COMPARATIVE EFFICIENCY MEASUREMENT OF TURKISH AND CHINESE MANUFACTURING FIRMS

Nizamettin Bayyurt,

Gokhan Duzu

Fatih University, TURKEY

Abstract

In this paper, the efficiencies of manufacturing companies of China, one of the countries (BRIC: Brazil, Russia, India, China) that are expected to dominate the world economy in 2050s, and Turkey, that is an attracting emerging market[1] with great potential, will be compared. Namely it will be determined the relative performance of Turkish and Chinese manufacturing firms using weight restricted Data Envelopment Analysis (DEA). Weights of inputs and outputs are estimated by canonical correlation analysis. Mean efficiencies of the firms of the two countries are compared by t-test. The result of DEA and statistical analyses indicate that Chinese manufacturing firms are highly efficient than Turkish manufacturing firms on average.

Keywords: DEA, CCA, Manufacturing, Turkey & China

Introduction

According to The Global Competitiveness Index (GCI) which assesses countries' overall competitiveness, China is 34th and Turkey's rank is 53rd out of 131 economies in the world in 2007-2008. The ranks of the two countries were 35th and 58th in 2006-2007 respectively [2].

In a survey called International Business Report conducted by Grant Thornton International Company in 2006, concerning growth, profit and expectations of manufacturing companies for the next 12 months, Turkish and Chinese manufacturers have the same level of confidence for future outlook. Turkey is %78 optimistic and China is %80. Below is the table that shows the expectation of business in the manufacturing sector.

[1] Morgan Stanley Emerging Markets Index, 2006

[2] The Global Competitiveness Report, 2005-2006.

Table 1: Businesses' Expectations of China and Turkey in Manufacturing Sector

	Increase (%)		Decrease (%)		Remain the same (%)	
	Turkey	China	Turkey	China	Turkey	China
Turnover/revenue	62	78	12	3	23	19
Selling prices	37	25	13	25	47	49
Exports	43	38	7	6	20	17
Employment	47	48	10	9	42	42
Profitability	35	63	22	19	42	17
Investment in new building	17	71	12	3	50	23
Investment in plant & machinery	50	67	7	4	33	23

Source: Grant Thornton International Business Report Survey, 2006

Table 1 displays that Chinese manufacturers have a higher expectation rate to increase of revenue, profitability, employment and investment in plant, new building and machinery than Turkish manufacturers while Turkish manufacturers expects their exports and selling prices to increase. The table also shows the portion of expectations that are foreseen "decrease or remain the same" by manufacturers.

Below, the table 2 compares two countries' share of manufacturing as percentage of GDP and annual growth. The share of manufacturing is approximately one third of GDP in China in the last three years, and has grown about 10 % every year. In Turkey, the share of manufacturing is about 14 % of GDP and has grown 12 % on average in the last three years.

Table 2: Share of manufacturing as percentage of GDP and annual growth:

	Value Added (% of GDP)			Value Added (annual % growth)		
	2004	2005	2006	2004	2005	2006
China	32	33	31	9	12	8
Turkey	14	14	NA	10	6	20

Source: World Development Indicators Database[3]

When Turkey and China are considered individually looking at expectations of manufacturing sectors; manufacturers of both countries mostly see the cost of raw materials as a pressure on profit margins[4].

As everyone knows China is frightening the sectors in other countries that compete in the same industry. According to Grant Thornton Survey (2006) again, 50% of Turkish

3 http://devdata.worldbank.org/dataonline/

4 Grant Thornton International Business Report Survey, 2006

manufacturers expect no impact from Chinese economic boom while 35% think that it will have negative impact on their business.

Huang et al.[5] (2005) says about the processing trade, which means that importing components then process and export the final goods, in explaining why manufacturing sectors are competitive in developing countries. The enforcement of competition is an aspect of the business climate that is much debated in the context of development. Firms that have higher efficiencies have important competitive advantages. Since highly efficient firms are able to achieve more outputs with fewer resources; they are more productive, more profitable, and candidate of superior growth. The relationship between competition and efficiency incentive are described in many studies signifying how comparative performance may enhance efficiency incentives, disappointing productivity growth is related with poorly competitive environment (Okada, 2005, Sekkat 2007).[6]-[7]

Productivity growth compensates for price increases and enhances competitiveness. Its changes greatly influence the economic growth since any productivity gains increase the real income. Efficiency which is the ability of converting inputs to outputs, directly affects costs and consequently profits and capital investments (Neda and Sowlati, 2006). The future competitiveness of firms depends on success of improving efficiency and productivity besides developing new products, technologies, and markets; establishing closer ties with customers; and maintaining a skilled and flexible workforce.

This study compares the efficiencies of the two countries regarding manufacturing firms of the subjects. The procedure of the paper is as follows. First a brief description of the methods; Canonical Correlation Analysis (CCA) and Data Envelopment Analysis (DEA), which are used in the study, are given. CCA is utilized to find out the relations between inputs and outputs. Secondly, using the relations as weight restrictions given by CCA, DEA is applied to determine the relative efficiencies of Chinese and Turkish manufacturing firms. Finally, the average efficiency scores of Chinese and Turkish firms are compared by independent samples t-test whether there is a statistically significant difference.

1. Canonical Correlation

Canonical correlation analysis seeks to identify and quantify the associations between two sets of variables (Johnson, Wichern, 2002)[8]. It is the most general method that can be used for both metric and non-metric values of the sets Y (dependent-criterion) and X

5 Can Huang, Mingqian Zhang, Yanyun Zhao, Why the manufacturing sectors in developing countries can be competitive? The Evidence of China, China's Economics Annual Conference, 2005

6 *Yosuke Okada, Competition and productivity in Japanese manufacturing industries, Journal of the Japanese and International Economies, Volume 19, Issue 4, December 2005, Pages 586-616*

7 *Khalid Sekkat, http://idrinfo.idrc.ca/archive/corpdocs/124650/90152.doc, access; Jan. 2008*

8 Johnson, Richard A., Dean W. Wichern, Applied Multivariate Statistical Analysis, Prentice Hall, 2002, pp.543

(independent-predictor) (Hair et. al. 1998)[9]. Moreover, it is the strongest and the most appropriate technique that can be applied when the number of variables in the dependent set is more than one. While canonical correlation is used for explaining the relation between dependent and independent variables, it explains not only which independent variable has an effect on which dependent variable but also which independent variable has a higher effect on which dependent variables (Levine, 1977:6)[10]. The formula can be shown as follows:

$$u = \sum a_i x_i \;, \quad v = \sum b_i y_i$$

Canonical variates u *and* v are linear composites of the variables of independent and dependent sets respectively. a_i *and* b_i, that are called canonical coefficients of the variates are found by maximixing the correlation between u *and* v under some constraints given below.

$$Max\,Kor(u,v) = \frac{Kov(u,v)}{\left[\mathrm{var}(u)\,\mathrm{var}(v)\right]^{1/2}} = \frac{a'\Sigma_{12}\,b}{\sqrt{a'\Sigma_{11}\,a}\,\sqrt{b'\Sigma_{22}\,b}} = \frac{Kov(u,v)}{(1\;\;1)^{1/2}}$$

$$= Kov(u,v) = a'\Sigma_{12}b = r$$

s.t.

$$s^2{}_u = a'\Sigma_{11}a = 1$$

$$s^2{}_v = b'\Sigma_{22}b = 1$$

Optimums of the function can be found by means of Lagrange Multipliers l_1 and l_2. $L = a'\Sigma_{12}g - \frac{1}{2}l_1(a'\Sigma_{11}a - 1) - \frac{1}{2}l_2(b'\Sigma_{22}b - 1)$

$$\frac{\partial L}{\partial a} = \Sigma_{12}b - l_1\Sigma_{11}a = 0$$

$$\frac{\partial L}{\partial b} = \Sigma_{21}a - l_2\Sigma_{22}b = 0$$

The solution of these partial differentials results an eigenvalue problem and solution of that problem will give r^2. The vectors a and b can be obtained from the equations by substituting r^2.These vectors are canonical coefficients that maximize the correlation between the linear combinations of the variables.

9 Hair, Anderson, Tatham, Black, Multivariate Data Analysis, Prentice Hall, 1998, pp. 443
10 Levine, M. S., Canonical Analysis and Factor Comparison, Sage Publications, 1977, pp.6

2. Data Envelopment Analysis

Data envelopment analysis (DEA) is a powerful tool for evaluating and improving the performance of organizations. It has a wide range of application in performance evaluation and benchmarking of hospitals, banks, schools, manufacturing plants, non profit organizations, etc.(Charnes et al., 1994). [11]

DEA is a multi-factor productivity analysis model for measuring the relative efficiencies of a homogenous set of decision making units (DMUs). The efficiency score in the presence of multiple input and output factors is defined as:

$$\text{Efficiency} = \frac{\text{weighted sum of outputs}}{\text{weighted sum of inputs}}$$

Assuming that there are n DMUs, each with m inputs and s outputs, the relative efficiency score of a test DMU p is obtained by solving the following model proposed by Charnes et al. (1978):

$$Max \ \frac{\sum_{k=1}^{s} v_k y_{kp}}{\sum_{j=1}^{m} u_j x_{jp}}$$

s.t

$$\sum_{k=1}^{s} v_k y_{ki} / \sum_{j=1}^{m} u_k x_{ji} \le 1; \quad \forall i$$

$$v_k, u_j \ge 0; \quad \forall k, j$$

Where

k = 1 to s, j = 1 to m, i = 1 to n,

y_{ki} = amount of output k produced by DMU i, x_{ji} = amount of input j utilized by DMU i,

v_k = weight given to output k, u_j = weight given to input j

The fractional program given above can be converted to a standard linear program:

$$Max \sum_{k=1}^{s} v_k y_{kp}$$

s.t

$$\sum_{j=1}^{m} u_j x_{jp} = 1$$

$$\sum_{k=1}^{s} v_k y_{ki} - \sum_{j=1}^{m} u_k x_{ji} \le 0 \qquad \forall i$$

[11] A. Charnes, W.W. Cooper, A.Y. Lewin and L.M. Seiford, Data envelopment analysis: Theory methodology and applications, Kluwer, Boston, 1994

$v_k, u_j \geq 0; \quad \forall k, j$

The above linear program is run n times for all DMUs in finding the relative efficiency score of each. Each DMU maximizes its efficiency score by selecting appropriate input and output weights. In general, a DMU is considered to be efficient if it's efficiency score is 1 and inefficient if it's efficient score is less than 1.

Weight Restrictions in DEA:
DEA allows for unrestricted weight flexibility in determining the efficiency scores of DMUs. This allows units to achieve relatively high efficiency scores by assigning inappropriate input and output weights. Weight restrictions permit for the integration of managerial preferences, expert opinions or prior knowledge in terms of relative importance levels of various inputs and outputs. Weight restrictions discriminate efficient and inefficient units effectively than unrestricted forms.
Some of the suggestions for weight restrictions are;
Absolute region: weights have upper and lower bounds.

$$A_i \leq v_i \leq B_i \quad ve \quad C_i \leq u_i \leq D_i$$

Assurance region: some relations between the ratios of two variables are known.

$$A \leq v_i / v_k \leq B \quad \Rightarrow \quad Av_k \leq v_i \leq Bv_k$$

$$C \leq u_i / u_k \leq D \quad \Rightarrow \quad Cu_k \leq u_i \leq Du_k$$

Cone ratio: a linear combination of variables is known

$$c_1 u_1 + c_2 u_2 + c_3 u_3 + \ldots\ldots + c_t u_t \geq 0$$

$$d_1 v_1 + d_2 v_2 + d_3 v_3 + \ldots\ldots + d_m v_m \geq 0$$

3. The Analysis

The firms included in this research are ISE (Istanbul Stock Exchange) and SSE (Shenzhen Stock Exchange) trade manufacturing companies in 2006 and 2005. Data was collected from CorporateInformation.com. This site holds "Best of the Web" recognition from FORBES Magazine. BARRON's Magazine featured the site as one of the best sources of company information for investors. This site is also one of the few sources in the world for English language reports on many companies in Asia, Latin American and Eastern Europe that do not release their results in English. Data of 166 Chinese and 65 Turkish firms were gathered. After excluding the firms with missing values and as outliers at 5% level of significance by the test of Mahalanobis Distance, the sample for analysis was made up of 126 Chinese and 47 Turkish manufacturing firms.

In the study independent variables (inputs in DEA) are number of employees (NE), inventory turnover (IT), receivable turnover (RT), total asset/total debt (TATD; 1/leverage), cash flow (CF), current ratio (CR), and property plant & equipment/total asset (PLTS), and dependent variables (outputs in DEA) are net income per employee

(NIPE), growth in sales (GS), net income per share (NIPS) and ebit margin (EM). Outputs of the paper evaluate firm performance in multidimensional aspects. Inputs are important determinants affecting firm performance.

IT: $\frac{\text{Cost of goods sold}}{(\text{Inventory at term beginning} + \text{Inventory at term end})/2}$ This ratio analyzes how many times the company's inventories have been sold in a year. A high value of this ratio reveals the profitability of the company.

RT: $\frac{\text{Net sales}}{\text{Short term receivables}}$ This ratio shows how many times the company is able to convert its short term receivables account into sales. In general, a high ratio and an upward trend indicate a good performance.

TATD: $\frac{\text{Total assets}}{\text{Total debt}}$ The value of this ratio shows the ability of the company's total assets to cover its total debt

CF: The sum of operating activities, financing activities and investing activities

CR: $\frac{\text{Total current assets}}{\text{Total current liabilities}}$ The value of this ratio shows the ability of the company's total current assets to cover its short term obligations

PLTS: $\frac{\text{Net property plant \& equipment}}{\text{Total assets}}$

GS: Percent change in sales

EM: Ebit margin shows the percentage of sales revenue that is left after all expenses have been removed, excluding net interest and income tax expenses. Ebit is calculated by taking the earnings before net interest has been deducted and before the income tax obligation on the earnings has been deducted.

Table 3: Canonical Correlations Section

	Canonical Correlation	R-Squared	F-Value	Num DF	Den DF	Prob Level	Wilks' Lambda
Turkey	0,820	0,672	3,04	28	131	0,000011	0,166
China	0,621	0,386	3,78	28	416	0,000000	0,442
Turkey&China	0,690	0,476	6,08	28	586	0,000000	0,399

- In the study canonical correlation was used to investigate the interrelationships between two variables sets: the criterion set includes performance factors (NIPE, GS, NIPS and EM) while the predictor set consists of variables (NE, IT, RT, TATD, CF, CR)

Table 3 displays the test statistics of canonical correlations of Turkish manufacturing industry, Chinese manufacturing industry one by one and together. Canonical correlations (R=0,82, R=0,621 and R=0,69) indicates a strong relationship between criterion and predictor variables. All the canonical correlations were found to be significant (p<0,00001) using Bartlett's chi-square test. Consequently, predictor variables are effective to explain (criterion variables) firm performance.

Table 4: Canonical loadings

	Turkey	China	Turkey & China
	U	**U**	**U**
NE	-0,203	0,581	-0,131
IT	-0,097	0,593	0,443
RT	-0,172	0,447	-0,006
TATD	0,776	0,142	0,715
CF	-0,192	0,719	0,387
CR	0,986	0,124	0,891
PLTS	0,052	0,112	-0,039
	V	**V**	**V**
NIPE	0,693	0,443	0,935
GS	-0,065	0,440	0,214
NIPS	0,248	0,765	0,745
EM	0,916	-0,101	0,684

The canonical loadings are shown in table 4. Canonical variable for the criterion set is a linear combination of the four performance variables (NIPE, GS, NIPS and EM). Canonical loadings show that EM has the highest correlation (0.916) with its variable and therefore is the most important variable and then NIPE (0,693) comes in their set for Turkey. NIPS is the most important variable (0,765) and then NIPE (0,443) and GS (0,44) come for China. When the analysis was applied to all the Turkish and Chinese firms jointly then the order of importance of the significant variables is NIPE (0,935), NIPS (0,745) and EM (0,684). NIPE>GS, NIPS>GS for all the three canonical loadings, and NIPE>NIPS, NIPE >EM, EM> GS and NIPS>EM for two of the loadings. As a result the rank of priority of variables can be as NIPE>NIPS>EM>GS. Loadings which are less than 0,40 assumed as not significant.

Canonical variable for the predictor set is a linear combination of the seven variables (NE, IT, RT, TATD, CF, CR, PLTS). Canonical loadings show that CR has the highest correlation (0.986) with its variable and therefore is the most important variable and then TATD (0,776) comes in its set for Turkey. CF is the most important variable (0,719) and then IT (0,593), NE (0,581) and RT (447) come for China. When the analysis was applied to all the Turkish and Chinese firms jointly then the order of importance of the variables is CR (0,891), TATD (0,715) and IT (0,443). When all the three canonical loadings are considered it can be revealed that IT>NE, CF>NE, IT>RT, TATD>PLTS, CR>PLTS, and for two of the loadings RT>NE, TATD>NE, CR>NE, PLTS>NE, IT>CF, TATD>IT, CR>IT, IT>PLTS, TATD>RT, CF>RT, CR>RT, RT>PLTS, TATD>CF, CR>TATD, CR>CF, CF>PLTS. As a result the rank of importance of variables can be as CR>TATD>IT>CF>RT>PLTS>NE

Consequently weighted restrictions which will be used in DEA are:
NIPE>NIPS>EM>GS
CR>TATD>IT>CF>RT>PLTS>NE

A constant return, input orientation DEA with assurance regions is applied to 173 manufacturing firms where 126 of them are from China and 47 are from Turkey. The mean efficiency of Chinese firms is 0,65 with a standard deviation of 0,15 and the mean efficiency of Turkish firms is 0,45 with a standard deviation of 0, 16. The means are compared by independent samples t-test. It is concluded that there is statistically significant difference between the mean efficiencies of Turkish and Chinese manufacturing firms. Chinese firms are 20 % on average more efficient than Turkish firms. The results are displayed in table 5.

Table 5: Comparison of efficiencies

Mean efficiencies

		N	Mean	Std. Deviation
Efficiency	China	126	0,65	0,15
	Turkey	47	0,45	0,16

Independent samples t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Efficiency	Equal variances assumed	0,23	0,63	7,57	1711	0,000	0,20	0,026	0,14	0,25

4. Conclusion

China has become important or dominant in several sectors, causing price collapses in some industries. It has several advantages, including labor cost, labor efficiency, cost of building factories, massive investments in new plant and equipment, large markets attracting local and foreign investment, the ability to carry out reforms, the ability to build and rebuild cities, world-leading infrastructure in some regions, and others (Enright, 2006)[12]. In addition to these, the result of the study has shown that China is more efficient in converting the resources to outputs than Turkey, when current ratio, total assets/total debt, inventory turnover, cash flow, receivable turnover, property plant & equipment/total asset, number of employees were used as the resources and net income per employee, net income per share, earnings before interest and taxes margin and growth in sales as outputs for firms.

Provided that we consider the efficiency scores of firms of the two countries, the rank of competitiveness by GCI of overall economies of Turkey and China among 131 economies is admissible in manufacturing industry. Chinese firms are more efficient and therefore more competitive than the Turkish ones concerning the utilized indicators in the study. The results of this study may affirm the negative expectations from Chinese economic boom on Turkish manufacturing industry based on the efficiencies of firms. Turkish manufacturing firms must evaluate their performance concerning competitors. For the inefficient firms the motivation for change is clear; your competitors are able to achieve similar outputs with fewer resources. DEA offers many opportunities for an inefficient firm to become efficient regarding its reference set of efficient units.

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