Structural Modeling of the Value of Patent

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Abstract

There is a considerable volume of prior research on the relationship between innovation and patents. Those research studies reveal that patents contain a great deal of noise, and unless a correction is made in terms of the value of individual patents, a simple count of the number of patents does not constitute a very useful indicator. From research that has been conducted for the purpose of finding such an indicator to show the value of individual patents (that is, research to identify the characteristics of valuable patents), many kinds of value indicators have been proposed. Nevertheless, research hitherto has focused primarily on business or private value derived from the possession of patents, and little attention has been paid to value in terms of technical knowledge or social value. In a survey of inventors conducted by RIETI in 2007, terminology describing broad concepts was used when questioning inventors about the value of individual patents, and this has provided an excellent opportunity to analyze the multiple factors lying behind the value of patents and how they impact one another.

The purpose of this research is to use data from the RIETI survey of inventors and structural equation modeling methods to elucidate the relationships between the technological and business value of patents, and the latent factors that influence them. The findings show that a scientific-technological motive for inventors would have a positive effect on both the business and technological value, meanwhile, the monetary or promotion motive would not have any direct effects on the value of a patent. The model also suggests that academic linkage would have a strong positive effect on the technological value but a weak negative effect on the business value. Furthermore, these relationships differ more markedly according to technological field.

Keywords: Patent value, Inventor survey, Structural Equation Modeling

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1. Introduction

Beginning first with Schmookler and then with Griliches, many researchers have used quantitative and qualitative analysis of patenting data for analysis of innovative activities. Data on patents is publicly available and has accumulated continuously in a uniform manner over a number of years. A globally uniform format and technological classification have allowed diverse analytical approaches to emerge, and have played an important role in the development of experimental studies of innovation. However, the nature of patent data is that some high value individual patents can be prejudicial to the overall distribution pattern; namely, that with the exception of a small number of patents, the value of most patents is low. According to research by Pakes and Schankerman (1986) around half the value of all patents is from 5% of patents. Due to this, databases which use an aggregate total weight for all patents (for instance, the number of patent applications by one company over the course of a year or comparing that with other companies) do not contain much information. In particular, the "Publication of Unexamined Patent Applications" available 18 months after filing is offered just as submitted by applicants without any validation by examiners, therefore contains a lot of "noise".

Weaknesses within this kind of patent data began to be corrected as their use became a proxy indicator for innovative activity as researchers began to use them from the latter half of the 1990s, triggering a lively body of research on patents (see the next section). From these researches it was possible to assess the various facets for the values of patent. However, until now empirical research specifically on patent value from various aspects has been immature.

The 2007 survey of inventors performed by RIETI (from hereon: RIETI survey; for an outline see: Nagaoka and Tsukada (2007) asked specific questions regarding the value of patents to inventors. This was the first such trial experiment in Japan. The question used in the survey was:

> *Question 6.1. Among the technical accomplishments in your technological field during the same period as you invented, how would you rate the economic value of your patent?*

In posing this question, the use of the term "economic value" is considered to be somewhat broader than the more limited "monetary value" term employed in the aforementioned European surveys. The RIETI survey used this terminology in light of Japan's own circumstances. In order to receive responses from corporate based inventors, the RIETI survey needs cooperation from the applicant company as the right holder. In many cases, for companies they are passive over the specific value of individual patents[1]. However,

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[1] Established in Article 35 of the Patent Law, issues surrounding "compensation for reasonable value" are

unwittingly the use of the wide general terminology provides a useful opportunity to test and analyze what influence a host of factors have on the value of patents.

Using data from the RIETI inventor's survey, this research will seek to shed light on the relationship and influence of the technological value and business value (discussed later) of patents.

The structure of this paper is as follows. Firstly, in Section 2, relevant prior research on the value of patents will be reviewed. Section 3 will present the structure and technique for the data analysis. In Section 4, preliminary consideration will be given to the multi-variate regression analysis and the modeling. Section 5 presents the results obtained from the analysis and the implications of the research.

2. Prior Research on the Value of Patents

Regarding innovation and patent indicators, a large body of prior research has accumulated. An early pioneer of such analysis was Schmookler, who undertook research on technology in the railroad, agriculture and the petroleum industrial sectors through chronological comparative analysis of the number of patents, finding that demand for inventions had a large influence on economic activities (Schmookler 1966). One of the leading figures within this field, and who performed extensive research on patent indicators was Griliches. In a comprehensive review of the literature performed in 1990, Griliches could find practically no correlation between a simple index of patent values and the valuation of a company on the stock market, stating that '"the needle might be there, but the haystack is very large" (Griliches 1990). Theoretically, the number of patent acquisitions by firms can be thought of as an indicator for the outputs from research and development, but without attaching weight on the value there is significant "noise" making it difficult to obtain useful information. To acknowledge the nature of this issue, researchers in North America and Europe began to perform further experimental research, a focus of which was to correct partial valuations of patents, and to clarify the role of patents as indicators of innovation.

Lerner (1994) used a number of individual patent classes (IPC subclasses) and used information presented on the patent cover to measure the technological scope of each patent, to which he then allocated weights. For 173 bio-venture companies in the US, he weighted the importance of the patent portfolio by the size of venture capital to test the statistical significance and any positive correlations. However, the idea to use the technological scope and attachment of weight to patents saw Lanjouw and Schankermann (1997) perform research

influencing the number of lawsuit problems between employer and employee.

on patent infringement lawsuits and the relationship with technological scope; although at the present time this relationship has been denied in detailed research of German patents by Harhoff et al. (2008).

As a general rule it is necessary to acquire patent rights in each country, and for these inventions the number of countries in which patent rights have been acquired can be evaluated to assess the geological scope of patent values. With important inventions there is a tendency for processing and translating the patent so that rights can be acquired that apply in a number of countries. For making an indicator of the geographical scope, the idea of a "patent family" is frequently employed. There are several definitions of a "patent family" which can create some opacity, but in basic terms it can be seen as those patents where the priority insistence is applied to claims in one country (based on the Paris Treaty) as the basis for applications in other countries. That is, the outline of the invention is the same but patents are obtained in other countries leading to a family size based on the original patent. Based on the Paris Treaty, the patent family size can be known in 12+18 month from the priority date. Guellec and Van Pottelsberghe de la Potterie (2000) have shown the correlation between the ratio of registrations and patent family size. Also, Harhoff et al. (2003) used a questionnaire survey to perform a financial assessment of the owners of patent rights and observed a correlation between monetary value and patent family size.

After a patent has been conferred, the length of duration for the maintenance of patent rights can be thought of as an indicator of the business value of a patent. For this, it is common for the patentee to pay an annual fee for maintaining the patent over the course of the 20 duration for a patent (requiring sufficient cash flow over the future for the patent) and it is likely that many patents will be abandoned during this period. Lanjouw and Schankerman (2004) showed that there was a powerful correlation between patent family size and the maintenance period. However, there are large differences between technological field in the period over which property rights are maintained due to the speed of technological change, corporate strategy, the economic environment and other external factors. Exemption or reductions to the maintenance fee can have a large influence on government owned patents, university patents and those by small and medium sized enterprises. Also, indicators on the duration and character of patent right maintenance after a long period are difficult to obtain.

A widely recognized indicator of the usefulness of individual patent values is the number of forward citations; namely, the number of citations received by an inventor or patent examiner. From this, based on the assumption that high-value information is included in patents, successive inventors and patent examiners will cite the literature; at the same time this indicator is widely used to measure the impact of scientific publications. However, for this indicator and the accumulation of forward citations a lengthy time period is required, and if

there exists highly citing group for certain prior patents, there could be a upward bias (for instance, there is a high frequency for within-firm patent citation; and the larger the company is, the greater the bias is expected). Trajtenberg (1990), Hall, Jaffe, and Trajtenberg (2002), Hall, Jaffe, and Trajtenberg (2005) have proposed using forward citations of patents as a method for correcting individual patent values.

In addition, research on patent value and the correlation between counts of the number of claims, opposition from rival firms, or the number of appeals for invalidations, backward citations (citations by inventors or examiners to prior patents), science linkage (citations by inventors or examiners to prior scientific papers) has been performed (see, for instance: Harhoff et al, 2003, Trajtenberg et al, 1997, Narin et al, 1997).

The aforementioned large-scale PatVal survey of inventors patent value implemented in six large European countries (Germany, France, the UK, Italy, Holland, Spain) in 2003/2004 has contributed to the accumulation of some of the prior research that has been presented above (PatVal-EU 2005; Giuri et al 2007). This survey collected over 9,000 responses and has permitted research on many fronts (EC Technical Report 2005, 2006). The PatVal survey in Europe triggered the RIETI survey in Japan, and using the same survey construction and items consistently should allow for comparison between the two data sets. As Nagaoka and Tsukuda (2007) have noted, there is now a broadly similar survey being implemented in the US and a second survey is now being planned in Europe.

Concerning patent value in the PatVal-EU survey, this is based on the assumed monetary value (the virtual value) of a patent by the inventor, who is asked to explain this in response to a question. Specifically, the following question is used:

> *This is a hypothetical question. "Suppose that on the day in which this patent was granted, the applicant had all the information about the value of the patent that is available today. In case a potential competitor of the applicant was interested in buying the patent, what would be the minimum price (in Euro) the applicant should demand?"*

In the PatVal-EU survey it was anticipated that there would be an uneven distribution of high patent values (with more than one opposition received or forward citations to patents) and some oversampling. Furthermore, because inventors were asked to evaluate the value of their patents, it was anticipated that there would be some inventor bias in the value estimation; in the survey implemented in France the value of similar patents that had been applied for by the inventor (or company) were matched and the values verified and compared. From this it was found that although there was some bias by inventors, the influence of this was not largely significant.

From the aggregate results and analysis of the PatVal-EU survey, both from the number of forward and backward citations, and the number of claims, until now each type of value indicator has been found to have a correlation. Attributes such as academic background, quantity of inventions, the number of patents produced, the maximum value (largest monetary value of various patents) and other indirect influences have been considered and clarified (an inventor with a lot of inventions has a larger maximum patent value in comparison to others). On the other hand, the attributes which influence the production and "average value" of inventions by inventors are not clearly known.

For measuring the above types of index (for patent value), what sort of component should first be introduced and how should these be constructed? Within this field there are a large number of researchers, and the construction of factors for "patent value" or "importance" have been put in place.

In the aforementioned review by Griliches, in the opening section it is stated that it is an "obvious fact" that there are large differences in the technological and economic value of individual patents. However, economic value in Griliches review was focused primarily on the individual private value of exclusive rights. Trajtenberg (1990), citing the description of the patent inspection process in the Office of Technology Assessment and Forecast (1976) report, noted that the number of forward citations to patents is the sufficient foundation for latent technological importance. It can probably be stated that the economical success or at least the expected value indicator is useful. Harhoff et al. (2003) shed light on the value of patents to business potential (such as corporate technologies and the defense or strategic value of patents through blocking to competitors). Lanjouw and Schankermann (2004) developed a synthetic index including patent family size, forward citation and backward citation, which became an indicator "to reflect the importance of technology to innovation and market opportunities".

In this way, "patent value" has mainly come to be seen as the basis of the value of invention and technological knowledge, or technological value. Those patents that are used or possessed (for new products, processes or licensed; or have the resemblance of blocking other firms' technologies) have "business value" or "private value". Until now, most of the above mentioned empirical research has focused on the latter, through focusing above all upon business value. Furthermore, Harhoff et al (2003) stated that in general researchers have used several indicators avoiding endogeneity problems prudently. For instance, it is assumed that there is a positive correlation between the number of inventors and patent values, but should the number of researchers in the field increase in the future then it is possible that the ratio of patent citations will also increase, suggesting a bias in the number of forward citations. Also, thinking of the business value of patents as a variable with regard of the aforementioned

period in which patents are maintained, patents maintained over an extended period may stimulate or attract the interest of other researchers, leading to a higher evaluation of the technology. According to an investigation by Arora and Ceccagnoli (2006), simultaneous equation estimations of the influence of the special characteristics of decision-making towards licensing and patent acquisition by firms and industry was undertaken, but they did not touch upon the technological value that a patent may possess.

This research will use structural equation modeling (SEM) and employ the use of intuitive path diagrams to analyze the components of patent value. In the next section the data, variables, and analytical method will be explained.

3. Data, Variables and Analytical Method

This research draws on the 5,278 sample cases used in the RIETI survey, covering 5,250 inventor responses regarding patents from 1995, and statistical data from a patent database. Drawing on the RIETI survey responses, in Figure 1 data by technological field is presented (based on US patent classification; see: Nagaoka and Tsuda 2007). In Section 4 these technological fields will form the basis for the analysis.

Figure 1

The RIETI survey data has an extensive coverage, and in each section there are a number of questions that are linked together which provide statistical data that can be synthesized to create 18 types of variable (Table 1).

(1) Patent Value Variables

Val_Dom (Inventor evaluation of economic value of patent): This variable is from Q6.11 in the survey, which has four ordinal category responses. Unfortunately this contained numerous data problems. In the RIETI inventor survey, respondents were requested to evaluate the domestic value and international value of their patent; as there were generally no major differences between the two, this research used the domestic valuation data.

Triadic_3 (existence of triadic applications/standards/important patents): This variable is an attribute of the survey sample data-source and with three ordinal categories. The sample consists of patent applications in Japan, America and Europe, or "triadic patents" which are divided from other applications. With the exception of these triadic patents, those patents that have become the basis for standardization or have been recognized as very important by experts within that field were included. Theoretically, as stated before this can be thought as a

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means of verification of the "family size".

Use_or5 (Existence of use of patent within the company) This variable has five ordinal categories. The division of the categories is basically based upon Q6.3, and is joined with the outline for the responses to Q6.8. In the case where the patent is not enacted by the company, categories on the reason for this corporate strategy (withdrawal from that particular research area etc.) or to block the use of the patent and technology to other competitors with the patent gaining strategic importance were included.

Lic_or5 (Existence of applicability of patent licensing): this variable has five ordinal categories. The category division is based on Q6.6, but also includes the outline from the above mentioned Q6.8. In the cases where there was no licensing there is a division of those patents with strategic value.

Paper_3 (Existence of publication in scientific journals of the invention outline): This variable has three ordinal categories. The division of categories is drawn from Q6.9, but in general publications by researchers in companies are subject to restraints; in synthesis with Q6.8, in the cases where scientific publication did not occur a category that included "technological level was not high" was included.

Ln_claim （The breadth of scope for patent coverage）: This variable is a natural logarithm of an integer of 1, or more is the scale variable which takes discrete value. This data was not drawn from the survey data, but the number of claims when applying for a particular patent from publicly information on unexamined patents was used.

I_fc5_tr (The number of citations received by the inventor five years after application): This variable has three categories. Drawing on the Tamada et al. (2003) method of calculating the number of patent citations from the patent description On the patent explanation form, the number of forward citations to the appropriate patent was assessed(Suzuki et. al., 2008). The value for this was divided into three categories. This citation data in aggregate at April 2005 covers patent applications in 2000 and 2001 but as their citation period had not expired there is a downward bias in these statistics. In this research, revisions for downward bias as performed in Hall et al. (2002) is not performed; there was insufficient data for patent applications in 2000 and 2001 for this variable.

Expct_use　(The expected use of the acquired rights; use within the company): This variable comprises two variables, from 5 ordinal categories. The categories have been divided based on the outline for Q6.2 although there were many missing data. This variable concerns the expected use for the invention at the time of patent acquisition for the company, and shows the recognized potential and utility value of the patent by the inventor.

Expct_bloc (The purpose of the invention rights; blocking): This variable concerns the

expected purpose of the invention rights with regard to the ability to block technological development by other companies. It concerns the understanding of the strategic value of the patent.

(2) Variables concerning Inventor Motivation

Mot_sci (The motive for invention; the contribution and progress of science and technology): This variable has five ordinal categories. The category division is based on the responses to Q5.1 in the survey. This variable looks at the motivation for the social contribution of science and technology research results since it was first initiated.

Mot_tech (The motive for invention: overcoming research challenges and issues): This variable concerns the attempts to overcome technological challenges by researchers and technologists, and the strong interest they have held for the first research results.

Mot_car (The motive for invention: career and status advancement): This variable concerns the career trajectory and status of inventors, as well as the motivations for career advancement since the highpoint of research results.

Mot_mony (The motive for invention: financial remuneration): This variable concerns financial remuneration and the profit incentive since the high point of the research results.

(3) Academic Linkage Variables

AcNW (Relationship with public research institutes and universities): This variable is from Q4.8 in the survey "existence of collaborative invention with university researcher and collaborative research"; Q.10 "existence of research cooperation with university/ies"; and, Q17, "existence of use of public funding", where respondents could select from two values (either: "0=no";"1=yes") which provides four categories. The smallest value is 0 and the largest value is 3; and, along with expectations there is a skew distribution towards zero values amongst the sample responses.

Num_SL (Science Linkage): Similar to the method this variable and *I_fc5_tr*, data was drawn from the patent description on academic publication citations to create a data-source. According to the number of citations, a categorization was performed whereby no citations = 0, 1 citation = 1, and more than 2 citations = 2. This variable had a similar skew to *AcNW*.

InConc_sci (Research idea conception and source of knowledge; science and technology publications): this variable includes 3 parameters and 6 ordinal categories; of these but some of these were not used due to data difficulties. Of the other categories, these are based on

responses from Q4.12 in the survey addressing the usefulness of the scientific literature for the conception of the idea.

InConc_ac (Research idea conception and source of knowledge: universities): This variable concerns the acquisition of the research conception from universities or other institutes of education through tacit knowledge (from other sources except scientific publications).

InConc_gov (Research idea conception and source of knowledge: public institutes): This variable concerns the conception for the research from sources other than universities, such as public research organizations through tacit knowledge (from other sources except scientific publications).

From the above observations, descriptive statistics related to each variable will be presented in Table 2.

[Table 1.]

[Table 2.]

(4) Structural Equation Modeling.

Structural Equation Modeling (SEM) is a technique which is developed as an expansion of factor analysis that can handle difficult latent factors, and is derived from observing at first hand research on the psychology, and pedagogy fields (Joreskog 1978). However, through the diffusion of high level handbooks and software the usability has now become widely recognized and a number of disciplines in the social sciences, such as management studies, and political science, and the natural sciences are applying SEM techniques.

As observed in Section 2, there are several component factors that are thought to complicate the direct observation of patent value. To deal with these, latent variables can be brought in and SEM allows for the modeling of the casual relationship between the observation and latent variables, whereby the factors that influence patent value can be investigated. The SEM analysis tool is the AMOS16.0J.

Firstly, the creation of the general outline of patent value was constructed from technological / social values; Technological Value (in the figure this is abbreviated to "TechValue") and Business Value as two latent variables. From this, for investigating the influence of 9 kinds of value on the observed variables, exploratory factor analysis was performed. In Figure 2 the assumptions in the early model are presented. In the figure the latent variables are elliptical, and the observation variables take on a rectangular form. E(X) is the measurement error. In

reality it can be thought that the Business Value and Technological Value have an influence on all the variables; however in order to discriminate two latent variables, in the early model the *Paper_3* variable can only be seen as related to technological value, also the *Use_or5* variable only to Business Value.

In Figure 2b, the results of the exploratory factor analysis assumptions are presented. The number attached to pass the standardization factor in the standardized estimates, here the number shown on the right shoulder of each variable are the squared correlations coefficient. For the observation variables, including the endogenous variables, the measurement error is set. For deciding the goodness of fit in the model, several types of goodness of fit indicators were used. CMIN (Chi-square) as well as AIC (Akaike Information Criterion) and various other hypothesis testing was performed. Through the comparison of several various models in use, in particular where the number of samples is large, CMIN hypothesis testing is difficult (whereby it is easy to dispose of the model). The Goodness-of-Fit-Index is in general widely used in SEM indicators, but the models which contain missing values are difficult to use. The Comparative Fit Index (CFI) and the Root Mean Square Error of Approximation (RMSEA) is useful for this study.

In order to understand Figure 2b, the three variables *I_fc5_tr*, *Triadic*, and *Ln_claim*, are influenced more strongly by Technology Value than Business Value. By contrast, *Expct_use and Expct_bloc* are influenced more strongly by Business Value. Theoretically, there are various strong influences attached to the latent variables which may not contradict the observation variables. Also in Figure 2b, Technological value has strong adverse effects on *Expct_use* and *Expct_bloc*. For this, patent possession and its "strategic significance" can have reversed technological and social implications (for high technological value patents, the objective of blocking their use to other companies may be rare) and there is no theoretical contradiction. *Lic_or5* presented in Figure.2b shows that Technological Value has a stronger influence than Business Value.

From this result, while considering the theoretical integrity and adjusting the path, the indicator of values in Figure 2c employed in the SEM model are presented. Namely, with the exception of economic value evaluated by inventors (*Val_dom*), the Technological Value and Business Value is attached to all the other observation variables. Finally, the paths with low influence were removed and in Figure 2c Business Value and Technological Value have a fairly high correlation coefficient of 0.48. In reality, the *Expct_use*、*Expect_bloc*、and *Lic_or5* observation variables give some influence, and there is a high possibility of this for the 3rd and 4th latent variables. However, because this model is unduly complex and its explanation difficult, it will not be dealt with further in this section.

Figure 2

If the causal model and the structural equation modeling are utilized, it is possible to examine the other latent factors that may indirectly influence the value of patents. With this analysis, there are assumed to be two latent variables which concern the *SciTechMotive*, regarding the general concept of inventor motivation such as contributing to the progress of science and technology, challenging technological issues and intellectual curiosity; and the BusinessMotive regarding the personal desire for career development or the acquisition of monetary remuneration. Furthermore, in relation to the academic sector there are two latent variables which include AcademicInf which concerns the utilization of research ideas from universities and public research institutions; and AcademicLink regarding the relationship for universities and public research institutes and the use or non-use of scientific publications. AcademicInf in a wider sense can be seen as one form of "absorptive capacity" outlined by Cohen and Levinthal in 1990.

For latent variables regarding motivation in the academic sector, there is a mutual correlation in place and the latent variables are seen to have some influence on patent values. This is the basic model for the next step analysis (Figure 3). The relationship between latent variables and observation variables are presented in Table 3.

Figure 3

Table 3

The properties of the dataset used in this research have a large number of deficiencies (missing values). As presented in Table 2, of the total variables, the valid list-wise sample is only 1,061 cases. For that reason, in order to compensate for the deficit in the assumed parameters of the SEM, I have employed Full Information Maximum Likelihood Estimation (from hereon abbreviated as FIML).

The FIML estimation method uses continuous variables assuming a multi-variate normal distribution for the estimators; for the parameter distribution there is a Gaussian distribution with high robustness (Arbuckle 2007). If the ordinal variables, and in particular the number of categories are small then there can be a large deviation from a Gaussian distribution, and also from the Maximum Likelihood Estimation. In this case the AMOS 16.0 as an alternative to the FIML, Bayesian - Markov Chain Monte Carlo estimators are used in the SEM. Therefore, to check the validity of the results in the FIML, recoding of the ordinal variables and the estimation using Bayesian-MCMC estimation was used.

(1)   Preliminary Analysis

As observed from the variables in the preceding section, a basic cross tabulation will be performed. In Figure 4 triadic patents and non-triadic patents are totaled against inventor estimates of the patent value (*Val_dom*). To compare the distributions of the triadic and non-triadic patents on the right side (where the value is high), for triadic patents (where there a large family size is held) certainly it can be assumed that there is a relationship with patent value indicators. However, it is useful to observe the value distribution for the non-triadic patents According to the above definition, within the Top 10% the expected value is 10%, for the Top 25% (excluding the Top 10%), the expected value is 15%, for the Top 50% the expected value is 50%. In practice (excluding the top 25%) the component comparative ratio for the expected value is greater than the expected value, for the lower 50% the total component comparative ratio is lower than the expected value. In general, this is the high estimated value by the inventor (inventor bias). Regarding this point, from the viewpoint of the technological value and the business value it is worthwhile considering this point further below.

(Figure 4)

Furthermore, observing the variable for patent value, simple multi-regression analysis will be performed. In Table 4, the totals are presented on a psychological scale for continuous variables with *Val_dom* as the explanatory variable for OLS regression analysis. For these variables, the number of valid list-wise observations is 2,039 cases. Looking at the results, and excluding *Ln_claim*, the variable coefficient has 1% significance, and the variance inflation factor value can be judged to not have too much multi-colinearity. The R-square value is 0.124 which is not particularly high. Also, the coefficient for *Expct_bloc* is negative, suggesting that the strategic value of patents (in contrast to expectations) and inventor recognition of economic value is on the whole holding a negative relationship.

Table 4

In Table 5 the results of the ordered probit regression are presented. To review this result, category 3 and category 4 for *Val_dom* (higher rank 25%; and 10%) is not significant. *Ln_claim* (the only continuous variable) is barely significant at the 10% level, but the reversed sign suggests a negative relationship. Also, identically the OLS results for one section category of *Expct_bloc* and *Val_dom* have a reverse threshold and a negative symbol.

From this multiple regression method various indicators on patents and the relationship to their economic value can be obtain and estimated. However, for estimating the patent values

various complex factors exist and to perceive the relationships may not be entirely possible.

Table 5

(2) Analysis of the model

Next, as was stated earlier, based on the whole constructed model in Figure 2, FIML estimation was used. In the early stages of the model the assumed results were not valid, so in Figure 5 the revised estimated results have been presented. Restricting our judgment to CFI and RMSEA, the goodness-of-fit for this model is not very high; however, with considering that the variables have been ordinal categories as a large part of the data, these CFI and RMSEA values could be judged as a acceptable level (the complete list for estimated parameters are in the appendix).

In addition, based on the model, *Val_dom's* squared correlation coefficient is 0.25, as presented in Figure 2c. In Figure 5 it is 0.3, and much greater than the multiple regression analysis coefficient of determination of 0.13 and 0.15 (Tables 4 and 5). On this point as well, the model that incorporates latent variables works well, and it can be considered that latent variables have been shown to have indirect validity.

Table 5.

In Table 6, for each of the path standardized coefficients, FIML estimates and Bayesian estimates were obtained and compared. As anticipated, concerning the variables that have skewed distribution (*Num_SL* and *AcNW* etc.), some degree of separation discrepancy can be observed, however, in general there is a coincidence and no contradictions can be confirmed; from hereon on the basis of the FIML estimation results debate will continue.

Table 6

Looking at the coefficients for the estimated results of the FIML method, for inventors the recognized value for patents (*Val_dom*) it is better explained by the technological value/social value than the business value. This is the case where the inventor evaluates the "economic value of the patent", the technological value is considered slightly more seriously. Regarding the actual condition of "inventor bias", unconsciously there is a greatest common denominator on inventor responses on the technological value and business value, with the production of an aggregation fallacy.　It had been reported based on the PatVal-EU survey

that inventors' evaluation on a "monetary value" of patent also had a tendency for a high evaluation (see section 2). These inventor biases are considered to be caused by the latent potential and value (shadow price) of the invention.

In this model, the correlation between the error terms for the technological value and business value (eS and eP) is seen to be high. It implies that the 3rd (and the 4th) factor should exist behind the scene. Those are factor(s) not included in this model, for instance, the attributes of inventors and their knowledge and experience, company strategy, project management, and the surrounding external environment. For the RIETI survey results, many potentially useful data is yet to be remained, and this is an issue for later analysis. In particular, for squared multiple correlation coefficient for business value in the model is only 0.12, with little explanatory power. Therefore, in order to enhance the explanatory power of business value, the management side should be incorporated in the future survey of patent value, or existing kinds of data from the results of the study could be joined together for the analysis.

According to this model, academic links has a strong positive influence on technological value, but in contrast, it has a negative influence on the business value. For companies it is suggested that university-industry-government links have two sides which can be both pluses and minuses. For this analysis, the observation and use of variables on Academic Links, the synthesis variable (*AcNW*) and the sequential categories there are issues surrounding linearities; it is considered that with *AcNW* and *Num_SL* the variable of analysis is extremely biased; there is still scope for further investigation from hereon.

From the result of this analysis, it is suggested that *SciTechMotive* has a direct positive effect on technological value as well as Business Value. To begin with, there is a debate that for researchers' intellectual curiosity stimulates a motivational incentive, but it is also possible that researchers hold a high *SciTechMotive* for high value inventions. On the other hand, *PrivateMotive* such as financial or status does not have any direct relationship with, technological value or business value and it should be a latent co-variant.

The use of information by inventors in the model through *AcademicInf* does not have a direct effect on *TechnologicalValue* and *BusinessValue*. However, for *AcademicInf* there are two types of motives for *AcademicLink* which are widely correlated. In this model, only academic information use has been considered, but for the RIETI survey the patent literature, company literature, and exhibitions also exist, other information for absorptive capacity can be investigated and incorporated into later issues.

(3) Analysis by Field

In this section, the results for parameter estimation by technological field with the same

model (same structure configural invariance) will be presented. In this paper the following technological fields were included:

Chem: Chemicals
Drug: Drugs and Medicals
Comp: Computers and Communications
Elec: Electrical and Electronic
Mech: Mechanical
Others: All other fields (including software etc.)

In Table 7 analysis results for the estimated coefficients for the technology fields are listed. To compare the Technological Value and Business Value on *Val_dom*, for Chem and Drug there is a large influence from Business Value, with the other fields being different. For this, the patents in these technological fields are largely substance patents, and they are appropriate for value appropriation of the invention. So, there is perhaps a relationship where the process for validity of the patent is high (Goto and Nagata 2002). Also, for Chem and Drug (in particular for Drug) the coefficient for *Triadic* has a small value. It is likely for these fields, by the way of recent PCT developments, international applications have increased (Japan Patent Office Annual Report 2007). To some degree for important inventions, triadic applications have possibly become the norm.

Furthermore, for Drug and other fields Technological Value has a large influence on Paper_3. For this field there is a trend for important technological developments to be published in the literature. Also for Chem, in comparison to other fields the contribution of *Ln_claim* is small. The cause for this is that a characteristic of substantive patents take the form of description of the structure of constitutional isomer and tend to have a large number of claims, and also for PCT applications, there is a tendency to include many claims in order only to get the priority date. In comparison to other fields, the Technological Value for Drug has only a small influence on *I_fc5_tr*. For inventor forward citation in general is seemed as the importance of technology indicators in such fields that a cumulative path plays an important roll. But for medical supplies it is suggested that the creative originality is more important than the cumulative progress.

Table 7

For the Comp field, the indicator for own-use by companies of patents, *Use_or5* and the indicator for licensing, *Lic_or5* both share a coefficient for Business Value which does not possess much meaning. By contrast, *Expct_bloc* is seen to possess significant meaning. For this, for patents in the Comp field, business value exists in a large part strategic blocking

rather than technology use, in the so-called "patent thicket" (Kash and Kingston 2001), which is one interpretation. Also, *Lic_or5* has low importance for Drug and Elec.

In comparison to other fields, for Mech, *Num_SL* has low importance. Within this field the automobile industry and other representative Japanese industries produce a large number of patents; within this field the academic linkage is small and the role of the scientific literature as a source for knowledge may contribute only a small amount.

Throughout the Table 7, both positive and negative influences which *AcademicLink* has on Technological Value and Business Value can be robustly observed. As stated before, for those that possess university-industry-government linkages there are two sides to this relationship and it may be suggested this has universal applicability.

Drug is unlike some other fields, from *SciTech_motive* to TechnologicalValue there is generally no influence. The cause for this could be understood that in this field science and industry are relatively proximate so it is thought that scientific motivation is an important requirement for invention. On the other hand for Chem and Comp the *SciTech_Motive* has less influence on *BusinessValue* than on *TechnologicalValue*.

For Drug, *Mot_sci* and also for *Chem, InConc_ac* dispersion is negative. The negative distribution tells us that this model does not fit well in those fields. So these results need to be interpreted with great care.

5. Implications

Employing the use of Structural Equation Modeling methods, the structure of the latent factors which influence patent values have been modeled. This model includes two latent factors; "technological value" and "business value" as the basis for a concept of patent values. This model, although a bit complicated, had a high goodness of fit to the observed data than a plain multiple regression model.

The implications suggested by this structural model are as follows: 1) the motivations for science and technology by researchers (contributing to the progress of science and technology and overcoming challenges and issues) are not only to raise the technological value of inventions; but also raising the business value. This suggests that plans for human resources involved in corporate R&D should be nurtured and given consideration. For these individuals, how should motivation for science and technology be given through some sort of incentives? Further examination is necessary in regard to this point; however, for employees participation in scientific meetings with the research community may provide intellectual stimulation, and researchers might have higher motivations if they can select technological issues to be tackled by themselves.

The second implication from this structural model is the private motivation held by researchers (financial remuneration and the desire for promotion); for companies it is suggested that the direct elevation of the business value is difficult. On this point, for instance Article 35 in the Japanese Patent Law has established that "the suitable compensation" for invention and incentive should be available, but the features of this have been questioned (equally, awareness of this issue is discussed in Owan and Nagaoka 2008). However, the results of this analysis at the same time suggest that the personal motivation of researchers and science and technology motivations and information absorption, or "Absorptive Capacity", have strongly positive relationships. Namely, a strong private motivation tends to accompany the strong technological motivation, and also accompanies the tendency for information absorption and its applicability. Conversely, the management, systems or customs which decrease private motivation may also perhaps decrease motivations for science and technology motivation. Or, would it also be possible for indicators on heightened personal motivation; that is, the motivation towards science and technology and the appointment of high level personnel? Whether or not the direction of these causal relations and necessary/sufficient condition is formed or not, requires further examination in the future.

The third implication from this structural model is that the influence of industry-university-government cooperation for the value of general patents has two characteristics which are "plus" and "minus". Namely, university-business cooperation operates in the direction in which the technological value of an invention rises, but, on the other hand it is suggested that value with respect to business is decreased. When viewed from the side business perspective, a reason why patents from university-industry-government cooperative activities have only moderate value is that for rights (rights that are shared with universities on the basis of public funding) there are complications. For instance, for the business value of patents one component is the "blocking" potential; for corporate strategy a reason is that patent possession can be self enforced and licensing not performed giving the patent value. For joint patents with universities, on the university side as a general rule the optimum putting into practice of the patent is sought; there are times when confrontation may emerge. Also, for universities and public research institutes, for the intellectual property rights from collaborative research performed through university-industry-government relations, the non-exclusive execution rights and the requests for compensation for non-execution compensation are large. The desire for restrictions regarding the handling of research results on the industry side are many and towards the partner, the direction in which licensing limitations are eased or modified, part of public organizations are in the process of doing (Advanced Industrial Research Institute 2007). In addition, as Nagaoka and Walsh (2008) have observed, many inventions produced from university-industry cooperation are at a fundamental level, and direct connection with business is difficult and it is thought that value

with respect to business is relatively low. Furthermore, as this analysis has shown, the influence of industry-university-government cooperation differs largely depending upon the technical field.

In the second section of this paper, drawing the analytical results for the PatVa-EU survey, the direct influence of the scope and attributes of the organizational affiliation of the inventor on the monetary value of patents were not able to be observed. Furthermore, as in the preceding paragraph, within this model only the framework variables, in particular the business value of patents have not been clearly explained and perhaps the age of inventors, academic background and other attributes, such as the size of their organization, projects etc. have a large number of exogenous and endogenous variables which do not include explanatory variables (included in the error term). As stated earlier, if through the method modeling the influence of indirect factors can be elucidated, and consideration of high value patents and their connection with corporate strategy and policy support would be useful.

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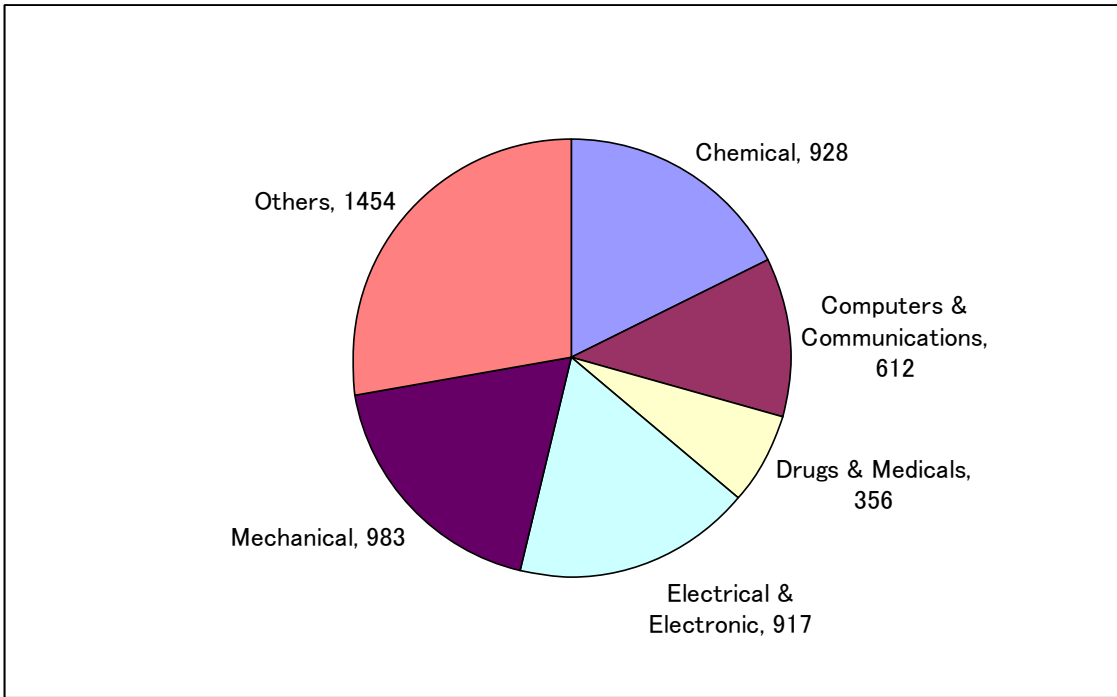
Figure.1   Technological field distribution in the RIETI survey sample
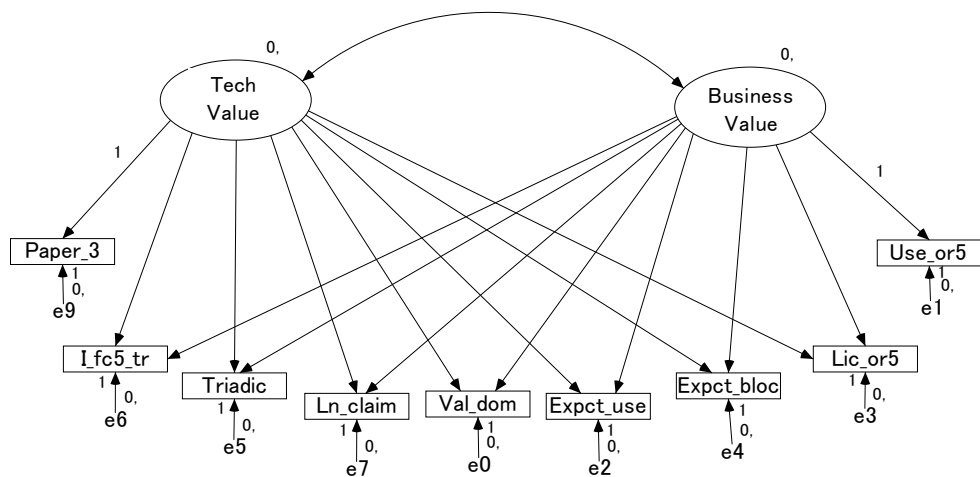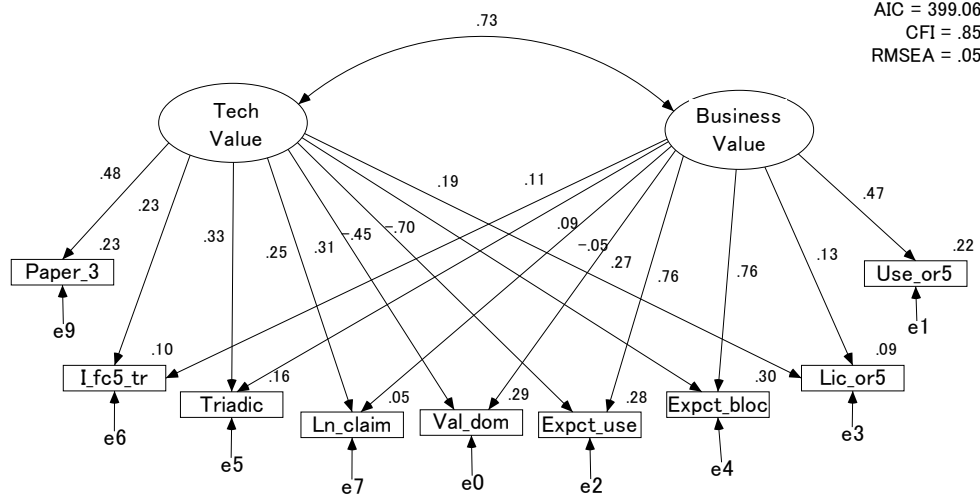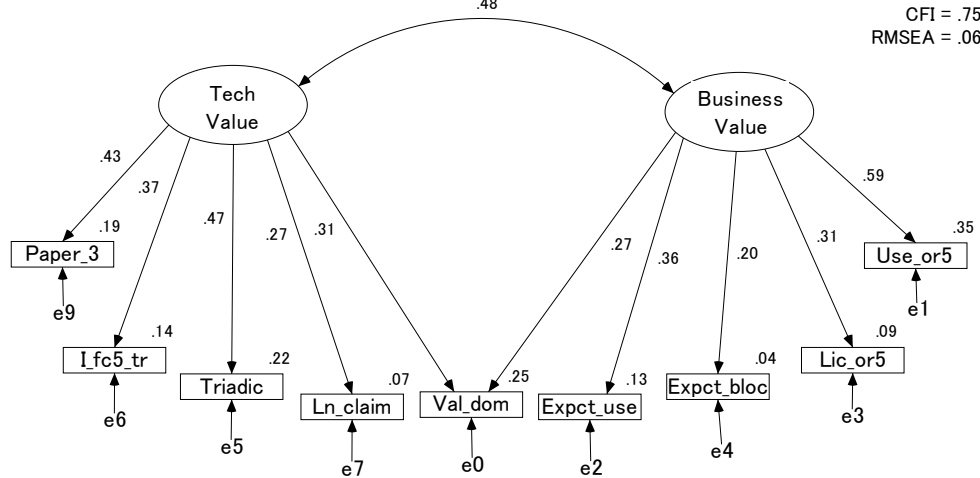
Figure.2a(upper)、2b (middle)、2c (lower)　Estimated Results of Factor Analysis of patent value variables
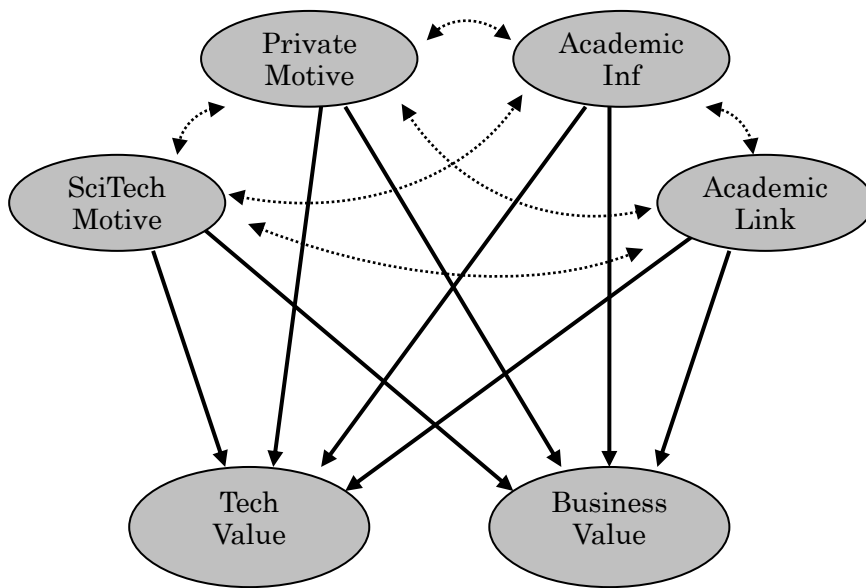
Figure.3　Basic Model of Correlation and causal relationship with Latent variables

	non-triadic	%	triadic	%	VIP	要 %	sub total
Lower 50%	382	(39.1)	675	(25.2)	10	(13.7)	1,067
Top 50% (excluding top 25%)	376	(38.4)	1,045	(39.0)	23	(31.5)	1,444
Top 25% (excluding top 10%)	149	(15.2)	671	(25.0)	22	(30.1)	842
Top 10%	71	(7.3)	288	(10.8)	18	(24.7)	377
Valid Total	978	100	2,679	100	73	100	3,730
Missing Val_dom	523		979		18		1,520
Grand Total (Year after 1995)	1,501		3,658		91		5,250
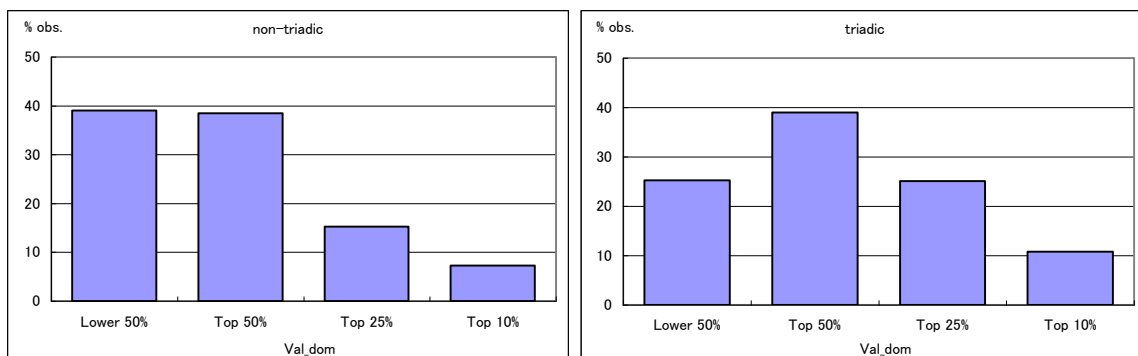
Figre.4　Cross tabulation on Patent Value and Triadic Patents
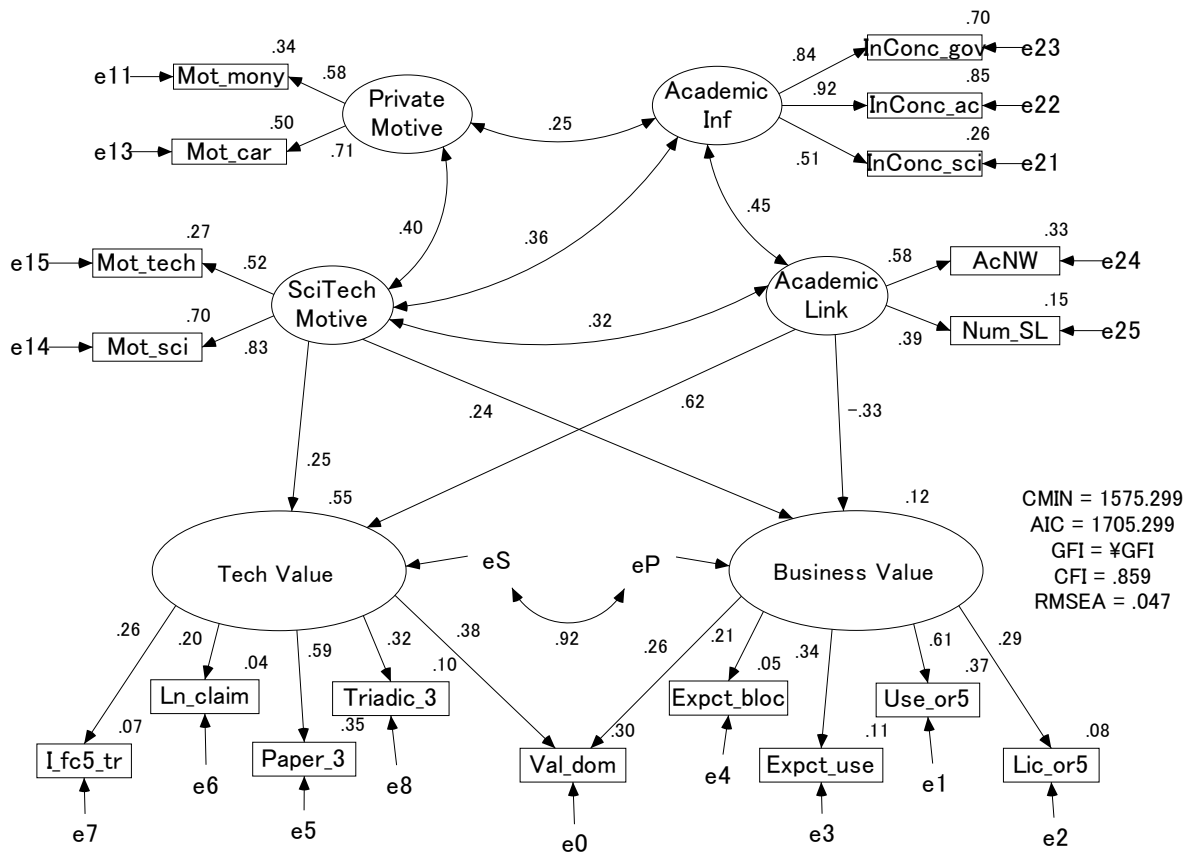
Figure.5   Construction of Patent Evaluation Model

Table.1　Definition of Variables: Categories and Data source

Variable Name	Outline	Variable Type	Category/Definition	Data source
Val_dom	Economic value of domestic patents at same time and same field	Ordinal	1：Lower 50% 2：Upper 50%（with the exception of categories 2 and 4) 3：Upper 25%（with the exception of category 4) 4：Upper end 10%	Survey Q6.11
Triadic_3	Existence of triadic patents, standards or important patents	Ordinal (Composite)	0：No triadic application 1：Triadic application（with the exception of category 2) 2：Standard/important patent	Survey sample attribute
Use_or5	Existence of use within the company	Ordinal (Composite)	0：No use within company（with the exception of categories 1 and 2) 1：No use within company (for the purpose of business elevation) 2：No use within company（possession of strategic value) 3：Use within company（with the exception of category 4) 4：Establishment of new company	Survey Q6.3+Q6.7+Q6.8
Lic_or5	Existence of licensing to another party	Ordinal (Composite)	0：No licensing（with the exception of categories 1 and 2) 1：No licensing（for business elevation) 2：No licensing（possession of strategic value) 3：Licensing (with the exception of category 4) 4：Licensing to various companies	Survey Q6.6+Q6.8
Paper_3	Existence of scientific publications	Ordinal (Composite)	0：Not published (technological level was low) 1：Not published 2：Published as a paper	Survey Q6.9+Q6.8
Ln_claim	Patent application scope	Scale	Number of claims at time of application (natural logarithm)	Patent Statistics
I_fc5_tr	Number of citations received within 5years of patent acquisition	Ordinal	0：None 1：1case 2：over 2 cases	Patent Statistics
Expct_use	Expected use: within firm	Ordinal	1：Totally unimportant 2：Not Important 3：Can't say 4：Important 5：Very Important	Survey Q6.2
Expct_bloc	Expected use: blocking			
Mot_sci	Motivation: Contribute to science and technology	Ordinal	1：Totally unimportant 2：Not Important 3：Can't say 4：Important 5：Very Important	Survey Q5.1
Mot_tech	Motivation: address scientific challenges			
Mot_car	Motivation: Career development			
Mot_mony	Motivation: financial remuneration			
AcNW	Relations with public research laboratory	Ordinal (Composite)	Coinv_ac_d（Existence or not of Collaborative Invention with University Researcher；2 values)；Coop_ac_d（existence or not of university research collaboration: 2 values)；Fund_gov_d（receipt or not of public funds: 2 values)	Survey Q4.9+Q10+Q17
Num_SL	Science Linkage (number of citations to scientific papers within the patent)	Ordinal	0：None 1：1 case 2：>2	Patent Statistics

InConc_sci	Source for Research Conception: Scientific publications			27
InConc_ac	Source for Research Conception: university	Ordinal	0： Do not use 1： Totally unimportant 2： Not important 3： Can't say 4： Important 5： Very important	Survey Q4.12
InConc_gov	Source for Research Conception: public research institute			

Table.2　Descriptive Statistics of Observed Variables

	Cases	Minimum	Maximum	Average	Standard Error	Skewness	Kurtosis
Val_dom	3,730	1	4	2.142	0.947	0.430	−0.740
Triadic_3	5,250	0	2	0.731	0.481	−0.567	−0.559
Use_or5	5,130	0	4	1.975	1.280	−0.539	−1.264
Lic_or5	5,010	0	4	1.194	1.412	0.751	−0.836
Paper_3	5,143	0	2	1.130	0.457	0.487	1.137
Ln_claim	5,250	0	5.170	1.683	0.843	−0.091	−0.012
I_fc5_tr	3,845	0	2	0.515	0.791	1.089	−0.525
Expct_use	3,865	1	5	4.177	0.924	−1.403	2.162
Expct_bloc	3,819	1	5	3.745	0.999	−0.948	0.715
Mot_sci	5,116	1	5	3.569	1.064	−0.719	0.081
Mot_tech	5,164	1	5	4.244	0.793	−1.458	3.465
Mot_car	5,081	1	5	2.833	1.084	−0.162	−0.714
Mot_mony	5,082	1	5	2.734	1.054	−0.107	−0.656
AcNW	5,128	0	3	0.137	0.436	3.571	13.568
Num_SL	5,250	0	2	0.193	0.544	2.707	5.832
InConc_sci	4,060	1	5	3.723	1.033	−0.900	0.413
InConc_ac	2,795	1	5	2.718	1.125	0.015	−0.819
InConc_gov	2,670	1	5	2.597	1.068	0.002	−0.821
Valid (list-wise)	1,065						

Table.3　Relationship between Latent variables and Observed Variables

Composition Outline	Latent Variable	Observation Variable
Patent Value	Tech Value	Paper_3
		Ln_claim
		I_fc5_tr
		Triadic_3
	Tech & Business Value	Val_dom
	Business Value	Use_or5
		Lic_or5
		Expct_use
		Expct_bloc
Inventor Motivation	SciTech Motive	Mot_sci
		Mot_tech
	Private Motive	Mot_car
		Mot_mony
Relations with the Academic Sector	Academic Link	AcNW
		Num_SL
	Academic Inf	InConc_sci
		InConc_ac
		InConc_gov

Table.4　Results of the OLS Regression Analysis on Patent Value

Model-1　OLS estimation
Dependent variable: Val_dom
Observations　2,039
R squared　0.127
Adj. R squared　0.124

Variables	Coefficient	t-value		VIF
(Constant)	0.853	(6.576)	***	
Use_or5	0.107	(6.113)	***	1.080
Lic_or5	0.077	(5.669)	***	1.032
Triadic_3	0.124	(2.703)	***	1.078
Paper_3	0.384	(8.528)	***	1.057
Ln_claim	0.039	(1.635)		1.048
I_fc5_tr	0.091	(3.701)	***	1.070
Expct_use	0.133	(5.733)	***	1.105
Expct_bloc	−0.057	(−2.80)	***	1.088

***: 1% significant

Table.5　Results of Ordered Probit Analysis of Patent Value

Model-2 Ordered Probit estimation

Observations	2,039	
-2Log likelihood	4555.7	
Chi-squred (d.f.)	333.3(23)	
Pseudo R squared	0.151	

Variables	Thresholds	Coefficient	Wald	
Val_dom	1	-2.385	(106.9)	***
	2	-1.263	(30.7)	***
	3	-0.315	(1.9)	
Ln_claim		0.052	(3.2)	*
Use_or5	0	-0.571	(16.1)	***
	1	-0.597	(9.8)	***
	2	-0.229	(2.5)	
	3	-0.225	(2.9)	*
Lic_or5	0	-0.387	(24.9)	***
	1	-0.344	(4.7)	**
	2	-0.247	(8.0)	***
	3	-0.151	(2.6)	
Triadic_3	0	-0.473	(7.0)	***
	1	-0.354	(4.3)	**
Paper_3	0	-0.945	(24.6)	***
	1	-0.426	(50.6)	***
I_fc5_tr	0	-0.238	(15.2)	***
	1	-0.270	(10.8)	***
Expct_use	1	-0.149	(0.7)	
	2	-0.585	(16.4)	***
	3	-0.406	(18.9)	***
	4	-0.339	(38.6)	***
Expct_bloc	1	0.327	(6.3)	**
	2	0.059	(0.3)	
	3	-0.038	(0.2)	
	4	-0.116	(3.0)	*

*: 10%、 **: 5%、 ***: 1% significant

Table.6　Comparative results of FIML estimate and Bayes estimates

Non-explanatory Variable		Explanatory Variable	Standardized Coefficient	
			FIML Estimate	Bayes Estimate
Val_dom	←	Tech Value	0.375	0.426
Val_dom	←	Business Value	0.260	0.275
Triadic_3	←	Tech Value	0.319	0.420
Use_or5	←	Business Value	0.612	0.627
Lic_or5	←	Business Value	0.290	0.329
Paper_3	←	Tech Value	0.593	0.716
Ln_claim	←	Tech Value	0.199	0.205
I_fc5_tr	←	Tech Value	0.256	0.323
Expct_use	←	Business Value	0.339	0.388
Expct_bloc	←	Business Value	0.214	0.253
Mot_sci	←	SciTech_Motive	0.834	0.884
Mot_tech	←	SciTech_Motive	0.518	0.574
Mot_car	←	Private_Motive	0.711	0.739
Mot_mony	←	Private_Motive	0.581	0.610
AcNW	←	Academic_Link	0.575	0.841
Num_SL	←	Academic_Link	0.386	0.529
InConc_sci	←	Academic_Inf	0.505	0.554
InConc_ac	←	Academic_Inf	0.924	0.951
InConc_gov	←	Academic_Inf	0.836	0.861
Business Value	←	Academic_Link	−0.332	−0.316
Tech Value	←	Academic_Link	0.620	0.557
Business Value	←	SciTech_Motive	0.244	0.278
Tech Value	←	SciTech_Motive	0.253	0.257

Table.7　Estimation Coefficient Results by Technological Field and Standardization

Non-explanatory variable		Explanatory variable	All fields	Chem	Drug	Comp	Elec	Mech	Others
Val_dom	←	Tech Value	0.38	0.29	0.37	0.42	0.35	0.47	0.41
Val_dom	←	Business Value	0.26	0.33	0.43	0.07	0.29	0.19	0.19
Triadic_3	←	Tech Value	0.32	0.16	−0.03	0.42	0.29	0.29	0.37
Paper_3	←	Tech Value	0.59	0.57	0.78	0.57	0.62	0.55	0.56
Ln_claim	←	Tech Value	0.20	0.06	0.14	0.28	0.25	0.18	0.16
I_fc5_tr	←	Tech Value	0.26	0.19	0.09	0.26	0.24	0.26	0.30
Use_or5	←	Business Value	0.61	0.72	0.38	0.03	0.58	0.60	0.65
Lic_or5	←	Business Value	0.29	0.30	0.12	−0.06	0.18	0.32	0.33
Expct_use	←	Business Value	0.34	0.34	0.51	0.50	0.32	0.43	0.30
Expct_bloc	←	Business Value	0.21	0.20	0.36	0.83	0.12	0.26	0.21
Mot_sci	←	SciTech_Motive	0.83	0.83	1.06	0.75	0.90	0.80	0.81
Mot_tech	←	SciTech_Motive	0.52	0.53	0.39	0.54	0.52	0.56	0.52
Mot_car	←	Private_Motive	0.71	0.71	0.52	0.75	0.79	0.73	0.68
Mot_mony	←	Private_Motive	0.58	0.61	0.59	0.51	0.56	0.56	0.64
AcNW	←	Academic_Link	0.58	0.75	0.62	0.50	0.55	0.54	0.52
Num_SL	←	Academic_Link	0.39	0.26	0.40	0.40	0.30	0.17	0.37
InConc_sci	←	Academic_Inf	0.51	0.39	0.46	0.51	0.49	0.50	0.59
InConc_ac	←	Academic_Inf	0.92	1.00	0.85	0.87	0.94	0.92	0.90
InConc_gov	←	Academic_Inf	0.84	0.77	0.84	0.88	0.86	0.85	0.84
Business Value	←	Academic_Link	−0.33	−0.25	−0.42	−0.37	−0.25	−0.32	−0.41
Tech Value	←	Academic_Link	0.62	0.75	0.78	0.45	0.68	0.57	0.46
Business Value	←	SciTech_Motive	0.24	0.12	0.26	0.18	0.22	0.31	0.28
Tech Value	←	SciTech_Motive	0.25	0.24	−0.01	0.42	0.28	0.32	0.24

Appended Table: Estimation Results for all Parameters

Most Likelihood Estimation

Coefficient：

			Estimated Value	Standard Error	Test Statistic	Probability
Business Value	<---	Academic_Link	−1.037	0.122	−8.526	***
Tech Value	<---	Academic_Link	0.669	0.051	13.184	***
Business Value	<---	SciTech_Motive	0.216	0.026	8.143	***
Tech Value	<---	SciTech_Motive	0.077	0.009	8.438	***
Use_or5	<---	Business Value	1			
Lic_or5	<---	Business Value	0.523	0.042	12.401	***
I_fc5_tr	<---	Tech Value	0.749	0.063	11.916	***
Val_dom	<---	Tech Value	1.315	0.088	14.858	***
Expct_bloc	<---	Business Value	0.274	0.03	9.026	***
Val_dom	<---	Business Value	0.315	0.034	9.156	***
Expct_use	<---	Business Value	0.401	0.031	12.744	***
InConc_gov	<---	Academic_Inf	1			
InConc_ac	<---	Academic_Inf	1.154	0.029	39.64	***
InConc_sci	<---	Academic_Inf	0.585	0.021	28.153	***
AcNW	<---	Academic_Link	1			
Num_SL	<---	Academic_Link	0.838	0.052	15.976	***
Mot_mony	<---	Private_Motive	0.795	0.052	15.37	***
Mot_sci	<---	SciTech_Motive	1			
Mot_tech	<---	SciTech_Motive	0.464	0.024	19.358	***
Ln_claim	<---	Tech Value	0.621	0.057	10.883	***
Triadic_3	<---	Tech Value	0.566	0.035	16.246	***
Paper_3	<---	Tech Value	1			
Mot_car	<---	Private_Motive	1			

***： 0.1% significant

Intercept :

	Estimated Value	Standard Error	Test Statistic	Probability
Val_dom	2.096	0.015	138.282	***
Use_or5	1.976	0.018	110.656	***
Lic_or5	1.194	0.02	59.912	***
Paper_3	1.13	0.006	177.654	***
Ln_claim	1.683	0.012	144.561	***
I_fc5_tr	0.517	0.013	40.772	***
Expct_use	4.134	0.015	279.037	***
Expct_bloc	3.715	0.016	230.221	***
Triadic_3	0.731	0.007	110.23	***
InConc_gov	2.574	0.019	133.422	***
InConc_ac	2.649	0.02	134.562	***
InConc_sci	3.691	0.016	228.849	***
AcNW	0.136	0.006	22.422	***
Num_SL	0.193	0.008	25.658	***
Mot_car	2.836	0.015	186.695	***

	Estimated Value	Standard Error	Test Statistic	Probability
Mot_mony	2.736	0.015	185.189	***
Mot_sci	3.571	0.015	240.574	***
Mot_tech	4.245	0.011	384.912	***

***: 0.1% significant

Variance：

	Estimated Value	Standard Error	Test Statistic	Probability
Academic_Inf	0.798	0.033	23.869	***
Academic_Link	0.063	0.005	13.313	***
Private_Motive	0.593	0.043	13.869	***
SciTech_Motive	0.786	0.043	18.302	***
eS	0.033	0.004	8.285	***
eP	0.54	0.046	11.746	***
e2	1.826	0.04	45.956	***
e0	0.632	0.02	32.003	***
e7	0.584	0.014	41.986	***
e5	0.135	0.004	30.796	***
e3	0.762	0.019	39.108	***
e6	0.683	0.014	49.94	***
e8	0.208	0.004	47.63	***
e1	1.025	0.045	22.638	***
e4	0.955	0.023	41.95	***
e23	0.345	0.019	17.966	***
e22	0.182	0.023	8.017	***
e21	0.798	0.02	39.387	***
e24	0.127	0.005	27.888	***
e25	0.252	0.006	43.549	***
e13	0.581	0.039	14.759	***
e11	0.736	0.028	26.373	***
e15	0.46	0.012	37.766	***
e14	0.345	0.038	9.078	***

***: 0.1% significant

Covariance, correlation coefficient;

			Estimated Value	Standard Error	Test Statistic	Probability	Correlation Coefficient
Academic_Inf	<-->	Academic_Link	0.101	0.007	14.984	***	0.448
Academic_Inf	<-->	Private_Motive	0.169	0.017	10.2	***	0.246
SciTech_Motive	<-->	Academic_Inf	0.281	0.018	15.483	***	0.355
SciTech_Motive	<-->	Academic_Link	0.07	0.006	12.32	***	0.316
SciTech_Motive	<-->	Private_Motive	0.273	0.016	17.087	***	0.4
eS	<-->	eP	0.123	0.007	16.575	***	0.917

***: 0.1% significant