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Innovation and FDI: Applying Random Parameters Methods to KIS Data

기술혁신과 FDI

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목 차

국 문 요 약

"시장규율로서의 FDI" 가설에 따르면 직접투자 자금유입은 국내기업의 혁신활동에 영향을 미치는 시장구조에 변화를 주는 메커니즘으로 작용한다. STEPI의 2008 KIS 데이터에 대한 프로빗 추정결과는 Bertschek(1995)이 분석한 독일기업의 경우와 달리, 한국기업의 제품혁신을 설명하는데 FDI가 설명력이 없는 것으로 나타났다. 이의 근거로 본 연구는 한국 산업의 시장구조가 독일의 경우보다 독점적인데서 기인한다는 추론을 제시하였다.

2005, 2008년 데이터로 구성된 패널데이터 분석의 경우, GLS와 OLS의 행렬가중평균을 추정하는 임의 파라미터 추정법을 적용하였다.

그 결과는 단순 패널프로빗추정 결과와 상당한 차이가 나, 기업간 파라미터에 많은 파라미터 추정치 변화가 있음을 보여준다. 그러나, 패널추정치와 횡단면 추정치간 타 계수의 부호는 달라도 FDI에 대한 결과는 동일한 것으로 나타난다.

핵심어 : 제품혁신, 공정혁신, 패널 프로빗, 파라미터 이질성

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ABSTRACT

According to the "FDI-as-market-discipline" hypothesis, inward FDI acts as a mechanism of change in market structure affecting innovative activities of domestic firms. We used panel KIS data for testing this hypothesis.

Binary probit estimation shows that, in contrast to the German case of Bertschek (1995), FDI is insignificant in Korean case for explaining product innovation. This result maybe comes from the fact that the industries in Korea are more monopolistic or oligopolistic than those of Germany.

Using panel data, we tried random parameter estimation using matrix weighted average of GLS and OLS. The result shows different estimates from cross-section outcome and panel estimation with parameter homogeneity, so we can infer large parameter heterogeneity across firms. But, interpretation for FDI variable is similar across panel and cross-section estimation.

Key Words : Product innovation, Process innovation, Panel probit, Parameter heterogeneity

I. Introduction

Is technological progress (product/process innovation) by R&D affected by inward FDI? Bertschek (1995) analyzed the innovation activities of Germans manufacturing firms using panel data (of Ifo-business survey) containing 1,270 firms observed over 5 years. She concluded that inward FDI has positive effects on the product/process innovations of German domestic firms. Main reason for this conclusion, she argues, is that the competitive pressure of foreign firms makes the domestic firms produce more efficiently. She chose the method of Chamberlin (1984)'s random effects (binary probit) model allowing for individual heterogeneity.

Using the same data, Bertschek and Lechner (1998) applied GMM estimation for panel probit model(for product innovation) to her original work and showed the expected efficiency gains in this estimation method.

In this study, we find that, in contrast to Bertschek (1995), the inward FDI does not affect the product innovation of Korean firms.[1] Bertschek (1995) suggests some explanation of this different outcome. She views that overall market structure in Germany is somewhat competitive. So, German firms responds to competition pressure of FDI by more effectively producing products and producing new products. Her argument supports implicitly Arrow hypothesis that predicts more innovation of more competitive firms.

In contrast, Korean industries may be relatively imperfectly competitive, so firms do not respond sensitively as German firms. Our conclusion also implicitly supports Arrow hypothesis, since more monopolistic firms lacks incentives for innovation. Or, our suggestion is that the point of current status of the relationship between market structure and innovation is the second part of inverted U curve, that is, downward sloping relation between two variables.

In addition to these facts, for more satisfactory explanation of the results in econometric estimation, we should consider the Schumpeterian arguments about the

1) Note that Bertschek et al. (1995, 1998) used the explanatory variable of ratio of industry foreign direct investment to (industry sales + imports). But, in KIS data analysis, we used quantitative variable indicating how much funds for business from FDI are used for the responding firms.

relation between market structure and innovation.

Sung (2005) estimated logistic model using 2002 KIS data. He analyzed the relationships between firm size, network and innovation. But, it is known that the magnitude of estimate is about 1.6 times that of probit estimation (Amemiya, 1981). Further, we use panel approach to binary choices as arranged in KIS data set (This is periodic survey results of Science and Technology of Policy Institute of Korea).

Our study has the following objectives. First, we apply Bertschek (1995)'s analysis to the case of South Korea, and compare the results. Second, we suggest alternative empirical method discussing Bertschek (1995)'s problem, that is, random parameters (panel) model.

Our discussion involves somewhat deep econometric methods, but our main focus is on finding the effects (significance) of FDI on innovation of South Korea.

Section 2 discusses simple theoretical model and econometric model. It provides main basis on which our analysis proceeds. Section 3 extends the anlaysis considering probability response, goodness of fit, and prediction. The latter part of Section 3 focuses on panel probit estimation. We consider parameter heterogeneity across firms and compare the results with cross-section and parameter homogeneity model. Section 4 concludes.

II. Econometric Model and Empirical Results

1. Previous Literature

There are increasing amount of theoretical research about FDI and technology transfer (Brecher and Diaz-Alezandro 1977, Krugman 1998, Rodrik 1999, Glass and Saggi 1988, 1999). Countries that receive fund (hosting countries) can benefit through technical diffusion like imitation or reverse engineering (Huizinga, 1995), labor mobility (Song, 2000), forward and backward industry linkages (Pack and Saggi, 2001).

Xu (2000) shows that firms of developing countries gained productivity promotion by inviting the US multinational firms. But, Baldwin et al. (1999) produce contrary

results at the industry level. Lichtenberg and Pottlesberghe (1996) argue that the estimate of international R&D stock elasticity of outward FDI is significant.

Hejazi and Safarian (1999) show that R&D spillover effect is larger than that of trade, after investigating the case of G7 and Israel.

Lei and Bang (2006) present that the effect ofinward FDI is important in tech. transfer, but the magnitude is relatively small. Brecher and Diaz-Alezandro (1977) suggest pessimistic view that FDI have negative effect on grow in the situation of market distortion. Krugman (1998) claim that FDI has no effect in financial crisis. Rodrik (1999) give logic for the causation from TFP to FDI.

For domestic study, Lee (2008, STEPI) shows inward FDI of South Korea has negative effect on innovation. As we see later, this suggestion coincides with ours.

2. Micro-economic Model

Bertschek (1995) presents simple micro-economic model for innovation behaviors of firms. She formalizes the profit-maximizing problem of a domestic innovative firm in a monopolistically competitive market:

$\Pi=p(Q, IP, FDI)Q-c(w, IP, IC)Q$

p: individual price

Q: output

c: marginal costs

The concept of monopolistic competition was introduced by Chamberlin (1933). It is the most prevalent form of industry structure. If a firm is making a profit in an industry, and other firms are not allowed to reproduce that product, they still may find it profitable to enter that industry and produce a similar product.(product differentiation) Each product has its following of consumers, and so has some market power. This market structure is widely used in IO, trade and growth theories (Grossman and Helpman 1991, Aghion and Howitt 2009).

Tirole (1988) describes the (long-run) equilibrium of the industry in the following

way:

(i) Each firm faces a downward-sloping demand.
(ii) Each firm makes no profit.
(iii) A price change by one firm has negligible effect.

Suppose that firms have U-shaped average-cost curves. Let D (p_i, p_{-i}) be the residual demand curve of firm i; that is, its demand curve given the vector of prices p_{-i} charged by the other firms. A free-entry equilibrium requires that each firm make zero profit. If we treat commercial research as an ordinary economic activity, returns to R&D come in the form of monopoly rents in (short-run) imperfectly competitive product markets (Tirole, 1988).

Product process (IP) enhances product quality and allows the firm to set a higher price than otherwise. Inward FDI (FDI) increases the product supply of foreign firms and, decreases the price of domestic firm. IP increases costs of firms but, process innovation (IC), per se, decreases them.

She, then, derives the following comparative statics (in the optimal choice of Q) : 〈Appendix〉

$d\,IC / d\,FDI > 0$
$d\,IP / d\,FDI > 0$
$d\,IC / d\,Q < 0$
$d\,IP / d\,Q < 0$

First two conditions say that inward FDI increases innovation activities and, second two conditions that more competitive firms (in terms of the magnitude of production) perform more innovation.

Theoretically, FDI can have the effect of transfer of technology or R&D spillovers. And, according to Arrow hypothesis, smaller firms (measured by magnitude of sales) have more incentive to perform innovative activities.

In the following section, we test these hypotheses by estimating standard binary

probit model for finding whether Koreans firms behave like these. As seen later, in two results for German and Korean firms, the contradictory outcome occurs in the second two conditions in which market structure variables affect innovation.

3. Econometric Model

Bertschek (1995) uses Chamberlin's (1984) panel probit method which allows for random effects. It regards individual random differences as linear function of exogeneous variables.

Meanwhile, Chamberlin's (1980) conditional ML controls fixed effects using the summation of observation of dependent variables as conditional information.

In this study, we first performed simple (cross-section) probit estimation.

1) Probit Model

Discrete dependent variable (binary choice) model captures the effects of firm characteristics on the probability of innovation. To overcome the shortcoming of LPM, researchers use probit or logit distribution for modeling the probability of occurring in events.

We express firms' choice for product innovation by the binary dependent variable:

y=1 : firm realized a product innovation within last three years
y=0 : does not

We can set the probability of realization of product innovation as F:

$Prob(Y=1)=F(x,\beta)$
$Prob(Y=0)=1-F(x,\beta)$

In this study, we use:

$$Prob(Y=1)= \Phi(\beta'x) = P[Z \leq \beta'x] = \int (1/\sqrt{2\pi})e^{-0.5u^2}du$$

$$=\Phi(\beta_0 + \beta_1 \ln(SALE) + \beta_2 FDI + \beta_3 INVEST + \beta_4 MATERIAL + \beta_5 \ln(EMPLOY))$$

where

SALE: sales of the firm, 1 million won

FDI: the amount of funds for business from FDI are used for the responding firms ($10,000)

INVEST: dummy variable indicating whether the firm is engaging in investment good industry

MATERIAL: dummy variable indicating whether the firm is engaging in material good industry

EMPLOY: total employment

This probability model is essentially regression:[2)]

$E(y|x)=F(\beta'x)$

There are some approaches that treat binary choice model: regression approach that is used in this study and latent regression (index function model) that is explained in the footnote.

2) Data and Estimation Results

We used KIS panel data consisting of 3,081 firms surveyed over 2005 and 2008.

The survey questionnaire asks firms whether the responding firms realized a product (or process) innovation within last three years. To question by yes/no categories like this makes the respondent answer more comfortably than quantitatively structured questions (Bertschek, 1995).

Firstly, we used cross-section data in 2008 containing 3,081 firms from KIS data set.

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2) The marginal effects are:
$\partial E(y|x)/\partial x=f(\beta'x)\beta$
We can also express firms' choice for product innovation by the index model using a latent variable:
y^* : expenditures of firm for product innovations within last three years
$y^*=x'\beta$
$y=1(y^*>0)$
$y=0(y^*\leq 0)$

Probit estimation results shows that all explanatory variables except FDI are significant. That is, we cannot reject the proposition that FDI is meaningless for explanation of innovation. We should notice that estimated coefficient is not marginal effect. It is pdf (standard normal) times estimated coefficients evaluated at the sample mean of explanatory variable, but if the coefficient is not significant, we can also regard marginal effect as insignificant. Like Bertschek (1995), we do not provide the estimate of marginal effect. Recently, average partial effects (APE) are used, which is sample average of individually calculated marginal effect, which is estimated respectively at each observation (Wooldridge, 2002).

The size of firm measured by the amount of sales seems to affect (product) innovation positively. This partially supports the Schumpeter hypothesis that more monopolistic firms do more R&D. This contradicts with that of Bertschek(1995) where all variables are significant. We can infer that Korean industries may be relatively imperfectly competitive, so firms do not respond to inward FDI as sensitively as German firms do.

Inward FDI usually makes domestic market more competitively, and indigenous firms react to this by producing more efficiently (Bertschek, 1995).

From another viewpoint, we can interpret this result as follows: The inward FDI to Korea does not increase innovation capacity of invested firms. This can be due to the fact that entrants to Korean industry by FDI do not consider domestic R&D seriously and only focus on the transfer of technology developed centrally in investing (host) countries. Also, we can give other reasons: high risk-taking of R&D in indigeneous firms, and concentration of smart brain and R&D funds in investing countries. But, more elaborate empirical study is needed.

Our main finding is that, in contrast to Bertschek (1995), FDI is *insignificant* in the case of South Korea. That is, FDI *cannot* explain innovation significantly in South Korea.

The maginitudes of SALE and EMPLOY can affect innovation, since so many IO literature points out this fact. Our results support the view that larger firms have more incentive in innovation. Our result also show that the industry characteristics like investment goods or service goods also serve to the behavior of firm innovation.

〈Table 1〉 Cross-section Probit Estimation

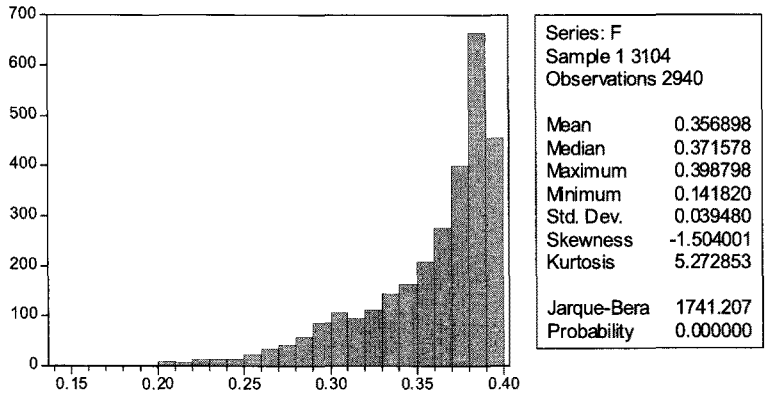
Dependent Variable: IP			
Method: ML - Binary Probit (Quadratic hill climbing)			
Sample (adjusted): 1 3081 (2008)			
Variable	Coefficient [Std. Error]		
C	2.61 [0.153]		
LOG (SALE)	0.139 [0.029]**		
FDI	0 [0.000]		
INVEST	0.434 [0.083]**		
MATERIAL	0.283 [0.091]**		
LOG (EMPLOY)	0.278 [0.040]**		
LR statistic (5 df)	664.8095	McFadden R-squared	0.165375

〈Table 2〉 The Composition of Dependent Variable and Correlation between Exogeneous Variables

Obs with Dep=0	1672	Total obs	2940
Obs with Dep=1	1268		

	EMPLOY	FDI	LOG (SALE)	INVEST	MATERIAL	LOG (EMPLOY)
EMPLOY	1.000					
FDI	0.062	1.000				
LOG (SALE)	0.344	0.118	1.000			
INVEST	-0.009	0.060	0.035	1.000		
MATERIAL	-0.001	0.012	0.060	0.206	1.000	
LOG (EMPLOY)	0.385	0.105	0.894	0.010	0.037	1.000

〈Table 2〉 shows correlation matrix of explanatory variables. It shows relatively weak correlation which may not lead to multicollinearity problem. Multicollinearity in binary choice model is not studied systematically yet, but we can decide there is little concern with this problem in our study. In addition, in least squares, pretest estimator, stepwise model building or RESET test is used for finding omitted or irrelevant



(Fig. 1) Estimated Probability (F*)

〈Table 3〉 Comparison of Estimation Results with German Case: Product Innovation[4] (Dependent Variable: IP)

	KIS	GERMAN-BL (1998)
Variable	Coefficient [Std. Error]	Coefficient [Std. Error]
C	2.61 [0.15]	-1.96 [0.23]
LOG (SALE)	0.14 [0.03**]	0.18 [0.022**]
FDI	0.00 [0.00]	2.85 [0.4**]
INVEST	0.43 [0.08**]	0.19 [0.039**]
MATERIAL	0.28 [0.09**]	-0.28 [0.081**]
LOG (EMPLOY)	0.28 [0.04**]	1.07 [0.14**]
IMPORT		1.13 [0.15**]
Log likelihood	-1677.6	-4114.05

variables. Applying this to probit is not systematically developed, so we omit this analysis.[3] In addition, we can apply Chow test for parameter stability depending on

3) In least squares, we can use nonsample information for solving multicollinearity.

4) Our comparison of results with those of the German case may be minor part of this study. Our main finding is FDI in insignificant in any econometric specification.

the characteristics of induatries.

Yatchew and Griliches (1984) have examined omitted variables and heteroscedasticity in probit and logit settings. Davidson and Mackinnon (1984) develop LM test for hypothesis testing in probit model, and perform Monte Carlo for size and power in heteroscedasticity test.

〈Table 4〉 Comparison of Estimation Results with German Case: Process Innovation

Dependent Variable: IC		
	KIS Data	GERMAN-BL Data
Variable	Coefficient	Coefficient
C	3.004 [18.183]	-
LOG (SALE)	0.126** [3.970]	-
FDI	0.000 [0.317]	1.7** [2.97]
INVEST	0.291** [3.397]	0.11 [1.82]
MATERIAL	0.284** [3.078]	-0.39** [-4.21]
LOG (EMPLOY)	0.280** [6.579]	41.19** [4.96]
IMPORT	-	0.61** [2.81]
ln L	1422.809	

[ ] means z- or t-statistics.

** means statistical significance at 5% level.

III. Extension and Implications

1. Panel Probit and Random Parameters model

As in linear regression model, there are two approaches to binary choice model. Random effects (RE) model used Butler and Moffit's quadrature method and maximum

simulated likelihood (MSL). Fixed effects (FE) model uses Chamberlin (1980)'s conditional likelihood function. Wedel et al. (1993) use latent class model for parameter heetero-geneity, adopting Poisson regression for counts of patents. This is an alternative to our random parameters model. Latent class model is estimated either maximum likelihood or Gibbs sampling.

In this paper, we used Newton-Raphson likelihood estimation.

$$yit^{*}=\beta_0 +\beta_1 \ln(SALE_{it}) + \beta_2 FDI_{it} + \beta_3 INVEST_{it} + \beta_4 MATERIAL_{it} +\beta_5 \ln(EMPLOY_{it}) + v_{it} + u_i$$

$$y_{it}=1(y_{it}^{*} > 0)$$

$$y_{it}=0(y_{it}^{*} \leq 0)$$

Next, we need to provide system for product innovation allowing for parameter heterogeneity across firms. A wide range of time series models, including the classical linear regression model and ARIMA models, are written and estimated as special cases of a state space specification providing random coefficient. The Kalman filter algorithm has been used, among other things, to compute exact, finite sample forecasts for Markov switching models and time varying (random) coefficient models.

In this paper, we use random coefficient model by expressing GLS estimator as a matrix weighted average of firm specific OLS estimators (Greene 2008, Swamy and Tavlas 2001).

Generally, the probit model $y = X\beta + \varepsilon$ is analyzed within the frameworks of constant coefficients. It does entail the not entirely plausible assumption that there is no parameter variation across firms. A fully general approach would combine all the machinery of the traditional models with a model that allows β to vary across firms.

Parameter heterogeneity across times can be modeled as stochastic variation. Suppose that we write

$$y_i = X_i\beta_i + \varepsilon_i$$

where

$$\beta_i = \beta + u_i, \qquad E[u_i | X_i] = 0, \; E[u_i \, u_i' | Xi] = \Gamma$$

The best predictors of the firm-specific coefficient vectors are averages of the GLS and OLS: (* denotes estimator)

$$\beta^*_i = Q_i\ \beta^* + [I-Q_i]b_i,$$
$$Q_i = [(1/s_i^2)X_iX_i+G^{-1}]^{-1}G^{-1}$$
$$G_i = [(1/(n-1))[\Sigma\ b_i\ b_i' - n\ (n\ \Sigma\ b_i)\ (n\ \Sigma\ b_i)']^{-}(1/N)\ \Sigma\ b_i\ V_i$$

GLS considering parameter heterogeneity produces the following results in 〈Table 5〉. It suggests, if we consider parameter heterogeneity, there occurs some change in estimates of coefficients. Using panel data, we tried random parameter estimation by using matrix weighted average of GLS and OLS. The result shows different estimates from cross-section outcome and general panel probit, so we can infer the existence of large parameter heterogeneity across firms. Further, we can use different method for parameter heterogeneity, like maximum simulated likelihood estimator (MSL), or hierarchical (mixed, random parameters) model. But, in this study, we omit these analyses.

In this analysis for panel data, we use a different set of data for which both 2005

〈Table 5〉 Estimation Results for Panel Probit Model (with Random Coefficients)

Dependent Variable: IP (2005, 2008) n=421		
	Panel (Newton-Raphson)	Panel Random Coefficients (GLS)
Variable	Coefficient [t-Statistic]	Coefficient
C	1.792 [3.18**]	24.66
LOG (SALE)	-0.228 [-2.49**]	-1.996
FDI	-0.000 [-0.30]	0.001
INVEST	-0.615 [-3.20**]	-0.075
MATERIAL	-1.462 [-8.01**]	-0.097
LOG (EMPLOY)	0.211 [-1.69*]	1.589
Log likelihood	-226.5	

and 2008 observations are available. Panel analyses show very different results from cross-section probit. We can interpret this as result of controlling individual heterogeneity. By doing this, we can get consistent estimator for explanatory variables. Our main question is that whether with unobserved individual effect controlled, FDI has significant effect on innovation. Results produce insignificance, and that is our main lesson from panel analyses. In addition, main objective of using Swamy (1971)'s random parameters model in that it allows us to estimate the sample mean of each individual-specific parameter estimates and compare with those of cross-section result. Our result shows that there are large differences between them, which means parameter heterogeneity across individual firms. But, the FDI coefficient, which is main object of our study, is similar across diverse estimation methods.

We compare results with diverse measurement for FDI. KIS survey question asks "what amount did your company used (inward) foreign direct investment fund as of ten thousand dollars"? We denote FDI1 for data with 0, missing value(coded by 99999) and amount. We denote FDI2 for data with 0, missing value(coded by NA) and amount. For solving non-positive value of FDI1 and FDI2 using log value, we use FDI3 for data NA(transforming answer of 0 into NA) and log value. 〈Table 6〉 shows main conclusion is invariant to the selection of FDI measurement variables.

All the results show that FDI is insignificant or significant negatively, and not positive.

〈Table 6〉 Estimation Results with Three Selection of FDI (Probit Model)

Dependent Variable: IPRODUCT			Dependent Variable: IPRODUCT			Dependent Variable: IPRODUCT		
	Coefficient	Prob.		Coefficient	Prob.		Coefficient	Prob.
C	-(2.61)	0.00	C	-(0.39)	0.00	C	0.98	0.00
LOG(SALE)	0.14	0.00**	LOG(SALE)	0.05	0.00**	LOG(SALE)	-(0.01)	0.84
FDI1	**0.00**	**0.82**	**FDI2**	**-(0.00)**	**0.14**	**LOG(FDI)**	**-(0.07)**	**0.05**
INVEST	0.43	0.00**	INVEST	0.14	0.00**	INVEST	0.19	0.33
MATERIAL	0.28	0.00**	MATERIAL	0.09	0.00**	MATERIAL	0.04	0.83
LOG(EMPLOY)	0.28	0.00**	LOG(EMPLOY)	0.09	0.00**	LOG(EMPLOY)	0.06	0.44

〈Table 7〉 shows Bertschek and Lechner (1998)'s results, which is successive empirical analysis of 1995s. It shows changes in coefficient estimate of FDI as different method

is applied. RP mean (second column) is the sample mean of each estimate of coefficient. RP SD is the squared root of the diagonal elements of Γ. Empirical Dist. is the sample mean of conditional estimates. RP mean is not largely different from Probit, which is similar to ours as far as FDI coefficient is concerned.

〈Table 7〉 Estimation Results for Panel Probit Model (with Random Coefficients): Bertschek and Lechner (1998)

	Probit	Random Parameters Mean	Random Parameters SD	Empirical Distribution
F D I	2.85	3.81	6.51	3.76
se	0.4	0.33		1.69 (SD)

2. Market Structure and Innovation

Schumpeter's Mark 1 and Mark 2 discuss the relationship between monopoly and R&D. Mark 1 says that monopoly is more advantageous for innovation than competition (Tirole, 1988).

Veugelers and Vanden Houte (1990) presented an econometric estimation result that there was a negative effect of FDI on innovation activities of Belgian firms. In cantrast, Bersheck (1995) shows there is a positive effect of FDI on innovation activities of German firms.

We can carefully interpret the fact that FDI is insignificant for innovation in Korea as showing Korean industry is more concentrated (monopolistic) than German industry (〈Table 6〉, 〈Table 7〉). Following Arrow hypothesis that argues that competitive firms have more incentive for R&D, our results shows that more monopolistic structure of

〈Table 8〉 Value Added per Establishment (Korea)

	2005	2006	Increase	Rate of Increase (06/05, %)
Value Added (1 billion Won)	314,441	329,201	14,760	4.7
Establishment	117,818	121,284	3,466	2.9
Value Added per Establishment (1 million Won)	2,669	2,714	45	1.7

South Korea makes firms respond less to inward FDI.

But, this table shows only the amount of sale per firm, and may be weak evidence for supporting our suggestion.

〈Table 7-1〉 Value Added per Establishment (Germany, Current Prices, OECD)

	2005	2006
GER3 (Mil. Won)	2,307.30	2,355.10
KOR3 (Mil. Won)	2,669,000.00	2,714,000.00

〈Table 7-2〉 Concentration Index (KOSIS)

	2001	
	CR4*100 Simple Average (%)	HHI*1000 Simple Average (%)
US (1997)	42.8	75.8
Korea (2001)	48.6	149.3

Korea	Simple Average (%) CR3	HHI
1980	62.4	263.8
1990	52.8	221.3
1995	47.8	173.4
1996	46.6	166.5
1997	48.6	179.4
1998	50.0	190.5
1999	45.4	158.6

Concentration indices like CR3 or Hirschman-Herfindahl index shows that market structure in Korea is relatively concentrated compared to that of US and had been stable until the late 1990s.

The share of employment in the medium-sized enterprises is similar to that of large corporations in Germany. Establishments of new enterprises is about 600 thousands in 2009. Though impossible to compare data directly, all these empirical evidences imply concentration of Korea is relatively high compared with that of Germany. More

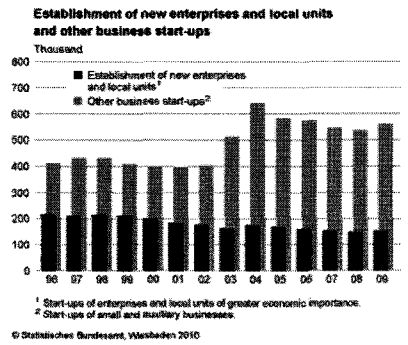
competitive market structure causes firms to respond to the pressures of competition from foreign firms. So, significant results of Berschek's study on the FDI may imply the appropriate application of Arrow's hypothesis for innovation and competitive markets.

In general, foreign direct investment means the export of physical factors of production like physical capital. It compares to the indirect investment such as investment in securities. So, FDI could affect competition strategies like R&D activities. The implication of this empirical study may be the fact that we can estimate these effects through microeconomic data such as KIS.

〈Table 7-3〉 Employment share and Establishment in Germany (German Federal Statistical Office)

Size class in Germany	Employees	Annual turnover
Micro-enterprises	Up to 9	And up to 2 Mill. EUR
Small enterprises[1]	Up to 49	And up to 10 Mill. EUR
Medium-sized enterprises[2]	Up to 249	And up to 50 Mill. EUR
Large enterprises	More than 249	Or more than 50 Mill. EUR

[1] and no micro-enterprise
[2] and no small or micro-enterprise



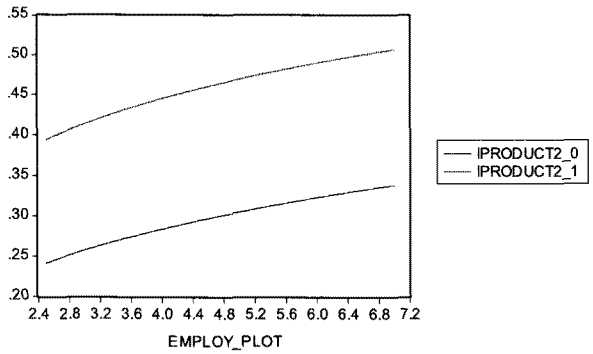
3. Probability Response Curve, Goodness of fit tests and Expectation-Prediction Evaluation

As the size of firm increases, we can expect that the marginal effect on product

innovation of whether the firm is engaged in investment good industry would increase. Because investment good industry means more technological opportunities, it is natural to think that they do more innovation than in other industries.

Also, we are interested in the effect of the characteristics of industry on the probability of innovation. Especially, firms engaging in investment good industry are likely to more innovate than in material goods industry.

From the probability response curve (〈Fig. 1〉), we can conclude that investment good producing firms do more product innovation by 15-16% than others irrespective of their size measured by the magnitude of (log) employment.



(Fig. 1) Effects of INVEST on Predicted Probabilities: Product Innovation (with INVEST and without INVEST, Employment: logarithm value)

For measuring goodness of fit of binary choice model, there are several fit measures: McFadden's (1974) LRI, Ben-Akiva and Lerman (1985), Cramer (1999), Efron (1978), etc. (Greene, 2008) In this study, we used two chi-squared tests: Hosmer-Lemeshow (1989) and Andrews (1988).

The main idea is to compare the actual value to expected value by quantile group (EViews, 2007).

The null hypothesis is:

H_0 : There is no difference between actual and fitted value of dependent variable.

In this section, we use again 2008 cross-section data previously used for estimation

probit model.

From the results for goodness of fit test (〈Table 9〉), we cannot reject the hypothesis, and conclude the model provides sufficient fit to the data.

〈Table 10〉 Goodness of Fit Tests

Andrews and Hosmer-Lemeshow Tests						
Grouping based upon predicted risk (randomize ties)						
	Dep=0		Dep=1		Total	H-L
	Actual	Expect	Actual	Expect	Obs	Value
Total	1672	1671	1268	1269	2940	8.081
H-L Statistic			8.08	Prob. Chi-Sq(8)		0.426
Andrews Statistic			9.87	Prob. Chi-Sq(10)		0.452

〈Table 11〉 Expectation-Prediction Evaluation[5)]

	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
E(# of Dep=0)	1102.42	568.9	1671.31	950.88	721.12	1672
E(# of Dep=1)	569.58	699.1	1268.69	721.12	546.88	1268
Total Gain*	9.06	12.01	10.33			
Percent Gain**	21.01	21.11	21.06			
*Change in "% Correct" from default (constant probability) specification						
**Percent of incorrect (default) prediction corrected by equation						

The classification table (〈Table 10〉) shows that in terms of expectation of the number of Dep=1, about 21.06% improvement occurs in this probit model over linear probability model (LPM) model.

IV. Summary and Conclusion

According to Arrow hypothesis (1961), more competitive firms have more incentives to innovate due to strong pressure for competiton. As in Bertschek (1995), domestic

5) In general, the share of correct prediction among observation 1 is called sensitivity.

firms respond to inward FDI by producing more efficiently through product / process innovation.

From the analysis using KIS data of Korea, Korean firms do not respond significantly to inward FDI. We presented carefully the possibility of more monopolistic market structure as a cause of this empirical outcome.

According to inverted U hypothesis, moderate level of competition is good for productivity growth. Our conclusion points out that Korean economy is at the increasing portion of inverted U curve. This means the fact that Korea is relatively monopolistic or oligopolistic, so inward FDI has no significant effect on innovation through discipline doctrine. Aghion and Howitt (2009) points out that initially more productive firms are more responsive to the entry rate of new firms in viewpoint of market structure, so this can also give alternative explanation for our empirical outcome. Their argument implies that Korean firms are mostly unproductive, so do not respond to new competition by inward FDI. Bertschek (1995) used FDI measure as (industry FDI)/(industry sales+imports), so we should notice that there is some difference from our FDI measure. Notwithstanding, our finding may be that, contrary to Bertschek, Korean firms do not respond sensitively to FDI.

For future research, we can consider the following:

First, we can estimate panel probit model with maximum simulated likelihood (MSL) estimation of Berry, Levinsohn, and Pakes (1995). It is used in studies based on log-likelihoods that involve integrals that are expectations (Greene, 2008).

Second, we can estimate this model with random effects by GMM. Bertschek and Lechner (1998) uses this method for their original panel data. This methods offer some comparison with Butler-Moffit quadrature and simulation-based estimators.

Since, KIS data has a good quality in characteristics, more sophisticated methods may give us more rich information of innovating firms in Korea.

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김병우

서울대학교에서 경제학 학사 및 박사학위(학위논문: 전력시장의 시장지배력)를 취득하고 현재 충주대 교양과정부 전임강사로 재직중이다. 주요 연구분야는 경제성장론, 기술경제학, 응용 계량경제 등이며 경제학 일반 및 기술경제학 관련 교육과 연구에 기여하고 있다. AEJ 등의 논문실적이 있다.

〈Appendix1〉

Random Parameters Model: RATS Program

```
*
* SWAMY.PRG
* Manual Example 14.5
*
cal(panelobs=2) 2005
all 421//2008
open data kis18.rat
data(format=rats,org=cols)
*
* There's a new procedure which does the analysis below
* regression since it will be wiped out as a time-invariant variable
SET DUMMY = %IF(IP1+IP2+IP3=0,0,1)
SET INVDUMMY = %IF(INVEST>=0,1,0)
SET MATDUMMY = %IF(MATERIAL>=0,1,0)
SET LOGSALE = LOG(SALE)
SET LOGEMPLOY = LOG(EMPLOY)
*
*
sweep(GROUP=%INDIV(T),VAR=HETERO) 1 421
# DUMMY
# CONSTANT LOGSALE FDI1 INVDUMMY MATDUMMY LOGEMPLOY
display %beta
display %xx
```

〈Appendix2〉

Bertschek (1995) presents simple IO model for innovation behavior of firms. The

profit-maximizing problem of a domestic innovative firm:

$\Pi = p(Q, IP, FDI)Q - c(w, IP, IC)Q$

p: individual price

Q: output

c: marginal costs

If we apply total differenciation setting profit as zero,

$$d\Pi = (\partial p/\partial Q\, dQ + \partial p/\partial IP\, dIP + \partial p/\partial FDI\, dFDI)Q + pdQ + (\partial c/\partial w\, dw + \partial c/\partial IP\, dIP + \partial c/\partial IC\, dIC)Q = 0$$

Product process (IP) enhances product quality and allows the firm to set a higher price than otherwise. Inward FDI (FDI) increases the product supply of foreign firms and, decreases the price of domestic firm. IP increases costs of firms but, process innovation (IC), per se, decreases them.

She, then, derives the following comparative statics :

$$dIC / dFDI = \partial p/\partial FDI / \partial c/\partial IC > 0$$

$$dIP / dFDI = - \partial p/\partial FDI / [\partial p/\partial IP - \partial c/\partial IP] > 0$$

$$dIC / dQ = (p-c)/(\partial c/\partial IC\, Q) < 0$$

$$dIP / dQ = - (p-c)/[\partial p/\partial IP - \partial c/\partial IP] < 0$$

All the inequalities are from assumptions for the model.