# Multiple Options for Appropriation Mechanisms in a Business Environment and Implications for Policy

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## Abstract

Appropriation is essential for innovators to succeed. Traditionally, among various appropriation mechanisms, patents and secrecy have received attention, and the differential role of patents has been highlighted according to different industries or sectors. These discussions give a rough idea, however, and do not yield concrete directives for strategies in the context of innovation management. This paper describes an analysis of the effect of a firm's position within the value chain and the objectives of innovative activities with appropriation mechanisms. Multivariate analysis of diverse appropriation mechanisms using Korean innovation survey data revealed a specific combination of mechanisms and significant determinants in the context of objectives of innovative activities.

Keywords
appropriation mechanism, objectives of innovative activities, value chain, multivariate probit model

## 1. INTORDUCTION

Appropriation is essential for innovators to innovate. Innovation studies have focused on these aspects for a long time, particularly on the nature of knowledge related to appropriation. In addition, they have tackled directly the various mechanisms of appropriation, such as patents and secrecy. Although these studies have centered mainly on short-term appropriation, they also have highlighted the meaning of appropriation mechanisms and the importance of appropriation.

This previous research has some limitations, however, in terms of not considering the diversity of

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appropriation mechanisms and the fact that firms usually make rational decisions about a proper mechanism given a specific business context. Innovation does not occur in a vacuum. Rather, it is done in a specific way with specific goals in a specific environment. These features hint at the need for more plentiful studies. This paper adds to the literature by considering that selection of a specific mechanism is one of multiple choices innovative firms make, based on their position in the specific business context, including the firm's position within the value chain. In addition, the nature of innovative activities associated with an appropriation mechanism can be captured by analyzing the effect of the objective of the firm's innovative activities.

We used the results of a 2005 Korean innovation survey done by the Science and Technology Policy Institute (STEPI) in Korea. The method of multivariate analysis, in particular the multivariate probit model, was applied to consider the multiple choices made in reviewing each appropriation mechanism simultaneously. In this vein, this paper also analyzes the effect of the specific business context and the nature of innovation pursued by innovative firms upon using an appropriation mechanism, and how innovative firms mix these mechanisms to appropriate their innovative output. This paper is organized as follows: Section 2 presents a review of the previous literature and limitations of these studies and the important determinants that are the focus of this paper. Section 3 presents data, basic statistics, and the methodology deployed. Section 4 gives the estimation results and their meaning. Finally, section 5 provides the discussion and conclusion.

## 2. PREVIOUS WORK AND LIMITATIONS

In this section, we examine previous studies and present directions to pursue for a better comprehension of the use of appropriation mechanisms.

### 2.1. Brief Review of Previous Literature

Patents comprise one appropriation mechanism that has received much more emphasis than anything else. If we limit previous literature mainly to the discussions on patents, two study categories emerge (Park, 2013). The first is relatively early compared to the second, and these early studies try to understand the effectiveness of patents as an appropriation mechanism and under which conditions a patent is effective (Levin Klevorick, Nelson, & Winter, 1987; Cohen, Goto, Nagata, Nelson, & Walsh, 2000). Their results suggest that a patent is not an effective appropriation mechanism and not a major mechanism even in large corporations engaged in massive patenting activities. In addition, use of patents has gone beyond the traditional incentive role through preventing competitors and being sued to becoming a so-called bargaining chip. The role of patents varies according to industry, typically between a discrete product industry such as the chemical industry and a complex product industry such as the electronics industry.

The recognition that patenting activities are to be strategic in nature from the business perspective and that using patents has expanded beyond the traditional areas has generated the second group

of studies. These reports focus on the determinants of patenting activities or factors influencing patenting activities, factors that can be summarized as external and internal. External factors are the differences in technological opportunities in each sector (Brouwer & Kleinknecht, 1999), the differences in national system and practice (Cohen et al., 2002), and the characteristics of a patent system and the technological competence of competitors (Harabi, 1995). Internal factors are firm size, innovation strategy, and ways of innovating (Brouwer & Kleinknecht, 1999; Arundel, 2001; Peeters & Potterie, 2006).

The limitations of previous studies can be summarized as follows. First, they assumed that the selection and use of some appropriation mechanism occurs independently of other choices. Therefore, these studies mainly focused on finding the most effective mechanism among diverse options. Second, even though they comprehend the difference and their differential role in each mechanism, in particular for patents, the considered factors are usually rough. It is not easy to derive concrete implications from making strategies in the view of innovation management.

Therefore, the framework for analyzing use of an appropriation mechanism, we think, must shift from a focus on individual choice to a focus on multiple choices involving diverse mechanisms simultaneously. At the same time, the nature of the innovative environment and of innovation itself should be considered to comprehend the use of appropriation mechanisms..

### 2.2. Multiple Choices

Innovative firms make a rational decision based on their recognition of the external environment and internal capability. In doing this, they usually review all of the mechanisms or tools they can select to maximize innovative returns. This approach also can apply to selecting an appropriation mechanism. When selecting a mechanism, the suitability for protecting or using innovative output including each benefit and cost is calculated for each option. Therefore, it is more plausible that selection of a specific mechanism results from this process of multiple consideration, rather than from independent consideration irrespective of other mechanisms. In other words, selection and use of a specific appropriation mechanism is the result of multiple choices.

To our knowledge, the recent literature dealing with these kinds of characteristics consists of Galia & Legros (2004) and Amara, Landry, & Traore (2008). Galia & Legros (2004) analyzed the relationship among the barriers to innovation that firms face. Amara et al. (2008) analyzed how knowledge-intensive business services protect their invention when choosing among various protection mechanisms. These reports share the fact that the objects to be analyzed are related to each other, and the authors try to analyze this relationship with the technique of multivariate analysis.

Appropriation mechanisms can be divided into the formal and informal. A formal mechanism is related to legal rights and usually includes patent, utility model, design rights, and trademark. An informal mechanism is not related to legal rights but is related with the way of using the innovative output and can be controlled more easily than formal approaches. Informal mechanisms include secrecy, complex design, and lead time (market preemption). Firms simultaneously consider the

nature of these mechanisms and select one or a mix of them.

The possibility of building a mix of each appropriation mechanism generates the issue of complementarity and substitutions between the choices, whether formal or informal, as indicated by Galia & Legros (2004) and Amara et al. (2008). In addition, in case of complementarity, the level of complementarity can be significant because it is plausible for each mechanism to reinforce the other when we consider them conceptually.

### 2.3. The Nature of the Innovative Environment and Innovation as Important Determinants

This section presents important determinants of use of an appropriation mechanism to be considered from the perspective of management innovation. An innovative environment that firms face can limit the scope of choices. In a similar way, a technological regime limits the nature of problems related to innovation and ways of solving problems. A different environment makes firms pursue different ways of innovation and accordingly different uses of an appropriation mechanism. At the same time, the nature or meaning of innovation to innovative firms is also important because an innovative activity itself is not the aim but rather is just one of several business activities from the perspective of firms. Therefore, the essential question becomes why they innovate or what they want with innovation. This question can shape the method of innovation and selection of an appropriation mechanism.

Among diverse innovative environments, the most important factors are industry (or sector) and the firm's position in its specific value chain. These factors can determine the recognition of firms, the available resources necessary to innovate, and further ways of innovation and the types of goods and services firms provide. The position within a value chain can be separated into material production, intermediate goods producing capital goods, final products yielding consumption goods, and, finally, service after sales are complete. The fact that firms are in a specific position in this chain can influence the methods of innovation and the use of an appropriation mechanism.

The reason a firm innovates or what firms want from innovation can be captured by recognition of the objectives of technologically innovative activities. The objectives can be diverse but can be summarized as follows, as reflected in the Korean innovation survey. (1) Substitution of old-fashioned products; (2) product diversification; (3) market share increase; (4) opening up new markets; (5) style and design improvement; (6) reflection of consumers' needs; (7) environment-friendly goods (services) development; (8) quality improvement of products; (9) flexibility increase; (10) production capacity increase; (11) labor cost reduction; (12) other cost reduction (raw materials, energy, etc.); (13) improvement in production time; (14) industrial technology standards (ISO, etc.); (15) logistics and delivery time improvement; (16) networking among departments; (17) sharing knowledge/information among departments; (18) response to the diverse needs of customers; (19) relationship with customers; (20) effectiveness of routine works; (21) work environment/safety improvement; and (22) domestic/international regulation (STEPI, 2005). These objectives can be grouped to estimate their effect on using an appropriation mechanism.

## 3. DATA AND METHODOLOGY

### 3.1. Data

Here we use the results of the Korean innovation survey done in 2005 by the Science and Technology Policy Institute in Korea. This survey was approved by the Korea National Statistical Office as Designated Statistics under the Statistics Law and aimed at analyzing the technological innovation of manufacturing firms. The definition and methodology of the survey are based on the revised edition of the Oslo Manual. The revised edition of the Oslo Manual defines innovation in a broad manner, where organizational and marketing innovations as well as technological innovation are also included. However, the survey mainly focuses on technological innovation, although it also covers issues related to organizational and marketing innovation (STEPI, 2006). We have data from 1457 firms when we limit the survey result to responses to the entire appropriation mechanisms–related question.

Table 1 gives a brief overview of variables. The mostly frequently used mechanisms were secrecy, patent, and lead time (market preemption). A total of 58.3 percent of firms used secrecy as an appropriation mechanism, and 57.5 percent and 57.9 percent used patent and lead time (market preemption), respectively. Meanwhile, 51.4 percent of firms employed a utility model to protect their innovative output. However, the rate of use in case of design, trademark, and complex design was not high compared to other mechanisms.

The position within the value chain can be captured by the question included in the Korean innovation survey. The question asks where a firm's products belong among raw materials, intermediate goods (service), final products, and services. In this question, intermediate goods (services) are defined as goods (services) that are not the products directly used by consumers but that are used in producing other final goods and services. In case of various types of products, firms can designate the position according to the size of each product. Applying this result, we use only the first position within a value chain designated by firms and regard it as each firm's primary position in this paper. As a result, only 4 percent of firms did business at the position of raw material and 0.9 percent offered a service-related position as their primary role.[1] The majority of firms belonged to the intermediate goods and final products positions, 42 percent to the intermediate goods, and 52 percent to final products.

In case of objectives of innovative activities, 22 objectives represented already are grouped by the technique of principal component analysis for the estimation to be feasible. Three groups are generated and can be interpreted as production-related, organization-related, and market-related objectives. But these groups do not exclude each other. That is, some firms can belong to multiple groups, indicating that they pursue production-related objectives and market-related objectives at

[1] This finding is expected because this survey targets mainly manufacturing firms.

the same time. As a result, we found that 60.3 percent of firms pursued market-related objectives when they did innovative activities and that while 57.1 percent pursued production-related objectives, 57.8 percent of firms had objectives related to organization.

Size is calculated as the logarithm of the number of employees, and R&D intensity is calculated as the percentage of R&D expenditure, compared to total sales. R&D intensity ranged from 3 percent to 27.7 percent in this analysis.

TABLE 1. Basic statistics

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Patent | 1457 | 0.575841 | 0.494384 | 0 | 1 |
| Utility | 1457 | 0.514756 | 0.499954 | 0 | 1 |
| Design | 1457 | 0.396019 | 0.489236 | 0 | 1 |
| Trademark | 1457 | 0.428277 | 0.494999 | 0 | 1 |
| Secrecy | 1457 | 0.583391 | 0.493166 | 0 | 1 |
| Complex design | 1457 | 0.356211 | 0.479043 | 0 | 1 |
| Lead time | 1457 | 0.579959 | 0.493735 | 0 | 1 |
| Material | 1457 | 0.042553 | 0.201917 | 0 | 1 |
| Intermediate | 1457 | 0.425532 | 0.494593 | 0 | 1 |
| Final | 1457 | 0.52162 | 0.499704 | 0 | 1 |
| Service | 1457 | 0.009609 | 0.097586 | 0 | 1 |
| Production | 1457 | 0.571036 | 0.495098 | 0 | 1 |
| Organization | 1457 | 0.578586 | 0.493955 | 0 | 1 |
| Market | 1457 | 0.603294 | 0.489382 | 0 | 1 |
| Size | 1453 | 4.795014 | 1.250164 | 2.302585 | 10.13452 |
| Rnd intensity | 1454 | 0.037643 | 0.27796 | 0 | 7 |

** We also calculated inter-correlations between each variable (Appendix).*

### 3.2. Methodology

To analyze the multiple choices, we used the multivariate probit model, as with Galia & Legros (2004) and Amara et al. (2008). This model makes it possible to analyze multiple choices simultaneously when the dependent variable has binary values and is an extension of the probit model dealing with just one dependent variable and the bivariate probit model dealing with two binary dependent variables. It assumes that error terms are distributed as multivariate normal, each with a mean of zero, and that the variance–covariance matrix has values of 1 on the leading diagonal and correlations as off-diagonal elements (Cappellari & Jenkins, 2003).

The multivariate probit model makes possible joint estimating of several equations while controlling for the existence of mutual correlations between their disturbances (Galia & Legros, 2004). This model also provides the estimates of the variance–covariance matrix of the equations' disturbance. That is, it tests the correlation between dependent variables, conditional on a certain number of explanatory variables. It can hint at the existence of substitution or complementary effects in the multiple choices. If the null hypothesis of absence of correlation between the residuals of probit regression models is rejected, the complementarity exists (Amara et al., 2008).

Using the technique of multivariate probit model, the following equation was estimated:
Each appropriation mechanism = R&D intensity + Size + dummy for position within value chain (raw material, intermediate goods, final products) + the objectives of innovative activities (production, organization, market) + industry dummies

The multivariate probit model consists of seven binary choice equations. The estimation result can represent the effect of each independent variable on each choice and each choice's relationship with the other, conditional on this effect of each independent variable.

## 4. RESULTS

Tables 2 through 8 show the results of the multivariate probit regression estimating appropriation mechanisms[2] The goodness of fit seems to be reasonable.

### 4.1. Formal Mechanisms

In case of using patents as an appropriation mechanism, R&D intensity indicating the innovative effort and the firm size was positive and significant. It hinted that a greater innovative effort and bigger firm have a positive relationship with the possibility of using patents. In terms of objectives, only organization-related objectives and market-related objectives had a positive effect on the possibility of using patents, but production-related objectives did not. Contrary to expectations, the specific position within the value chain did not have a positive effect, but the coefficient was not statistically significant.

TABLE 2. The result of multivariate probit regression in the case of patents

| Patent | Coef. | Std. | z | P>z |
|---|---|---|---|---|
| R&D intensity | 1.44371*** | 0.472715 | 3.05 | 0.002 |
| Size | 0.167741*** | 0.029986 | 5.59 | 0 |
| Material | -0.31991 | 0.378459 | -0.85 | 0.398 |
| Intermediate | -0.3743 | 0.343518 | -1.09 | 0.276 |
| Final | -0.17354 | 0.341333 | -0.51 | 0.611 |
| Production | 0.038376 | 0.072642 | 0.53 | 0.597 |
| Organization | 0.175563** | 0.072397 | 2.42 | 0.015 |
| Market | 0.468601*** | 0.072905 | 6.43 | 0 |
| ind15 | -0.7125 | 0.390031 | -1.83 | 0.068 |
| ind17 | -1.11151 | 0.405459 | -2.74 | 0.006 |
| ind18 | -1.30165 | 0.487154 | -2.67 | 0.008 |

[2] Wald chi = 702.16, Log likelihood = -4461.994, prob>chi$^2$ = 0

| | | | | |
|---|---|---|---|---|
| ind19 | -1.38931 | 0.510298 | -2.72 | 0.006 |
| ind21 | -0.93407 | 0.446169 | -2.09 | 0.036 |
| ind22 | -1.28783 | 0.443605 | -2.9 | 0.004 |
| ind23 | -0.13412 | 0.468692 | -0.29 | 0.775 |
| ind24 | -0.17036 | 0.382212 | -0.45 | 0.656 |
| ind25 | -0.49981 | 0.394047 | -1.27 | 0.205 |
| ind26 | -0.39744 | 0.41796 | -0.95 | 0.342 |
| ind27 | -0.0968 | 0.409236 | -0.24 | 0.813 |
| ind28 | -0.10161 | 0.388984 | -0.26 | 0.794 |
| ind29 | -0.0217 | 0.379004 | -0.06 | 0.954 |
| ind30 | -0.03359 | 0.461954 | -0.07 | 0.942 |
| ind31 | -0.10108 | 0.387546 | -0.26 | 0.794 |
| ind32 | -0.11036 | 0.382916 | -0.29 | 0.773 |
| ind33 | -0.17815 | 0.415886 | -0.43 | 0.668 |
| ind34 | -0.36237 | 0.391726 | -0.93 | 0.355 |
| ind35 | -0.98818 | 0.458322 | -2.16 | 0.031 |
| ind36 | -0.48288 | 0.411552 | -1.17 | 0.241 |
| _cons | -0.43116 | 0.518095 | -0.83 | 0.405 |

*Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level*

In case of the utility model, the so-called petty patent to protect minor incremental invention, firm size mattered in positive ways, contrary to the general expectation that it is more likely to be used by smaller firms. It can be said that all of the objectives had a positive effect on the possibility of using this appropriation mechanism. But like patents, all the positions within the value chain were shown not to be significant.

TABLE 3. The result of multivariate probit regression in the case of the utility model

| **Utility** | **Coef.** | **Std.** | **z** | **P>z** |
|---|---|---|---|---|
| Rndin | 0.1882303 | 0.1505678 | 1.25 | 0.211 |
| Size | 0.1224284*** | 0.0291162 | 4.2 | 0 |
| Material | -0.1692568 | 0.3584592 | -0.47 | 0.637 |
| Intermediate | -0.3179371 | 0.3220602 | -0.99 | 0.324 |
| Final | -0.0508999 | 0.3197677 | -0.16 | 0.874 |
| Production | 0.2017853*** | 0.0718063 | 2.81 | 0.005 |
| Organization | 0.1835779** | 0.0714044 | 2.57 | 0.01 |
| Market | 0.497836*** | 0.0718275 | 6.93 | 0 |
| ind15 | -0.3712529 | 0.3581114 | -1.04 | 0.3 |
| ind17 | -0.3838263 | 0.3751775 | -1.02 | 0.306 |
| ind18 | -1.43782 | 0.5759698 | -2.5 | 0.013 |
| ind19 | -0.62743 | 0.4978743 | -1.26 | 0.208 |
| ind21 | -0.280807 | 0.4147913 | -0.68 | 0.498 |
| ind22 | -0.2972819 | 0.4110895 | -0.72 | 0.47 |
| ind23 | 0.067316 | 0.4479046 | 0.15 | 0.881 |

| | | | | |
|---|---|---|---|---|
| ind24 | -0.1375412 | 0.3492178 | -0.39 | 0.694 |
| ind25 | 0.3909019 | 0.3602563 | 1.09 | 0.278 |
| ind26 | 0.2142655 | 0.3871368 | 0.55 | 0.58 |
| ind27 | 0.4260194 | 0.3762945 | 1.13 | 0.258 |
| ind28 | 0.8135098 | 0.3566933 | 2.28 | 0.023 |
| ind29 | 0.6283253 | 0.3453916 | 1.82 | 0.069 |
| ind30 | 0.3544024 | 0.4259174 | 0.83 | 0.405 |
| ind31 | 0.4524323 | 0.3544138 | 1.28 | 0.202 |
| ind32 | 0.4878381 | 0.3491933 | 1.4 | 0.162 |
| ind33 | 0.6916512 | 0.3848011 | 1.8 | 0.072 |
| ind34 | 0.2661517 | 0.3595549 | 0.74 | 0.459 |
| ind35 | 0.0022544 | 0.4270031 | 0.01 | 0.996 |
| ind36 | 0.3709254 | 0.3777295 | 0.98 | 0.326 |
| _cons | -1.133547 | 0.4798994 | -2.36 | 0.018 |

*Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level*

Design right is usually given to protect the external aspects of products. As in the utility model, firm size, production-related objectives, organization-related objectives, and market-related objectives had a significant positive relationship with the possibility of using design rights. In addition, as expected, the position of final products positively influenced the possibility of this mechanism because the external aspects of products are important to individual consumers.

TABLE 4. The result of multivariate probit regression in the case of design

| **Design** | **Coef.** | **Std.** | **z** | **P>z** |
|---|---|---|---|---|
| Rndin | 0.2996624 | 0.1874389 | 1.6 | 0.11 |
| Size | 0.1777979*** | 0.0296609 | 5.99 | 0 |
| Material | 0.408256 | 0.4111985 | 0.99 | 0.321 |
| Intermediate | 0.1983111 | 0.3760931 | 0.53 | 0.598 |
| Final | 0.6564568* | 0.3734828 | 1.76 | 0.079 |
| Production | 0.1868383** | 0.0730046 | 2.56 | 0.01 |
| Organization | 0.1454601** | 0.0726524 | 2 | 0.045 |
| Market | 0.5560371*** | 0.0730873 | 7.61 | 0 |
| ind15 | -0.5563046 | 0.3586495 | -1.55 | 0.121 |
| ind17 | -0.7334949 | 0.3831224 | -1.91 | 0.056 |
| ind18 | -1.257537 | 0.4846018 | -2.59 | 0.009 |
| ind19 | -0.5323665 | 0.4733102 | -1.12 | 0.261 |
| ind21 | -1.006397 | 0.4553614 | -2.21 | 0.027 |
| ind22 | -0.579851 | 0.4240759 | -1.37 | 0.172 |
| ind23 | -0.1236321 | 0.4483425 | -0.28 | 0.783 |
| ind24 | -0.5282094 | 0.3511636 | -1.5 | 0.133 |
| ind25 | -0.0138282 | 0.3604099 | -0.04 | 0.969 |
| ind26 | -0.1420055 | 0.3956754 | -0.36 | 0.72 |
| ind27 | -0.1397388 | 0.3783743 | -0.37 | 0.712 |

| | | | | |
|---|---|---|---|---|
| ind28 | 0.2339708 | 0.3562826 | 0.66 | 0.511 |
| ind29 | -0.0253944 | 0.3456654 | -0.07 | 0.941 |
| ind30 | -0.0980699 | 0.4277465 | -0.23 | 0.819 |
| ind31 | -0.0578564 | 0.3541169 | -0.16 | 0.87 |
| ind32 | -0.0633571 | 0.3495114 | -0.18 | 0.856 |
| ind33 | 0.1693364 | 0.3832104 | 0.44 | 0.659 |
| ind34 | -0.1591346 | 0.3611132 | -0.44 | 0.659 |
| ind35 | -0.5182622 | 0.4289723 | -1.21 | 0.227 |
| ind36 | -0.0368527 | 0.3758149 | -0.1 | 0.922 |
| _cons | -1.895118 | 0.5180798 | -3.66 | 0 |

*Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level*

Trademark exists to protect brands. Larger firms are more likely to use the appropriation mechanism of trademark. In addition, among objectives, only organizational-related and market-related objectives were positively significant at the 1% level.

TABLE 5. The result of multivariate probit regression in the case of trademark

| **Trademark** | **Coef.** | **Std.** | **z** | **P>z** |
|---|---|---|---|---|
| Rndin | 0.1359574 | 0.1601303 | 0.85 | 0.396 |
| Size | 0.1479318*** | 0.0293975 | 5.03 | 0 |
| Material | 0.0965696 | 0.3715421 | 0.26 | 0.795 |
| Intermediate | -0.048681 | 0.333886 | -0.15 | 0.884 |
| Final | 0.3893743 | 0.331155 | 1.18 | 0.24 |
| Production | 0.1015695 | 0.0719271 | 1.41 | 0.158 |
| Organization | 0.2563107*** | 0.0717386 | 3.57 | 0 |
| Market | 0.5733548*** | 0.0722847 | 7.93 | 0 |
| ind15 | 0.0117662 | 0.372416 | 0.03 | 0.975 |
| ind17 | -0.1850777 | 0.3879965 | -0.48 | 0.633 |
| ind18 | 0.2713177 | 0.4494336 | 0.6 | 0.546 |
| ind19 | -0.5948693 | 0.484221 | -1.23 | 0.219 |
| ind21 | -0.6087734 | 0.4453812 | -1.37 | 0.172 |
| ind22 | -0.2626689 | 0.4262878 | -0.62 | 0.538 |
| ind23 | 0.4342452 | 0.4513482 | 0.96 | 0.336 |
| ind24 | 0.0613115 | 0.3660977 | 0.17 | 0.867 |
| ind25 | 0.0801419 | 0.3768301 | 0.21 | 0.832 |
| ind26 | -0.0996479 | 0.4088535 | -0.24 | 0.807 |
| ind27 | 0.2043962 | 0.3915835 | 0.52 | 0.602 |
| ind28 | 0.0470008 | 0.3734984 | 0.13 | 0.9 |
| ind29 | 0.0316235 | 0.3625898 | 0.09 | 0.931 |
| ind30 | 0.2244519 | 0.4382922 | 0.51 | 0.609 |
| ind31 | -0.094812 | 0.3715416 | -0.26 | 0.799 |
| ind32 | 0.0551429 | 0.3666674 | 0.15 | 0.88 |
| ind33 | 0.2606649 | 0.3994036 | 0.65 | 0.514 |

| | | | | |
|---|---|---|---|---|
| ind34 | -0.2666024 | 0.3781721 | -0.7 | 0.481 |
| ind35 | -0.3451707 | 0.4410747 | -0.78 | 0.434 |
| ind36 | 0.0960124 | 0.3919087 | 0.24 | 0.806 |
| _cons | -1.619568 | 0.4998353 | -3.24 | 0.001 |

*Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level*

Patent, utility model, design right, and trademark can be classified as formal appropriation mechanisms that are given legal rights by government. R&D intensity indicating the innovative effort made by firms is likely to have a positive effect only on patents among the formal mechanisms. Firm size, however, had a positive influence on all of the formal mechanisms. It can be conjectured that using a formal mechanism has much to do with a firm's capabilities, as reflected in firm size from this evidence. Among positions within the value chain, only the position of final products was shown to have a significantly positive relationship with design rights. The objectives of innovative activities were generally positive with statistical significance. When approached in detail, while utility model and design rights were likely to be influenced by all three objectives, patent and trademark had a relationship only with organization- and market-related objectives. The production-related objectives that had something to do with process type innovation were not significant in terms of effect on the use of patent and trademark.

### 4.2. Informal Mechanisms

Meanwhile, the most frequently used mechanism, based on previous studies, is secrecy (Levin *et al*., 1987; Cohen *et al.*, 2000). In the current analysis, R&D intensity and size had a positive impact on use of the secrecy strategy. At the same time, unlike patents, production-related objectives in addition to organization-related objectives and market-related objectives had a positive relationship with the possibility of using this mechanism.

TABLE 6. The result of multivariate probit regression in the case of secrecy

| Secret | Coef. | Std. | z | P>z |
|---|---|---|---|---|
| Rndin | 0.3390064* | 0.1973734 | 1.72 | 0.086 |
| Size | 0.1364151*** | 0.0298995 | 4.56 | 0 |
| Material | -0.0682093 | 0.3701043 | -0.18 | 0.854 |
| Intermediate | 0.208929 | 0.3346101 | 0.62 | 0.532 |
| Final | 0.2254203 | 0.332382 | 0.68 | 0.498 |
| Production | 0.2092436*** | 0.0720261 | 2.91 | 0.004 |
| Organization | 0.354197*** | 0.0718886 | 4.93 | 0 |
| Market | 0.6760431*** | 0.0723278 | 9.35 | 0 |
| ind15 | 0.1667231 | 0.3631567 | 0.46 | 0.646 |
| ind17 | 0.0793848 | 0.3741143 | 0.21 | 0.832 |
| ind18 | -0.1012386 | 0.4444205 | -0.23 | 0.82 |
| ind19 | -0.6453661 | 0.4760974 | -1.36 | 0.175 |

| | | | | |
|---|---|---|---|---|
| ind21 | -0.1167504 | 0.4217025 | -0.28 | 0.782 |
| ind22 | -0.2827033 | 0.4186263 | -0.68 | 0.499 |
| ind23 | 0.4843431 | 0.4529339 | 1.07 | 0.285 |
| ind24 | 0.426367 | 0.355786 | 1.2 | 0.231 |
| ind25 | 0.3906573 | 0.3678044 | 1.06 | 0.288 |
| ind26 | 0.3149742 | 0.3957254 | 0.8 | 0.426 |
| ind27 | 0.1338873 | 0.3865194 | 0.35 | 0.729 |
| ind28 | 0.4502954 | 0.3626506 | 1.24 | 0.214 |
| ind29 | 0.2383002 | 0.3519746 | 0.68 | 0.498 |
| ind30 | 0.9438971 | 0.4500305 | 2.1 | 0.036 |
| ind31 | 0.1986898 | 0.362743 | 0.55 | 0.584 |
| ind32 | 0.3708888 | 0.3567647 | 1.04 | 0.299 |
| ind33 | 0.5806296 | 0.3942525 | 1.47 | 0.141 |
| ind34 | 0.1117345 | 0.36624 | 0.31 | 0.76 |
| ind35 | 0.1633219 | 0.4390058 | 0.37 | 0.71 |
| ind36 | -0.129017 | 0.386992 | -0.33 | 0.739 |
| _cons | -1.593528 | 0.4931918 | -3.23 | 0.001 |

*Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level*

Complex design or complexity of design is for preventing easy imitation by competitors. This mechanism is likely to be used by larger firms and firms that pursue at least one of the three objectives.

TABLE 7. The result of multivariate probit regression in the case of complex design

| **Comdesign** | **Coef.** | **Std.** | **z** | **P>z** |
|---|---|---|---|---|
| Rndin | 0.0281464 | 0.1165995 | 0.24 | 0.809 |
| Size | 0.1442447*** | 0.0293439 | 4.92 | 0 |
| Material | 0.38427 | 0.4385633 | 0.88 | 0.381 |
| Intermediate | 0.424615 | 0.4041248 | 1.05 | 0.293 |
| Final | 0.5108823 | 0.4022558 | 1.27 | 0.204 |
| Production | 0.1766143** | 0.0733155 | 2.41 | 0.016 |
| Organization | 0.3397432*** | 0.0735543 | 4.62 | 0 |
| Market | 0.5947953*** | 0.0744774 | 7.99 | 0 |
| ind15 | -0.0948687 | 0.363266 | -0.26 | 0.794 |
| ind17 | -0.0588539 | 0.3766005 | -0.16 | 0.876 |
| ind18 | -0.4105836 | 0.4766045 | -0.86 | 0.389 |
| ind19 | -0.5779938 | 0.5169325 | -1.12 | 0.264 |
| ind21 | -0.4772778 | 0.4343739 | -1.1 | 0.272 |
| ind22 | -0.4117787 | 0.4281584 | -0.96 | 0.336 |
| ind23 | 0.1313554 | 0.4569776 | 0.29 | 0.774 |
| ind24 | 0.0987032 | 0.3540035 | 0.28 | 0.78 |
| ind25 | 0.2264048 | 0.3668545 | 0.62 | 0.537 |

| | | | | |
|---|---|---|---|---|
| ind26 | -0.090662 | 0.4021282 | -0.23 | 0.822 |
| ind27 | 0.2216034 | 0.3843473 | 0.58 | 0.564 |
| ind28 | 0.3437629 | 0.3611353 | 0.95 | 0.341 |
| ind29 | 0.2536316 | 0.350301 | 0.72 | 0.469 |
| ind30 | 0.4482335 | 0.4283119 | 1.05 | 0.295 |
| ind31 | 0.0530043 | 0.361316 | 0.15 | 0.883 |
| ind32 | 0.0532618 | 0.3547872 | 0.15 | 0.881 |
| ind33 | 0.8565399 | 0.3897802 | 2.2 | 0.028 |
| ind34 | -0.0469821 | 0.3653492 | -0.13 | 0.898 |
| ind35 | 0.0561865 | 0.4323832 | 0.13 | 0.897 |
| ind36 | 0.1742944 | 0.3846319 | 0.45 | 0.65 |
| _cons | -2.303218 | 0.5440483 | -4.23 | 0 |

*Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level*

The appropriation strategy of lead time (market preemption) might be selected to capture returns before competitors arrive. In the case of lead time, it is likely that firm size, production-related objectives, organization-related objectives, and market-related objectives positively influence the possibility of using the lead-time strategy.

TABLE 8. The result of multivariate probit regression in the case of lead time (market preemption)

| **Mktpreemp** | **Coef.** | **Std.** | **z** | **P>z** |
|---|---|---|---|---|
| Rndin | 0.1559134 | 0.1422511 | 1.1 | 0.273 |
| Size | 0.1261819*** | 0.0298597 | 4.23 | 0 |
| Material | -0.0164015 | 0.3778286 | -0.04 | 0.965 |
| Intermediate | 0.1579908 | 0.3411455 | 0.46 | 0.643 |
| Final | 0.2978853 | 0.3388361 | 0.88 | 0.379 |
| Production | 0.296226*** | 0.0723571 | 4.09 | 0 |
| Organization | 0.3932377*** | 0.0723156 | 5.44 | 0 |
| Market | 0.7365075*** | 0.0727423 | 10.12 | 0 |
| ind15 | 0.2030043 | 0.3669617 | 0.55 | 0.58 |
| ind17 | 0.391445 | 0.3787319 | 1.03 | 0.301 |
| ind18 | -0.0910749 | 0.4434937 | -0.21 | 0.837 |
| ind19 | -0.2756487 | 0.4662056 | -0.59 | 0.554 |
| ind21 | -0.4153209 | 0.4289751 | -0.97 | 0.333 |
| ind22 | 0.0050742 | 0.4216023 | 0.01 | 0.99 |
| ind23 | -0.0188572 | 0.4658407 | -0.04 | 0.968 |
| ind24 | 0.516962 | 0.3595593 | 1.44 | 0.151 |
| ind25 | 0.5831387 | 0.3722079 | 1.57 | 0.117 |
| ind26 | 0.3462167 | 0.3999314 | 0.87 | 0.387 |
| ind27 | 0.5130543 | 0.391123 | 1.31 | 0.19 |
| ind28 | 0.7699362 | 0.3670887 | 2.1 | 0.036 |
| ind29 | 0.5654819 | 0.3562047 | 1.59 | 0.112 |

| | | | | |
|---|---|---|---|---|
| ind30 | 0.4431495 | 0.4403512 | 1.01 | 0.314 |
| ind31 | 0.334267 | 0.3661583 | 0.91 | 0.361 |
| ind32 | 0.5032854 | 0.360233 | 1.4 | 0.162 |
| ind33 | 0.7707032 | 0.3997479 | 1.93 | 0.054 |
| ind34 | 0.3519358 | 0.3699762 | 0.95 | 0.341 |
| ind35 | 0.4977134 | 0.4453103 | 1.12 | 0.264 |
| ind36 | 0.4211312 | 0.392376 | 1.07 | 0.283 |
| _cons | -1.853907 | 0.5013249 | -3.7 | 0 |

*Note: * significance at 10% level, ** significance at 5% level, *** significance at 1% level*

Secrecy, complex design, and lead time can be classified as informal appropriation mechanisms. Among independent variables, R&D intensity is likely to have a positive effect only on using the secrecy strategy. Larger firms and firms that pursue at least one of objectives, however, are likely to use all three informal mechanisms.

### 4.3. The Relationship Among the Mechanisms

Table 9 shows the estimates of the disturbance covariance matrix, i.e., the correlation coefficients of the error terms of the seven equations. We can conjecture the relationships among appropriation mechanisms by referring to the corresponding correlations between estimated disturbances.

In our estimation, all of the correlation coefficients were significant and positive, suggesting interdependence -- or complementarity -- among the mechanisms. As noted, it is more realistic for firms to consider each mechanism simultaneously, and once more, this analysis confirmed that using each mechanism occurs simultaneously and complementarily.

If we refer to a higher value of correlation indicating a strong relationship among the mechanisms, we can identify three characteristics. First, there are strong complementarities among formal mechanisms (patent, utility model, design right, and, trademark). Second, there are strong complementarities among informal mechanisms (secrecy, complex design, and lead time). Finally, there is strong complementarity between trademark and complex design. These findings suggest the following picture: Firms are likely to use formal mechanisms as a group. At the same time, firms are inclined to use informal mechanisms, combining each other. The mix of complex design and trademark makes it possible to capture market share while preventing competitors from catching up rapidly because the effect of trademark on product image lasts much longer than any other formal mechanisms beyond the time period guaranteed by laws.

TABLE 9. Estimate of the disturbance covariance matrix

| | Coef. | Std. | z | P>z |
|---|---|---|---|---|
| rho21 | 0.7980793 | 0.0218691 | 36.49 | 0 |
| rho31 | 0.7021487 | 0.0287547 | 24.42 | 0 |
| rho41 | 0.709952 | 0.0272566 | 26.05 | 0 |
| rho51 | 0.4381581 | 0.0382882 | 11.44 | 0 |
| rho61 | 0.529067 | 0.0360777 | 14.66 | 0 |
| rho71 | 0.4726901 | 0.0370849 | 12.75 | 0 |
| rho32 | 0.8625301 | 0.0177462 | 48.6 | 0 |
| rho42 | 0.7727733 | 0.0238616 | 32.39 | 0 |
| rho52 | 0.4949973 | 0.0363724 | 13.61 | 0 |
| rho62 | 0.6233181 | 0.0324235 | 19.22 | 0 |
| rho72 | 0.5082084 | 0.0358007 | 14.2 | 0 |
| rho43 | 0.8724743 | 0.0165362 | 52.76 | 0 |
| rho53 | 0.5424739 | 0.0362897 | 14.95 | 0 |
| rho63 | 0.6892145 | 0.029326 | 23.5 | 0 |
| rho73 | 0.5226858 | 0.0368422 | 14.19 | 0 |
| rho54 | 0.620389 | 0.0319514 | 19.42 | 0 |
| rho64 | 0.7174114 | 0.0269108 | 26.66 | 0 |
| rho74 | 0.6026075 | 0.0332402 | 18.13 | 0 |
| rho65 | 0.8155456 | 0.023973 | 34.02 | 0 |
| rho75 | 0.7951624 | 0.0218335 | 36.42 | 0 |
| rho76 | 0.7512204 | 0.026795 | 28.04 | 0 |

*Note: Boldface indicates higher values of correlation; 1 – patent, 2 – utility model, 3 –design right, 4 – trademark, 5 – secrecy, 6 – complex design, 7 – lead-time advantages*

## 5. CONCLUDING REMARKS AND POLICY IMPLICATIONS

This paper considers that using a specific mechanism results from one of multiple choices made by innovative firms, based on their position in the specific business context. Particularly, we have analyzed the effect of the specific business context and the nature of innovation pursued by innovative firms on use of an appropriation mechanism and how innovative firms mix appropriation mechanisms to retain ownership of their innovative output.

Previous authors have assumed that the selection and use of any given appropriation mechanism occurs independently of use of another mechanism and that therefore, their main interest was finding the most effective mechanism among diverse choices. However, it is not easy to give concrete guidance about innovation strategies in the view of innovation management. Therefore, a shift is needed in the framework for analyzing use of appropriation mechanisms, from a focus on individual choice to a focus on multiple choices involving diverse mechanisms simultaneously. In addition, the nature of the innovative environment and innovation itself should be considered as important factors to comprehend the use of appropriation mechanisms.

Among multiple innovative environments, the most important factor is the industry (or sector) and

where firms are positioned in their value chain. At the same time, also important is a firm's recognition of the objectives of technologically innovative activities.

Based on the results of the Korean innovation survey, we used a multivariate probit model that is an extension of the probit model dealing with binary dependent variables. The estimation model in this study consists of seven binary choice equations. The estimation result can represent the effect of each independent variable on each choice and each choice's relationship with another, conditional on the effect of each independent variable.

This paper's main finding can be summarized as follows. In case of formal mechanisms, R&D intensity is likely to have a positive effect only on patents among the formal mechanisms. However, firm size has a positive influence on all of the formal mechanisms. Among positions within the value chain, only the position of final products is significantly and positively associated with design rights. The objectives of innovative activities are generally positive with statistical significance. However, although the utility model and design rights are likely to be influenced by all three objectives, patents and trademark have a relationship only with organization- and market-related objectives. The production-related objectives are not significant in terms of effect on the use of patent and trademark. In case of informal mechanisms, R&D intensity is likely to have a positive effect only on using the secrecy strategy. Larger firms and firms that pursue at least one of the objectives, however, are likely to use all three informal mechanisms.

Finally, regarding the relationships among mechanisms, firms are likely to use formal mechanisms in a group. At the same time, they are inclined to use informal mechanisms in the manner of weaving each other. Complex design and trademark can be said to go hand in hand with each other.

Furthermore, we can imagine the possibility of a strong mix of appropriation mechanisms according to objectives, based on the results of estimation (Table 10). First, in case of production-related objectives, among diverse options, utility model, design, secrecy, complex design, and lead time are likely to be used more than others. Specifically, innovative firms are inclined to use a mix of utility model and design, and the mix of secrecy, complexity, and lead-time advantages. The use of a utility model can reflect the level of technological capabilities of Korean firms.

Second, in case of organization-related and market-related objectives, all of the mechanisms are used. However, also in this case, it can be conjectured that the mix of patent, utility model, design right, and trademark; the mix of secrecy, complex design, and lead-time strategy; and the mix of trademark and complex design are more preferred than any other mix.

TABLE 10. Possible mix of appropriation mechanisms according to objectives

| | Patent | Utility | Design | Trademark | Secrecy | Complexity | Lead time |
|---|---|---|---|---|---|---|---|
| Production- related | | ○ | ○ | | △ | △ | △ |
| Organization-related | ○ | ○ | ○ | ○ ◇ | △ | △ ◇ | △ |
| Market-related | ○ | ○ | ○ | ○ ◇ | △ | △ ◇ | △ |

*Note: Same shape indicates strong complementarities between mechanisms.*

Based on these findings, we can draw some implications for policy. On the whole, these findings call for an integrated appropriation strategy for innovation firms. Therefore, we can approach appropriation-related policy from this perspective. At this point, it should not be neglected that the set of appropriation mechanisms goes beyond intellectual property or intellectual property rights. Considering this, we can recognize that there can be some desirable direction for policy and some areas that need policy interventions, summarized as follows.

First, the policy biased toward patents should be reconsidered. Among diverse mechanisms for appropriation, this formal choice has been given relatively focused attention compared to informal options, and patents have been given unequal attention even in policy dimensions. This kind of policy stance can hinder use of an integrated appropriation strategy and the diffusion of its practice. Second, it is necessary to provide integrated Intellectual Propertypolicy service to firms, in particular to small and medium enterprises that usually lack competence to consider diverse appropriation mechanisms from the integrated point of view. The service can consist of the information related to an integrated appropriation strategy and consulting service, which can give them the necessary information about how to design and implement that strategy.

Last, it is necessary to coordinate among diverse institutions including policy makers and implementers, which involves diverse appropriation strategies of firms. There should be continuous adjustment among the entities, considering the change of technology and competition between firms. Each body comprises a fair-trade commission that is responsible for fair-trade and anti-trust behavior related to trade secrecy, in addition to a traditional body that covers patents, utility model, design right, and trademark.

This work is exploratory research using evidence from Korea. In the future, we need to analyze differential innovative activities according to different positions within value chains, various objectives of innovation, and their interaction. In addition, we need to analyze the effect of specific combinations of appropriation mechanisms on innovative output such as the percentage of sales of new product of all sales.

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