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TECHNICAL EFFICIENCY AND HUMAN CAPITAL IN CHINA'S PROVINCES

The purpose of this paper is to analyze technical efficiency of provinces in China and the ways the efficiency is affected by human capital factors using the stochastic frontier approach. The results of the study show that the Eastern region is the most efficient one as compared to the Western and Central region with average efficiency scores of 54.39%. The results also show that feminization, public investment in science and technology, and higher standard of living contribute to higher inefficiency level of the provinces in China. On the other hand, investment in education is positively related to efficiency level. Consequently, it is crucial to upgrade the education level of labour force, provide equal access to education irrespective of gender, and stabilize inflationary pressures as a result of higher standard of living to reduce inefficiency level of the provinces.

Keywords: *efficiency; human capital; stochastic frontier analysis.*
JEL classification: *E23, E24, O47.*

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ТЕХНІЧНА ПРОДУКТИВНІСТЬ І ЛЮДСЬКИЙ КАПІТАЛ У ПРОВІНЦІЯХ КИТАЮ

У статті проаналізовано технічну продуктивність провінцій Китаю і те, як продуктивність залежить від людського капіталу. Результати дослідження з використанням стохастичного граничного підходу показують, що східний регіон країни є найбільш ефективним у порівнянні із західною і центральною областями із середньою оцінкою продуктивності 54,39%. Результати також показують, що фемінізація, державні інвестиції в науку і технології і вищий рівень життя сприяють зростанню неефективної діяльності в провінціях Китаю. З іншого боку, інвестиції в освіту позитивно впливають на загальну продуктивність. Отже, дуже важливо підвищити рівень освіти робочої сили, забезпечити рівний доступ до освіти незалежно від статі і стабілізувати інфляційний тиск як результат більш високого рівня життя в цілях зменшення неефективності діяльності провінцій.

Ключові слова: *продуктивність, людський капітал, стохастичний граничний аналіз.*
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ТЕХНИЧЕСКАЯ ПРОИЗВОДИТЕЛЬНОСТЬ И ЧЕЛОВЕЧЕСКИЙ КАПИТАЛ В ПРОВИНЦИЯХ КИТАЯ

В статье проанализирована техническая производительность провинций Китая и то, как производительность зависит от фактора человеческого капитала. Результаты исследования с использованием стохастического граничного подхода показывают, что восточный регион страны является наиболее эффективным по сравнению с западной и центральной областями со средней оценкой производительности 54,39%. Результаты также показывают, что феминизация, государственные инвестиции в науку и технологии и более высокий уровень жизни способствуют росту неэффективной деятельности в провинциях Китая. С другой стороны, инвестиции в образование положительно влияют на общую производительность. Следовательно, очень важно

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повысить уровень образования рабочей силы, обеспечить равный доступ к образованию независимо от пола и стабилизировать инфляционное давление как результат более высокого уровня жизни в целях уменьшения неэффективности деятельности провинций.
Ключевые слова: *производительность, человеческий капитал, стохастический граничный анализ.*

1. Introduction. Chinese economy had undergone transformation since 1978 from a closed-economy system to market-oriented economy. The reform has led to spectacular economic performance with an average growth of 9% in real gross domestic product (GDP) for the past decade. According to Gravier-Rymaszewska, Tyrowicz and Kochanowicz (2010), the key success factor of Chinese economy lies in the progressive openness in terms of trade and foreign direct investment. The reform has been further accelerated with China's accession to World Trade Organization (WTO). Nevertheless, in order to guarantee the long-term growth and economic development in China, one could not ignore the importance of human capital development. Therefore, this paper aims to analyze the effects of human capital on the economic efficiency of Chinese provinces.

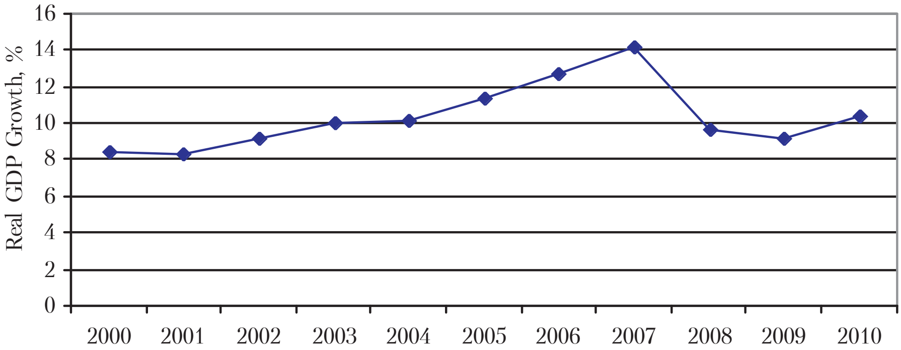
The study of economic efficiency is important because economic development of a country not only depends on economic growth but also on the efficiency in allocation of resources in the economy as a whole. On the other hand, the study on human capital as human capital investment is considered as a key factor in enhancing output growth (Mankiw, Romer and Weil, 1992; Barro and Lee, 2001). In addition, Lucas (1988) shows that investment in human capital induced labour to become more productive and provide the impetus for technological change and innovation which contributes to higher growth of output.

This paper contributes to the literatures on efficiency of China's provinces in 2 ways. First, we estimate the efficiency of the provinces by using the parametric stochastic frontier analysis (SFA) approach. Second, the paper also analyzed human capital's contribution to the province's efficiency by including various measures of human capital factors such as the degree of feminization, public investment in science and technology, and public investment in education.

The rest of the paper is organized as follows. Section 2 provides some background on the economic conditions in China. Section 3 reviews the literatures on provinces efficiency in China. Section 4 discusses the methodology and data. Section 5 presents and discusses the empirical results. Finally, section 6 concludes.

2. Overview of Chinese economy. Chinese economy maintained a steady growth rates between 8% to as high as 14.2% for the period 2000 to 2007 (Figure 1). The growth rate declined in 2008 to 9.6% and to 9.4% in 2009 mainly due to the global financial crisis. However, due to strong economic fundamentals, China was still able to maintain high growth rates of above 9% during the global financial crisis.

Besides the high growth rates with average of 10% since 2000, the government expenditure on education as % of total gross domestic product (GDP) had also increased steadily from 1.84% in 2005 to 2.98% in 2009 based on the data obtained from Euromonitor International database. This shows the importance of human capital development in the country for promoting long-term economic growth and development.



Source: Euromonitor International Database.

Figure 1. **Real Gross Domestic Product growth in PRC, 2000–2009**

3. Literature Review. Studies on the efficiency of provinces in China started with Fleisher and Chen (1997). They examined the determinants of total factor productivity (TFP) and it decompositions using the non-parametric approach. They found that foreign direct investment and investment in higher education contributed to the growth of TFP in the coastal region causing the inequality among regions. Since then, the studies on efficiency of provinces in China have widely been done using the TFP method (Ezaki and Sun, 1999; Wu, 2000; Zheng and Hu, 2006; Li, Liu and Yun, 2007; Yu, 2008; Yu, 2009; Zhang, 2009; He, Zhou and Zhou, 2009; Fleisher, Li and Zhao, 2010; Heshmati and Kumbhakar, 2011). The plethora of studies on efficiency of the provinces since the 1990s suggests its importance for Chinese economy.

Ezaki and Sun (1999), Fleisher and Chen (1997) and Unel and Zabregs (2006) studied the TFP in China at the national, regional and provincial levels. Their results suggested that the share of capital contribute significantly to explaining TFP growth at the national, regional and provincial levels. They also found that increase in foreign direct investment and human capital development contributes to the productivity increase in China. In addition, Unel and Zabregs (2006) also found that larger inflow of foreign direct investment leads to increase in TFP in the coastal region. Li et al. (2007) by using stochastic frontier approach (SFA) for the period from 1984 to 2004 also found similar results suggesting that physical capital is the most important determinant of Chinese economic growth during the post-reform period.

Similarly, Yu (2009) also used SFA to estimate the provincial productivity and examine the impact of human capital, road density, railways, degree of openness, percentage of urban population, size of state-owned enterprises, government size and region-specific factors on Chinese productivity growth. He found that higher level of human capital, higher engagement in international trade and relaxation of the hukou system contributes to higher efficiency level of the provinces in China. This result supports the earlier study by Yu (2008) where openness is found to be positively related to TFP growth, efficiency improvement and technological progress. He also found that coastal provinces are more efficient in production as compared to the Central and Western regions.

Fleisher, Li and Zhao (2010) analyzed the effects of human capital, infrastructure capital and foreign direct investment on regional inequality and economic growth in China for the period 1988 to 2003. They found that human capital is positively related to productivity growth of the provinces. In addition, they found that investment in human capital contributes to higher returns in the coastal region.

Using the data on 30 provinces in China from 1993 to 2003, Hesmati and Kunbhakar (2011) estimated the TFP growth and its decomposition. Their results suggested that investment in information and communication technology (ICT) and foreign direct investment are negatively related to technological change. On the other hand, human capital and economic reform are found to be positively related to the change in technological progress.

The studies mentioned above found strong differences in productivity among the provinces in China. In addition, investment in both physical and human capital is important in boosting the TFP growth in Chinese's economy. Nevertheless, the studies on the effect of human capital are not comprehensive enough. This paper further disaggregated the components of human capital and analyzed its effect on economic efficiency of the provinces. Furthermore, most studies focused on TFP growth. Our study used the SFA methods to analyze the ability of China's provinces in using their capital and labour inputs to maximize the provincial's real gross regional product (GRP).

4. Methodology and Data.

4.1. Methodology. The parametric approach to estimate the technical inefficiency using stochastic frontier approach (SFA) was first proposed by Aigner, Lovell and Schmidt (1977), Meeusen and van den Broeck (1977). The estimation of the SFA involves imposing an explicit functional form and distribution into the production function. The general equation for the SFA in estimating the provinces' efficiency is given as follows:

$$Y_{it} = \exp(x_{it}\beta + V_{it} - U_{it}), \quad i = 1,2,\ldots,N, \quad t = 1,2,\ldots,T, \tag{1}$$

where Y_{it} is defined as the output for ith province at time t; x_{it} is the (1 x k) input vectors for ith province at time t; V_{it} is the error component of random disturbances which is assumed to be independent and identically distributed (i.i.d) with $N(0,\sigma^2)$ and U_{it} is the measure of technical inefficiency and represents the non-negative truncated normal random error with probability distribution $N(\mu,\sigma_u^2)$.

This study uses Battese and Coelli (1992) and Battese and Coelli (1995) to incorporate the time-varying inefficiencies and factors that contributes to inefficiency in the provinces' production function. The Battese and Coelli (1992) specification is presented in Equation (2):

$$U_{it} = \{\exp[-\eta(t-T)]\}u_i, \tag{2}$$

where η is the parameter to be estimated and it will determine whether inefficiencies are time-varying or time-invariant; U_{it} is assumed to be i.i.d with truncations at zero of the $N(u,\sigma_u^2)$ distribution. In this context, if exp[$-\eta(t - T)$ > 1 technical inefficiency of the provinces is said to decline over time. If $\eta > 0$, $-\eta(t - T) = \eta(T - t)$ is positive for $t < T$. If $\eta < 0$, then $-\eta(t - T) < 0$, hence, technical inefficiency is said to increase over time. Technical inefficiency remains constant if $\eta = 0$.

In determining the factors that contribute to technical inefficiency of the provinces in China, the Battese and Coelli (1995) model is employed. In this case, U_{it}

is truncated at zero of the normal distribution of $N(z_{it}\delta,\sigma_u^2)$, where z_{it} represents the explanatory variables that could further explain the inefficiency of the provinces over time and δ is a (m x 1) vector of unknown coefficients to be estimated. The technical inefficiency effect in (1) is then being specified as follows:

$$U_{it} = zi_t\delta + W_{it}, \quad (3)$$

where W_{it} is truncation of the normal distribution with zero mean and variance, σ^2. U_{it} is the technical inefficiency and is to be independently distributed as transactions at zero of the $N(m_{it},\sigma_v^2)$ distribution.

This study employs the SFA based on the translog production function to estimate the technical efficiency of the provinces in China. The provinces efficiency is defined as the ability of the province to use its inputs of labour and capital to produce outputs measured by the provincial GRP. The translog specification is shown by Equation (4):

$$\begin{aligned}\ln Y_{it} &= \alpha_0 + \alpha_i \ln L_{it} + \alpha_j \ln K_{it} + \alpha_{LK} \ln L_{it} \ln K_{it} \\ &+ \frac{1}{2}\alpha_{LL}(\ln L_{it})^2 + \frac{1}{2}\alpha_{KK}(\ln K_{it})^2 + (V_{it} - U_{it}),\end{aligned} \quad (4)$$

where Y_{it} is the real provincial gross regional product (GRP) deflated by the GRP deflator with the based year 1995. The inputs vector is given by L_{it} and K_{it} which is measured by total employment and capital stock in real term in the provinces at time t respectively. The technical inefficiency effects are defined by (5):

$$\begin{aligned}U_{it} &= \delta_0 + \delta_1 Female_{it} + \delta_2 Science_{it} + \delta_3 Human_{it} + \delta_4 Teaching_{it} \\ &+ \delta_5 Engle_{it} + \delta_6 GRPcap_{it} + \delta_7 CPI_{it} + W_{it},\end{aligned} \quad (5)$$

where U_{it} – efficiency score for province i at time t; $Female_{it}$ – female to male ratio for province i at time t; $Science_{it}$ – total government spending in sciences and technology to GRP ratio for province i at time t; $Human_{it}$ – human capital represented by natural logarithms of secondary school enrolments for province i at time t; $Teaching_{it}$ – natural logarithm of the number of teaching staff in higher institutions and secondary school for province i at time t; $Engel_{it}$ – engel coefficient in percentage point for province i at time t; $GRPcap_{it}$ – natural logarithm of real GRP per capita for province i at time t; CPI_{it} – natural logarithm of consumer price index (CPI) for province i at time t.

Equation (5) is estimated using the maximum-likelihood estimation (MLE) method with the variance parameter of σ^2 and γ measures the total variation of the composed error term of $V_{it} - U_{it}$ and relative importance of the two errors. σ^2 is given by $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}$.

4.2. Data and definition of variables. The sample consists of 30 provinces over the time period of 31 years (1978 to 2008) with the total number of observations of 930. The balanced-panel data based on SFA Battese and Coelli (1992) and Battese and Coelli (1995) is utilized to estimate the efficiency scores for each province.

Following Halkos and Tzeremes (2009), the technical inefficiency for each province is estimated based on production function comprising of two inputs and one output. The inputs uses are the total number of employed persons and capital stock calculated using Equation (6) and then deflated using the GRP deflator (1995 = 100).

$$K_t = (1-\delta)K_{t-1} + I_t, \quad (6)$$

where K is the capital stock; I is the investment measures by gross capital formation; δ is the depreciation rates and t is used to represent the time period. The depreciation rate of 4% is used basing on the study by Zheng and Hu (2006).

Table 1 presents the descriptive statistics for the output and inputs use for the period 1978 to 2008. The average output produced by each province is about 148.89 bln. yuan. The average real capital stock amounted to 137.95 bln. yuan for each province. The total employed persons in each province are 18.331 mln. The standard deviation reported are relatively high for all the output and inputs vectors indicating that over the years there is a high variation in the gross regional product, capital stock and total employed persons for each province.

Table 1. **Descriptive statistics of inputs and output vectors**

	Real Gross Regional Product (mln. yuan)	Real Capital Stock (mln. yuan)	Total employed persons (1,000 persons)
Mean	148891.91	137952.59	18331.27
Standard Deviation	151483.46	196004.88	13633.00
Minimum	2650.73	417.78	930.90
Maximum	1294345.64	1577365.36	61876.00
Count	930	930	930

This study aims to determine the effect of human capital on China province's technical inefficiency. The explanatory variables included in this study are ratio of female to male, public investment in science and technology, public investment in education and total enrolment in secondary education.

The ratio of female to male is used to measure the extent of feminization of the provinces' contributions to the provinces' economy. Public investment in science and technology is believed to enhance the productivity of provinces. Likewise, public investment in education is also believed to exhibit a positive relationship with the province efficiency level as it allows the region to produce educated and skills labour in enhancing the productivity level. Investment in education is measured by the total number of teaching staff in higher education and secondary schools. On the other hand, total enrolment in secondary education is used to measure the contribution of human capital on efficiency.

In addition, Engel coefficient, GRP per capita and CPI are included as independent variables to control for the standard of living, economic growth and inflation which could affect the efficiency level of an economy. All the data are extracted from the China Compendium of Statistics 1949–2008 published by Department of Comprehensive Statistics, National Bureau of Statistics (2009).

5. Results and Discussion.

5.1. Estimated Technical Efficiency Scores. Table 2 presents the average efficiency scores of all 30 provinces in China for the period 1978 to 2008. We can see there that the Eastern region is the most efficient as compared to the Western and Central ones with the reported average efficiency scores of 54.39%, although the region on average experienced inputs waste of 45.61%. Furthermore, the top 5 most efficient provinces are located in the Eastern region, namely Hebei, Hainan, Shanghai, Beijing and Tianjin. As pointed out by Cai, Wang and Du (2002) the opening-up policy which is confined to the coastal region resulted in advancement in industrial structure, hence contributing to the region's higher efficiency level. The results are consistent with the studies by Tong (1997), Yang (2002), Unel and Zebreg (2006) and Bian and Yang (2010).

Table 2. **Average efficiency scores of provinces in China, 1978 to 2008**

Province	Efficiency Score
East	
Beijing	0.7278
Fujian	0.4357
Guangdong	0.3952
Hainan	0.8060
Hebei	0.9387
Jiangsu	0.2751
Liaoning	0.3574
Shandong	0.2316
Shanghai	0.7600
Tianjin	0.6072
Zhejiang	0.4478
Average Efficiency Scores	0.5439
Central	
Anhui	0.1951
Guangxi Zhuang	0.2096
Heilongjiang	0.3639
Henan	0.1670
Hubei	0.3815
Hunan	0.1824
Inner Mongolia Autonomous	0.3389
Jiangxi	0.2055
Jilin	0.3436
Shanxi	0.2808
Average Efficiency Scores	0.2668
West	
Chongqing	0.2241
Gansu	0.1886
Guizhou	0.1569
Ningxia Hui	0.4463
Qinghai	0.3874
Shaanxi	0.2194
Sichuan	0.1488
Xinjiang	0.4770
Yunnan	0.2038
Average Efficiency Scores	0.2725

On the other hand, in contrast with most studies on the provinces efficiency in China, the results found that the Western region is more efficient compared to the Central region. This might be due to the implementation of Western Development Region which started in 2001. The Chinese Academy of Social Sciences (2011) Annual Report on Economic Development in Western Region of China reported that growth rates in the Western region have increases steadily since 2006 as most of the provinces are rich on agricultural resources. Besides, the region has also been reported to have higher GDP growth rates as compared to the Central and Eastern region.

5.2. Technical Efficiency and Human Capital Variables. First, the log-likelihood ratio test is conducted to determine the appropriateness of the production function as well as the existence of time-invariant effects and inefficiency effects. The results are presented in Table 3.

Table 3. **Log-likelihood ratio test for parameters in the stochastic frontier estimations**

Null Hypothesis	Log-likelihood	ч$^{2}_{0.95}$	Test Statistics
$H_0: \gamma = \delta_0 = \delta_1 = \ldots = \delta_7 = 0$	-489.375	15.51	711.414**
$H_0: \gamma = 0$	-160.718	3.84	27.05**
$H_0: \delta_0 = \delta_1 = \ldots = \delta_7 = 0$	-67.010	14.07	133.316**
$H_0: \eta = 0$	-67.010	3.84	97.228**

The first null hypothesis of $H_0: \gamma = \delta_0 = \delta_1 = \ldots = \delta_7 = 0$ is used to test the existence of inefficiency effect in the model. The null hypothesis is rejected at the 5% significance level indicating that the inefficiency effects are appropriate. The second null hypothesis of $H_0: \gamma = 0$ is rejected at the 5% significance level indicating that the inefficiency effects are stochastic in nature. The third null hypothesis of $H_0: \delta_0 = \delta_1 = \ldots = \delta_7 = 0$ is used to test for the appropriateness of the Battese and Coelli (1995) model against the normal translog model. The results shows that the explanatory variables used in this model are significant in explaining the inefficiency effects. Finally, the fourth null hypothesis of $H_0: \eta = 0$ is rejected indicating the presence of time-invariant factors in the inefficiency model. All the results of the likelihood ratio indicate the appropriateness of the Battese and Coelli (1995) model to estimate the efficiency scores with the inclusion of inefficiency effects is appropriate.

Table 4 presents the maximum likelihood estimates of the stochastic production frontier of the provinces in China. Model 1 refers to the normal translog specification estimated based on Equation (4). Model 2 refers to the estimation of Battese and Coelli (1992) model which incorporate the time-varying inefficiencies and Model 3 presents the estimation based on Battese and Coelli (1995) model to incorporate the factors that contribute to the inefficiency level of the provinces. The estimate of the variance parameter of γ is close to the one indicating that the inefficiency effects are able to explain the total variation in the models estimated.

Table 4. **Maximum likelihood estimates of production efficiency with human capital variables**

	Model 1	**Model 2**	**Model 3**
Variable	**Coefficient**	**Coefficient**	**Coefficient**
Constant	-18.134 (2.732) [-8.344}***	-33.224 (4.677) [-7.104]***	3.605 (2.833 [1.273]
$\ln L_{it}$	2.344 (0.321) [7.304]***	1.360 (0.333) [4.088]***	0.284 (0.249) [1.140]
$\ln K_{it}$	0.229 (0.526) [0.436]	4.001 (0.843) [4.745]***	1.744 (0.315) [5.527]***
$\ln L_{it} \ln K_{it}$	-0.048 (0.022) [-2.214]**	-0.026 (0.025) [-1.041]	-0.140 (0.014) [-10.289]***

The end of *Table 4*

	Model 1	Model 2	Model 3
Variable	Coefficient	Coefficient	Coefficient
$(\ln L_{it})^2$	0.060 (0.027) [2.191]**	-0.012 (0.009) [-1.473]	0.071 (0.015) [4.846]***
$(\ln K_{it})^2$	-0.023 (0.008) [-3.052]***	-0.080 (0.040) [-2.000]**	0.045 (0.006) [7.134]***
Province-specific correlates			
Constant			9.623 (0.458) [20.991]***
Female			1.671 (0.3885) [4.302]***
Science			6.912 (0.753) [9.178]***
Human			0.010 (0.022) [0.441]
Teaching			-0.175 (0.032) [-5.533]***
Engel			-1.215 (0.164) [-7.398]***
GRP cap			-0.629 (0.018) [-34.988]***
CPI			0.019 (0.032) [0.605]
σ^2	0.331 (0.032) [10.432]***	0.273 (0.064) [4.231]***	0.039 (0.002) [21.416]***
γ	0.871 (0.013) [66.991]***	0.861 (0.027) [31.421]***	0.998 (0.031) [31.926]***
μ	1.074 (0.137) [7.868]***	0.969 (0.145) [6.698]***	
η		0.012 (0.001) [10.505]***	
λ			
Log likelihood	-67.010	-115.624	133.668

*Notes:*significance at 10%, ** significance at 5 % level, *** significance at 1% level.*
Standard errors in parentheses and z-statistics in [ ].

Results from Model 2 illustrate that Eta (η) is positive and significant at the 1% significance level. This revealed that the inefficiency level of the provinces in China is decreasing overtime.

The effects of human factor explained by feminization are found to have positive relationship with the inefficiency level of the provinces. This means that the higher the domination of female is the higher will be the inefficiency level of the province. This is supported by Boserup (1970) who suggested that women were not being treated equally in their access to new technologies and education and hence contribute to lower women's productivity resulting in lower efficiency level. Similarly, Pampel and Tanaka (1986), Hill and King (1995), Ranis, Stewart, and Ramirez, (2000) and Knowles et al. (2002) also found that women may negatively affect economic growth because of the gender educational differences.

Engel coefficient is significant and negative suggesting that higher Engel coefficient contributes to lower inefficiency level. A higher Engel coefficient indicates a lower standard of living in the province. This might lead workers to devote more time to working to increase their standards of living. This eventually increases the availability of labour at low cost and leads to increases in employment and output level of the economy. Low labour cost may also help in capital accumulation and technology advancement as entrepreneurs shift their money usage from wages to capital accumulation. Consequently, this leads to increase in the efficiency level (Meade, 1967).

Public investment in science and technology creates adverse effect on the province efficiency level. This is consistent with the study by Hesmatti and Kumbhakar (2011) who found that investment in technology creates negative effects to technological change in the total factor productivity in China. Hornstein and Krusell (1996) highlighted that negative relationship could be expected with the economic efficiency because adoption of new capital required time to reorganize management and workplace as well as to acquire new knowledge. Besides, the change in technology will also lead to more resources to be allocated to new capital. This may result in an initial productivity level of the economy below their optimal level. This is supported by Greenwood and Yorukoglu (1996) and Gust and Marquez (2004). Hence, a longer time-span may be required to realize the potential gain in economic efficiency resulting from investment in science and technology.

On the other hand, public investment in education by increasing the number of teaching staff in higher education and secondary schools lowers the inefficiency level of the province. According to Mankiw et al. (1992) and Barro and Lee (2001) investment in education enhanced the productivity of the provinces and thus resulted in higher efficiency level of the provinces. This is consistent with the study by Fleisher and Chen (1997), Li et al. (2008), Yu (2009) and Fleisher et al. (2010). Increase in the gross regional product per capita is found to lower the inefficiency level of the provinces. Higher per capita income of the provinces shows that the province operates in a matured and stable economic environment and this enhances the province's efficiency level.

6. Conclusion. The purpose of this paper is to analyze technical efficiency of provinces in China and the way it is affected by human capital factors using the stochastic frontier approach developed by Battese and Coelli (1995). The results of the study show that the Eastern region is the most efficient one as compared to the Western and Central regions with the reported average efficiency scores of 54.39%. This might due to the reason that most of the opening-up policy is confined to this region (Cai et al., 2002). The results are consistent with the study by Tong (1997), Yang (2002), Unel and Zebreg (2006) and Bian and Yang (2010). In contrast with the previous studies on the provinces' efficiency in China, the results suggest that Western region is more efficient as compared to the Central one. This might be due to the results of the implementation of Western Development Region in 2001.

The results also show that feminization, public investment in science and technology and higher standards of living contribute to higher inefficiency level of the provinces in China. According to Boserup (1970), the fact that women may not be treated equally in terms of access to new knowledge had resulted in lower productivity and efficiency levels. The result is consistent with Hill and King (1995), Ranis, Stewart, and Ramirez, (2000) and Knowles, Lorgelly and Owen (2002) studies.

On the other hand, negative effects of the public investment in science and technology might be due to the fact that it requires a relatively longer time-span to realize the efficiency gains from investments in new capital and technology. This is consistent with the findings of Hornstein and Krusell (1996), Cooley, Greenwood and Yorukoglu (1997) and Gust and Marquez (2004). Consistent with the growth theory, investment in education helps to increase the efficiency level of the provinces in China. This supports the study of Fleisher and Chen (1997), Li et al. (2008), Yu (2009) and Fleisher et al. (2010).

Consequently, it is crucial to upgrade the education level of labour force in the provinces and provides equal access to education irrespective of gender. This is crucial as the population of women has been increasing steadily in the past 3 decades. In addition, Chinese government needs to find ways to stabilize inflationary pressures as a result from higher standards of living to reduce the inefficiency level of the provinces.

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