\_E$ was not significant in either sample. These results indicate that although export discovery spillover is not limited by regional boundaries, it is stronger among plants which are more closely located to each other geographically.

TABLE 11—REGIONAL AND ECONOMY-WIDE SPILLOVER FROM EXPORT DISCOVERY

Model	All Industries [1]	Machinery [2]	Non-machinery [3]
XDISCDUM	0.009** (0.003)	0.011* (0.007)	0.005 (0.004)
XCONTDUM	0.007*** (0.003)	0.002 (0.005)	0.007** (0.003)
XDISCDUM_E	0.006* (0.003)	0.014 (0.009)	0.005 (0.003)
XCONTDUM_E	0.012*** (0.002)	0.014** (0.007)	0.013*** (0.003)
VRRELEVD	0.028*** (0.002)	0.045*** (0.006)	0.020*** (0.003)
VMSD	0.054*** (0.013)	0.048** (0.023)	0.059*** (0.018)
product*year dummy	Y	Y	Y
plant*year dummy	Y	Y	Y
Observations	221,517	68,383	153,134
R-squared	0.120	0.097	0.143

Note: Numbers in the parenthesis are robust standard errors. Asterisks ***, **, and * indicate that the coefficient is significant at the 1, 5, and 10 percent level. Constants are not reported.

TABLE 12—RESULTS WITH SEVEN-DIGIT PRODUCT*YEAR DUMMY VARIABLES

Model	All Industries [1]	Machinery [2]	Non-machinery [3]	All Industries [4]	Machinery [5]	Non-machinery [6]
XDUM	0.010*** (0.002)	0.009* (0.004)	0.008*** (0.003)			
XDISCDUM				0.010*** (0.003)	0.015** (0.007)	0.006 (0.004)
XCONTDUM				0.010*** (0.003)	0.006 (0.005)	0.008** (0.003)
VRRELEVD	0.028*** (0.002)	0.044*** (0.006)	0.020*** (0.003)	0.028*** (0.002)	0.044*** (0.006)	0.020*** (0.003)
VMSD	0.029*** (0.013)	0.024 (0.022)	0.031* (0.018)	0.029*** (0.013)	0.024 (0.022)	0.032* (0.018)
product*year dummy	Y	Y	Y	Y	Y	Y
plant*year dummy	Y	Y	Y	Y	Y	Y
region*year dummy	Y	Y	Y	Y	Y	Y
Observations	221,517	68,383	153,134	221,517	68,383	153,134
R-squared	0.196	0.169	0.227	0.196	0.169	0.227

Note: Numbers in the parenthesis are robust standard errors. Asterisks ***, **, and * indicate that the coefficient is significant at the 1, 5, and 10 percent level. Constants are not reported.

Finally, Table 12 shows again the region-level regression results with demand side factors controlled with seven-digit, instead of five-digit, product×year fixed effects.

Most of our main regression results remain intact, at least qualitatively.[18]

V. Summary and Concluding Remarks

Utilizing a plant-product dataset in the Korean manufacturing sector, this paper empirically examined, first, which types of plants are more likely to discover new export products, paying special attention to the role of existing exporters and, second, whether there is evidence of spillover from export discovery. We find that existing exporters are more likely to discover new export products than non-exporters and that larger plants, innovative plants, or multiproduct plants are more likely to discover new export products or begin to engage in imitative exporting as compared to smaller, non-innovative, or single-product plants, respectively. We also find evidence of spillover from the discovery of new export products. Export discovery of a product by some plants had the effect of increasing the probability of any subsequent export market penetration of the same product by other plants. This effect is more pronounced in the machinery (heterogeneous goods) industry than in the non-machinery (homogeneous goods) industry. The evidence suggests that information spillover is a part of the story: you learn from your neighboring discoverers about the profitability of potentially exportable products.

One important limitation of this study is that it uses plant-product level data, not firm-product level data. Export decisions or export discovery and imitation decisions, in particular, are likely to be made at the firm level, not at the plant level. It would be interesting to observe whether an analysis of firm-product level data, if such a dataset is available,[19] would provide results similar to those found in this paper. This is left for a future study.

[18]The regression results with six-digit product×year fixed effects are quite similar to those in Table 11.

[19]It appears that the Statistics Korea has a firm-plant matching table which is not released into the public domain. Unfortunately, the author could not gain access to this information.

APPENDIX

TABLE A1—NUMBER OF PLANTS AND WORKERS BY REGION: 1995

Region	Number of Plants	Exporting Plants		Number of Workers (person)
		Number	Share (%)	
Seoul	13,452	1,963	14.6	336,672
Busan	7,301	1,217	16.7	119,472
Daegu	4,579	769	16.8	112,682
Incheon	5,710	882	15.4	206,625
Gyunggi	21,043	3,054	14.5	673,592
Gangwon	1,232	106	8.6	34,249
Chungbuk	1,773	331	18.7	96,189
Chungnam	3,465	488	14.1	130,561
Jeonbuk	1,803	270	15.0	68,299
Jeonnam	3,400	281	8.3	122,407
Gyungbuk	3,818	657	17.2	205,050
Gyungnam	5,729	1,024	17.9	388,484
Jeju	277	14	5.1	4,502
Total	73,582	11,056		2,498,784

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