Finance, Production Efficiency, and Growth: Evidence from the Korean Manufacturing Industries

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Numerous studies have focused on the development of financial market as a driving force in economic growth. We find that the provision of financial services enhances production efficiency, and thereby promotes economic growth. Applying the stochastic frontier production function approach to the panel data of the Korean regional manufacturing industries, we show that an increase in financial services is associated with the reduction in technical inefficiency. It implies that the supply of financial services is essential to economic growth. (*JEL* classification: C23, C24, O10, O18)

I. Introduction

Since Schumpeter (1911) argued that the development of the financial system promotes economic growth, numerous research has investigated the effect of finance on the economy. Goldsmith (1969), McKinnon (1973), and Shaw (1973) present the seminal works which establish the relationship between financial development and economic growth, and the new economic growth theorists revitalize the topic with emphasizing the role of financial development in economic growth.

While various empirical studies suggest a strong positive relation-

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ship between financial development and economic growth, there are controversies on identifying the channels of transmission from finance to growth. In a broad classification, researchers present two alternative hypotheses about the role of financial services for economic growth: one emphasizes the financial system as a lubricant for the engine of economic growth, and the other considers the importance of financial services in the production process.

The first hypothesis contends that the financial system stimulates economic growth by evaluating entrepreneurs, pooling resources, diversifying risk, and valuing the expected profits from innovative activities. In this respect, King and Levine (1993a), Bencivenga and Smith (1991), Pagano (1993), and Greenwood and Jovanovic (1990) clarify the theoretical nexus of finance and growth.

Most empirical researches investigate the cross-country evidence for the relationship between the development of financial markets and economic growth. Among them, King and Levine (1993b) find that some measures of financial development are closely related to the economic growth rate. Despite a growing body of cross-country evidence, empirical support is not strong enough to corroborate the significant role of financial development for economic growth. The scepticism mainly stems from the ambiguity about whether the causality runs from finance to economic growth or vice versa.[1]

The second hypothesis stresses a direct role of financial services in the production process. Researchers argue that financial deepening increases economic efficiency of a monetary economy compared with a barter economy. Monetary economy requires less labor and capital to be diverted into exchange-related activities instead of being used in production. Therefore, productive efficiency increases as labor and capital services are solely concentrated in production instead of being engaged in the special tasks required in a barter system. Friedman (1969), Lehvari and Patinkin (1968), and Bailey (1971) pioneered research on this line of argument.

To test for the second hypothesis, researchers regard the money stock or similar financial aggregates as an input in the production function and prove the importance of financial variables in the

[1]Barro and Sala-i-Martin (1995, p. 443) point out that, "It is unclear whether the relation between growth and financial sophistication isolates the effect of an exogenous improvement in the financial system on the growth rate, or in reverse, reflects the impact of good growth prospects on the incentive to develop financial sector."

production process. Estimating a production function with financial variables as an input, we can judge the role of finance from the significance and the magnitude of the estimates of financial variables.[2]

However, some critics argue that finance does not work directly in the production process like labor service and capital stock, but just enhances production efficiency by reducing transaction costs. For example, Moroney (1972) suggests that money can be treated as an economic innovation noticing that money should not be considered as an ordinary input of the firm's production. Money is instead a source of technological change that may be regarded as an external economy for each firm. He suggests that money is external in the sense that the creation of a generally accepted means of exchange is a matter over which the firm exerts no control. Yet money is clearly an innovation for which the firm is willing to pay. If financial deepening acts as a technological improvement in the production function, then poorly functioning financial system would become a constraint on the implementation of technological improvement in the production function.

DeLorme, Thompson, and Warren (1995) also claim that an increase in the money stock tends to render production efficient but not as a direct input to production. They show that an increase in the money stock reduces technical inefficiency using stochastic frontier production model. In this approach, they derive the technical inefficiency level over time from the stochastic frontier estimation, then regress the estimated technical inefficiency level on the M1 or M2 stocks.

The purpose of this paper is to analyze effects of an increased financial services on the improvement of production efficiency using a stochastic frontier production model. We follow the line of research investigating the direct role of financial services in the production process, but embrace the criticism of Moroney (1972), and DeLorme, Thompson, and Warren (1995). While DeLorme, Thompson, and Warren adopt the aggregate data in the U.S., we utilized the regional data in the Korean manufacturing industries.

[2]Among them, Sinai and Stokes (1972) estimate a Cobb-Douglas production function in which various aggregates of the money stock are included as an input. Nguyen (1986), Betancourt and Robles (1989), and Kahn and Ahmad (1985) also adopt the similar method and show that the financial service is a significant production factor.

Although there are various empirical studies which examine the association between finance and growth using the national level data, the studies investigating the association in the context of a regional data are rare. Among them, Samolyk (1994), and Jayaratne and Strahan (1996) exploit inter-state data within the U.S. The former demonstrates the existence of regional credit channel by which the bank performance in a certain region crucially affects regional economy. Because of asymmetric information inherent in the financial market, banks tend to provide funds to the firms within the region. The fund-demanders also face the financial restriction because higher costs are imposed on the funds outside the region. In this framework, regional financial markets affect the regional real performance in a serious manner. The latter investigates whether bank branch deregulation in the U.S. stimulates economic growth. It suggests that the changes in the banking system give rise to the changes in the growth path.

The main findings in this paper are: first, there is a wide range in technical inefficiencies in the manufacturing industries across regions; secondly, the more financial services are provided in a certain region, the less technical inefficiency occurs.

The result that financial markets play a role in increasing production efficiency can be regarded as an explanation on why the development of financial markets is essential to economic growth. Financial markets foster economic growth by helping firms to produce more efficiently. The development of financial market and an increase in the supply of financial service are necessary to improve production efficiency in a region. Despite rapid economic growth, the regional income disparities problem is frequently discussed in Korea. The empirical findings in this paper imply that more financial services should be channelled to underdeveloped regions to alleviate income inequality across regions.

II. The Model

This section presents a model to test for the hypothesis that the provision of financial services influences production efficiency. Although financial services should not be regarded as an input factor, it has an indirect effect on production. In this case, the traditional regression of the production function with a financial variable as one of the input factors is not valid. Instead, we design a two-step procedure following DeLorme, Thompson, and Warren (1995). First, we estimate measures of production inefficiency using stochastic frontier production function approach. Second, we regress the estimated production inefficiency level on measures of financial services to investigate whether an increase in financial services improves production efficiency.

The production function, by definition, specifies the maximum output level produced by given input levels. A typical production function is specified as follows:

$$y = f(x;\ \beta) + v, \tag{1}$$

where y is the output level; x is the production input vector; and β is the parameter vector. The unobserved error v is independently and identically distributed as $N(0,\ \sigma_v^2)$.

Using the least squares method, we can estimate the production function. The estimated function, however, does not show the maximum product level but the average product level, given input levels.

In a stochastic frontier framework, the basic specification is:

$$y = f(x;\ \beta) + v - u, \tag{2}$$

where u represents output loss due to technical inefficiency. The u is assumed to be an independent and identically distributed non-negative random variable.

Aigner, Lovell, and Schmidt (1977) assume that the u is distributed as one-sided half-normal or exponential distribution, independent of v. Various models can be set up depending upon the assumption about the stochastic distribution of u.[3] Once we assume the distribution of u, we can derive the probability density function of the composite error, $\varepsilon\ (= v - u)$ and obtain maximum likelihood estimates.

Assuming a Cobb-Douglas production function, we can specify a stochastic frontier function in region i at time t as follows:

$$y_{it} = e^{v_{it}} e^{-u_{it}} A L_{it}^{\beta_L} K_{it}^{\beta_K}, \quad i = 1, \cdots, N, \quad t = 1, \cdots, T, \tag{3}$$

[3]Pitt and Lee (1981) and Schmidt and Sickles (1984) consider the half-normal model where the mean of the frontier errors becomes zero. Stevenson (1980) generalizes the model to the truncated-normal model with the non-zero frontier errors.

where L stands for labor services; K denotes capital stock; and y is the output level. We assume the technical inefficiency term, u has a truncated normal distribution and the remaining error, v is distributed normally with mean zero and variance σ_v^2, independent of u. If there is no technical inefficiency, then u_{it} should be zero.

Equation (3) is reduced to:

$$\ln y_{it} = \ln A + \beta_L \ln L_{it} + \beta_K \ln K_{it} + \varepsilon_{it}, \tag{4}$$

where $\varepsilon_{it} = v_{it} - u_{it}$. Under the assumption about the distribution of ε, we can estimate equation (4) by the maximum likelihood method.

The inefficiency level u_{it} is estimated from the conditional distribution of the composite error. According to Jondrow *et al.* (1982), the conditional expectation of u is calculated as:

$$E(u|\varepsilon) = \frac{\sigma_u^2 \sigma_v^2}{\sigma^2} \left\{ \frac{\phi(\varepsilon \lambda / \sigma)}{1 - \Phi(\varepsilon \lambda / \sigma)} - \left(\frac{\varepsilon \lambda}{\sigma} \right) \right\}, \tag{5}$$

where $\varepsilon = v - u$, $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\lambda = \sigma_u / \sigma_v$. The $\phi(\cdot)$ and $\Phi(\cdot)$ are the standard normal density function and the corresponding distribution function, respectively.

Next, we test the hypothesis that financial services supplied in the region reduce the technical inefficiency level in production. The equation (6) is estimated to analyze whether and to what degree the technical inefficiency level is related to financial variables.

$$\widehat{u_{it}} = \alpha_0 + \alpha_1 \ln F_{it} + e_{it}, \tag{6}$$

where $\hat{u}$ stands for the estimated technical inefficiency, and F is a proxy variable for financial services.

We expect that the sign of α_1 is negative and statistically significant. It then implies that, the more financial services are supplied, the more efficient is the production.

III. Empirical Analysis

A. The Data

We construct a panel data set composed of 11 regions and 17 years from 1977 to 1993. Since regional capital stock and labor service in all industries are hardly obtained in Korea, we focus on the manufacturing industry only. The output level (*VA*) is real value-added and the capital stock (*K*) is the real amount of tangible fixed assets. The labor service input (*L*) is proxied by the number of workers regularly employed.[4] The data is constructed from various issues of *Report on Mining and Manufacturing Surveys*.

The main financial variable we focus on is the total loans (*LOAN*) made by commercial banks.[5] The credit data proxies the degree of financial development better than various monetary aggregates because it excludes the credit to the public sector. In some cases, we tried the ratio of the loans to gross regional product (*GRP*) or loans per worker. The loan data is derived from various issues of *Regional Financial Statistics* and gross regional product series is drawn from Koo (1996).

B. Empirical Results

We estimate a traditional specification of the production function containing a financial variable as an input. The value-added (log*VA*) is regressed on the labor service (log*L*), the capital stock (log*K*), and the loans outstanding (log*LOAN*). All variables are logarithm-transformed. To apply a fixed-effects model, the regional dummies are included in the estimation even if they are not reported in Table 1. It is noted that the finance elasticity is large and statistically significant. When we do not impose any restriction on the production function specification, the elasticity of output with respect to the financial variable is estimated to be 0.427 (See column (1) in Table 1) and statistically significant at the conventional level. It implies that an increase in loans by 1 percent increases the output by 0.427 percent.

The estimation results under the assumption of homogeneity of the production function are presented in column (2) of Table 1. However, an F test for the restriction of homogeneity is rejected at the 1 percent significance level, implying that the homogeneity property is not fulfilled in the Korean manufacturing industry.

Some critics argue that financial services do not work as a direct input in the production process and that it only helps firms to produce efficiently. To consider this, we estimated a stochastic frontier

[4]Work hours are not reported at the regional base. We implicitly assume that there is no difference in work hours per worker over time and across regions.

[5]The data for loans made by nonbank financial institutions is not available for the sample period.

TABLE 1

ESTIMATION RESULTS OF THE AVERAGE PRODUCTION FUNCTION

variables	(1) logVA	(2) log(VA/L)
logK	0.446*** (0.049)	
logL	0.446*** (0.073)	
logLOAN	0.427*** (0.044)	
log(K/L)		0.546*** (0.051)
log(LOAN/L)		0.427*** (0.049)
R^2	0.994	0.945

Notes: Standard errors are in parentheses.
*** stands for significance at the 1% level.
The coefficients in regional dummies are not reported.

production function. For the sake of comparison, the ordinary least squares estimation results of the production function including only the capital stock and labor services as production factors are presented in the first column of Table 2. The elasticity of output with respect to the capital is 0.764 while that with respect to labor is 0.313.[6]

We make two types of assumption about the distribution of technical inefficiency. Under the first assumption that technical inefficiency terms are drawn from a half-normal distribution, we present the maximum likelihood estimates in the second column of Table 2. The capital elasticity is estimated to be larger than that in the OLS case. We test for the presence of technical inefficiency according to Battese and Coelli (1988). The test is applied by the estimate of λ, the ratio of the variance of the technical inefficiency to statistical noise. We tested the null hypothesis of $\lambda=0$, that is, there is no technical inefficiency. Under the null hypothesis, the OLS

[6]These estimates are not unusual in case of the estimation of the Korean production function. Our estimates are a little larger than those reported by Pyo (1991). He found that the labor elasticity is 0.21 and the capital elasticity is 0.55 from the estimation of the aggregate production function in Korea.

TABLE 2

ESTIMATION RESULTS OF THE FRONTIER PRODUCTION FUNCTION

(dependent variable: log*VA*)

	(1) OLS	(2) ML half-normal	(3) ML truncated normal
constant	-0.347*** (0.139)	-0.901*** (0.256)	-0.254 (1.018)
log*L*	0.313*** (0.023)	0.213*** (0.045)	0.198 (0.144)
log*K*	0.764*** (0.022)	0.903*** (0.018)	0.873*** (0.044)
$\lambda\left(=\frac{\sigma_u^2}{\sigma_v^2}\right)$		3.967 (5.252)	7.937 (25.93)
σ_v^2		0.024*** (0.002)	0.024*** (0.004)
μ/σ_u			0.429*** (0.040)
LL	31.193	62.312	67.416

Notes: Standard errors are in parentheses.

*** denotes the significance at the 1% level.

LL: log-likelihood

estimators are the same as the ML estimators. The negative of twice the log-likelihood ratio has a chi-square distribution with the degree of freedom one. The test statistic is 62.238 and rejected at the 1 percent level. We can thus conclude that some degree of technical inefficiency is involved in the Korean manufacturing production.

We make another assumption that the distribution of technical inefficiency is truncated-normal. While the first moment is zero in the half-normal distribution case, the mean is not necessarily zero in this truncated normal distribution case.[7] The maximum likelihood estimation results are presented in the third column of Table 2. Overall, the estimates are not much different from those in the half-normal distribution case.

In the truncated normal model, the frontier errors can exist in

[7]The half-normal distribution is a special case of the truncated normal distribution.

the form of degeneration at a point μ, even if $\lambda=0$. Thus, to test for the existence of frontier errors, we have the null hypothesis of $\lambda=\mu=0$. The negative of twice the logarithm of the generalized-likelihood ratio has approximately chi-square distribution with the degree of freedom equal to two. The log-likelihood of the restricted model, in which $\lambda=\mu=0$, is 31.193 and that of the unrestricted model is 67.416. Then the log-likelihood ratio statistic is 72.445, rejecting the null hypothesis at the 1 percent level. It suggests that the hypothesis of non-existence of technical inefficiency is rejected in the case of truncated normal distribution.

To test which assumption about the distribution of technical inefficiency is more appropriate, we adopt the log-likelihood ratio test for the null hypothesis of $\mu=0$. The statistic, which is derived by doubling the difference between the log-likelihood in the half-normal case and that in the truncated normal case, is 10.208. The null hypothesis is rejected at the 1 percent level. Therefore, we conclude that the assumption of the truncated normal distribution is appropriate in the estimation of stochastic frontier production function in the Korean manufacturing industry. Hereafter, we report the results from the truncated normal distribution only.

We estimate the technical inefficiency level($\hat{u}$) over time in each region from equation (5). Table 3 shows the mean and standard deviation of the estimates of the technical inefficiency in each region. Technical efficiency measured by $\exp(-\hat{u})$ is the ratio of actual product to the potential product which can be produced if no technical inefficiency is involved, that is, $u=0$. Results in Table 3 indicate that there exists considerable size of technical inefficiency in each region. For example, in Seoul region, on average, the output loss from technical inefficiency is 2.0 percent of the amount which may be possibly produced if no technical inefficiency exists. It amounts to 98 billion won in 1985 price. It is also noted that the technical efficiency level differs widely across regions. Kyungbuk, the least efficient region, produces only 60 percent of the maximum product while Seoul produces 98 percent of its potential output.

We investigate whether financial development is related to production efficiency. The maintained hypothesis is that the development of financial market reduces the technical inefficiency. We measured the degree of the development of financial market with some proxies. The first one is the total real loans made by commercial

TABLE 3

AVERAGE TECHNICAL INEFFICIENCY AND EFFICIENCY IN EACH REGION

	technical inefficiency		technical efficiency	
region	mean	s.d.	mean	s.d.
Seoul	0.025	0.106	0.980	0.108
Pusan	0.181	0.117	0.839	0.102
Kyunggi	0.249	0.113	0.784	0.092
Kangwon	0.454	0.239	0.651	0.147
Chungbuk	0.278	0.173	0.767	0.123
Chungnam	0.244	0.131	0.789	0.099
Chonbuk	0.119	0.095	0.891	0.083
Chonnam	0.450	0.142	0.643	0.089
Kyungbuk	0.524	0.245	0.608	0.146
Kyungnam	0.413	0.145	0.668	0.095
Cheju	0.201	0.122	0.822	0.099

Notes: Technical inefficiency($\hat{u}$) is calculated by Jondrow *et al.* (1982).
Technical efficiency is measured by $\exp(-\hat{u})$.
s.d. is standard deviation.

banks. If financial services are proportional to the loans made, the total loans outstanding can be a reasonable proxy variable for financial development. To adjust the economic scale, we used the ratio of loans to gross regional product and loans per worker as well.[8]

We regressed the estimated technical inefficiency level on various financial variables. Table 4 reports three regression results. The estimates are not quite different between three cases. The coefficient in log(*LOAN*) is estimated to be -0.377 and statistically significant at the 1 percent level. It implies that an increase in bank loans by 1 percent reduces the technical inefficiency level by 0.377 percent. When we include the social overhead capital stock in the regression to test the robustness of our results, the loan variable is estimated to be -0.711 and statistically significant at the 5 percent level.[9] The ratio of loans to *GRP* and loans per worker also appear to play a

[8]The "financial depth" is measured by the value of financial assets to the total product in many studies, for example, King and Levine (1993b).

[9]Kim, Koo, and Lee (1999) show that the production inefficiency level is reduced as social overhead capital is accumulated.

TABLE 4

ESTIMATION RESULTS OF TECHNICAL INEFFICIENCY EQUATION

(dependent variable: $\log\hat{u}$)

independent variable	coefficient	R^2
(1) log(*LOAN*)	-0.377*** (0.103)	0.313
(2) log(*LOAN/GRP*)	-0.349*** (0.109)	0.305
(3) log(*LOAN/L*)	-0.250*** (0.080)	0.302

Notes: Standard errors are in parentheses.
The coefficients in regional dummies are not reported.
*** denotes the significance at the 1% level.

significant role in enhancing production efficiency. We therefore conclude that financial services are essential to increase production efficiency.

IV. Concluding Remarks

A lot of researches have focused on the development of financial markets as a driving force of economic growth. Most empirical supports for the association between financial development and economic growth are, however, based on the observed correlation between them, which does not necessarily imply a causal relationship.

To avoid the causality problem, the more research effort should be devoted to investigating how financial markets affect economic performance. While the existing literature mainly focuses on the impact of financial development on the efficiency of investment as well as investment volume, this paper examines whether the provision of financial services facilitates economic growth by enhancing production efficiency.

Previous empirical studies focusing on the role of financial services in the production process regard the money stock or similar financial aggregates as an input in the production function. We, however, adopt the rather convincing argument that finance does not work directly in the production process like labor service and capital stock, but just enhances production efficiency by reducing transaction costs.

Using the panel data of the Korean regional manufacturing industries, we derive the technical inefficiency level over time using stochastic frontier production model and regress the estimated technical inefficiency level on various financial variables. We find that production efficiency in a certain region is improved as the more financial services are supplied. It suggests that financial markets play a crucial role for economic growth, and that more financial service should be channelled into underdeveloped regions to provide a favorable environment to economic growth.

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