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The Effect of the 2007 Financial Crisis on the Information Technologies Sector: Application of Malmquist Productivity Index Method[1]

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ABSTRACT

The purpose of this paper is to investigate the effect of the 2007 financial crisis on the productivity of information technologies sector by applying Malmquist Productivity Index method. In the research, 20 enterprises operating in the information technologies sector in the list of Fortune 500 and their 6 years data are taken between the periods of 2005-2010. In the method, short and long term liabilities and shareholders' equity are used as inputs while total income and net profit are used as outputs. As a result, it is observed that productivity of information technologies sector decreased, each year in compare to previous year, respectively in 2007, 2008 and 2009 while it increased in 2005 and 2010. It is additionally observed that in those years when the productivity decreased, component of technical change also decreased while component of efficiency change increased.

Keywords: Global financial crisis, efficiency, Malmquist productivity index.
JEL Codes: C02, C67, D24, L86.
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1.0 INTRODUCTION

One of the main reasons of the globalization process which has been taking place since the end of the 20th century is the development of information technologies. Moreover, it is an undeniable fact that the tools of information technologies hold an important place in human life. While the size of global information technologies market was 1.3 trillion dollars in 2005, it reached to 1.7 trillion dollars showing approximately 31% growth within 6 years period (Yased, 2012).

In the process of accelerating globalization with the impact of the rapid development of information technologies, the economic crisis in one country affects the entire economy in any other country. 2007

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economic crisis took place in the housing market in the US, which in a short time affected first the US financial system and then the other economies negatively. And this is considered to be the biggest crisis in the world financial history (Kutlu & Demirci, 2011).

It is impossible not to be affected by information technologies sector by this crisis while the whole world gets affected. In this paper, the effects of the global crisis, which began in the US towards the end of 2007, on the productivity of enterprises operating in the information technologies are examined by using the method of Malmquist Productivity Index (MPI) which is a mathematical method that can be used to calculate the efficiency changes of enterprises between two different time periods. This paper also tries to bring some comments on the responses of enterprises managements against crisis while analyzing the reliable and accessible data of 20 companies (2005-2010) that are in the list of Fortune 500. These are used since most of the enterprises in large and global scale operating in information technologies are in the US.

Although there are studies in the literature conducted by using MPI method on the change of productivity of enterprises operating in the information and communication sectors, we could not reach any study focusing on the changes during any economic crisis.

The rest of the paper is organized as follows: the second section is devoted for a literature survey while the third section presents the research methodology. The fourth section is the application section which includes the structure of the data used, variables and empirical results. We have concluded with a discussion of the implications of the results in the last section.

2.0 LITERATURE SURVEY

In the literature there are studies conducted by using the method of MPI on many sectors such as banking (Zhang, Qu, Xu & Wang, 2012; Ngo & Nguyen, 2012), health (De Castro Lobo, Özcan, Da Silva, Lins & Fiszman, 2010; Roh, Moon & Park, 2011), tourism (Barros, 2005; Benli, 2012), transportation (Parelman & Serebrisky, 2010; De Nicola, Gitto & Mancuso, 2013; Ahn & Min, 2014), education (Brennan, Haelermans & Ruggiero, 2014; Yaisawarng & Ng, 2014; Johnson & Ruggiero, 2014). Some of the studies on information technologies and telecommunication sectors are summarized below.

Shao and Shu (2004) calculated the efficiency change in knowledge and information technologies sector by using the 13 years of data of 14 OECD countries between 1978 and 1990. In the study two inputs are used, capital and labor. Capital is the total value of existing equipment; labor is the expenditure of employees. The output is the total dollar amount of the ICT products produced by an industry. According to the result of the research it is concluded that there was an increase in the average level of productivity of 10 OECD countries.

Chen and Ali (2004) in their study assessed the effect of 2 components of technological change on MPI by taking all possible scenarios into account in detail. They analyzed the data of 8 companies, which are in the Fortune Global 500 list, between the 1991-1997 period, producing computers and office equipment, and used assets, shareholders' equity and number of employees as input, output is taken as the revenue.

Bollou and Ngwenyama (2008) examined all the data of 6 West African countries between 1995 and 2002 in order to calculate the change in the productivity status of the sector of information-communication technologies by using MPI. In this research, the amount of investment and the number of employees are used as input; revenue, number of internet users, the number of main telephone lines, total telephone traffic and number of cellular phones are used as the output. Although productivity of countries grows according to the results of research, it is concluded that in the recent years there was a decline in the increment ratio and countries which did not work at appropriate scales.

Dişkaya, Emir and Orhan (2011) evaluated how telecommunication sector in Turkey and the G8 countries are affected by the global crisis in 2007 by using DEA and MPI. In the study the data (2007-2010) of 9

telecommunication companies in 8 different countries was used. Capital expenditures, total debt, total access lines and employees units used as input; revenue, net income and mobile subscribers were used as output. Annual productivity change results for each company are given as a result of the study and it was concluded that the industry was not very seriously affected by the economic crisis.

Studies which made by using MPI method on the effect of 2007 financial crisis, are carried out mainly on banking sector. In the literature there are studies measuring the size of effect caused by the crisis such as Park and Baek (2014) on 30 banks in the US, Ngo & Nguyen (2012) on 27 banks in Thailand, Forughi and De Zoyna (2012) on 10 banks in Australia, Madhanagopal and Chandrasekaran (2014) on 55 banks in India, Popovici (2014) on 9 banks in Romania. In the literature, however, there was no study reached about the effects of the crisis on the sector of information technologies.

3.0 METHODOLOGY

One of the most used methods to carry out relative efficiency measurements of enterprises producing multiple outputs using multiple inputs is the Data Envelopment Analysis (DEA) which is a non-parametric efficiency measurement method. DEA is developed by taking the production functions frontier concept of Farrell (1957) (Baysal, Alçılar, Çerçioğlu & Toklu, 2005)as a ground and the enterprises whose efficiency measurements to be calculated are called decision making units (DMUs). In efficiency measurement with DEA, using input-output data of DMUs different production functions are defined for each DMU, the production functions of DMUs that are producing most output using least input create the production frontier by encapsulating all possible producible input-output combinations. Efficiency values of DMUs are calculated according to the distance to production frontier (distance functions). In DEA, which can be used to calculate the relative efficiency measurement at a specific time period, according to its envelopment type; Charnes, Cooper and Rhodes (1978) introduced the constant returns to scale (CRS) and Banker, Charnes and Cooper (1984) introduced the variable returns to scale (VRS) model. DEA models can also be defined as radial input oriented, output oriented or additive (both inputs and outputs are optimized) (Paradi & Schaffnit, 2004).

Index is a concept used for measuring of proportional changes of observation values for a specific statistical event based on some characteristics such as time, place, etc. (Çabuk, 1995; İşçil, 1978). The MPI method took its name from the article published by Sten Malmquist (1953) titled "Index Numbers and Indifference Surfaces". In his study, Malmquist suggested the idea to set up an index by the help of distance functions. MPI measures the change in total factor productivity of two observations as the proportion of distances from a common technology.

Distance functions, which can be used without specifying the aims like the cost minimization or profit maximization in identification of the multiple input-output production technologies (Cingi & Tarım, 2000), can be identified according to input or output oriented.

Input distance function; when the output vector is given, defines the production technology according to proportionally the most contracted input vector. Similarly, the output distance function; when the output vector is given, defines the production technology according to proportionally the most expanded output vector (Çakır & Perçin, 2012; Tarim, 2001).

Input distance function at period t is defined as (Fare, Grosskopf, Lindgren & Ross, 1992),

$$D_i^t(y^t, x^t) = \sup\left\{\lambda: \left(\frac{x^t}{\lambda}, y^t\right)\epsilon S^t\right\} = [\inf\{\lambda: (\lambda x^t, y^t)\epsilon S^t\}]^{-1}$$

while the output distance function by (Fare, Grosskopf, Norris & Zhang, 1994),

$$D_o^t(x^t, y^t) = \inf\left\{\theta: \left(x^t, \frac{y^t}{\theta}\right)\epsilon S^t\right\} = [\sup\{\theta: (x^t, \theta y^t)\epsilon S^t\}]^{-1}$$

can be given and there is a relation $\left[D_i^t(y^t, x^t)\right]^{-1} = D_o^t(x^t, y^t)$ between input and output distance functions.

Here;

x^t : Input vector at period t
y^t : Output vector at period t
S^t : Production technology (the set of all feasible input and output vectors)
λ : Contraction coefficient
θ : Expansion coefficient
$D_i^t(x^t, y^t)$: Distance of input-output vector at period t to the production technology at period t (for input)
$D_o^t(x^t, y^t)$: Distance of input-output vector at period t to the production technology at period t (for output)

MPI, that defines the efficiency differences of two enterprises or one enterprise between two time periods, predicates the reason of productivity changes on the efficiency change (EFFCH) and technical change (TECHCH). Efficiency change measure relative technical efficiency at t and t +1, that is, whether production is getting closer (catching up) or farther from the frontier (Fare et al., 1994). Technical change measure the shift in the frontier between periods t and t+1 (Fare et al., 1992).

As in the distance functions, MPI can be calculated input or output oriented as well. Output oriented MPI between t and t+1 can be calculated with the following equation (Fare et al., 1994).

$$M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \overbrace{\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}}^{\text{Efficiency Change (EFFCH)}} \times \overbrace{\left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}}}^{\text{Technical Change (TECHCH)}}$$

Here;

$D_o^{t+1}(x^{t+1}, y^{t+1})$: Distance of input-output vector at period t+1 to the production technology at period t+1 (S^{t+1}),
$D_o^t(x^{t+1}, y^{t+1})$: Distance of input-output vector at period t+1 to the production technology at period t (S^t),
$D_o^{t+1}(x^t, y^t)$: Distance of input-output vector at period t to the production technology at period t+1 (S^{t+1}).

Since EFFCH in any period is the ratio of distance function to the production frontier at its own period, EFFCH measures the change of efficiency relatively (Fare et al., 1994). TECHCH on the other hand measures the change in production technology. The word technology here not only means production or machine technologies, but also it may be extended to production process policies, regulations which affect the efficiency as well as including the effect of the environment (Lorcu, 2010).

After calculations M_o can take three different values such that equal to 1, less than 1 or greater than 1. If the comparison result of the relevant period (t+1) of KVB in concern to the previous period (t) is: M_o=1 then no changes in productivity; M_o<1 then a decrease; M_o>1then an increase is concluded (Ar, Gergin & Baki, 2014; Yolsal, 2010).

In order to calculate the numerical values of distance functions, Fare et al. (1992) in their study defined an input oriented model based on a nonparametric linear programming ((LP)/DEA with the constant return to scale assumption. Fare et al. (1994) in their study has given the output oriented LP models of distance functions with the constant return to scale assumption. With (n) KVB, (m) input, (s) output; for any (k^{th}) KVB, linear programming models that has to be solved for 4 different distance functions, which defined as output oriented, are as follows (Fare et al., 1994):

$$\left[D_o^t(x_k^t, y_k^t)\right]^{-1} = max\theta \qquad \left[D_o^{t+1}(x_k^{t+1}, y_k^{t+1})\right]^{-1} = max\theta$$

$\theta y_{rk}^{t} \le \sum_{j=1}^{n} \beta_j y_{rj}^{t}$ r=1,... s	$\theta y_{rk}^{t+1} \le \sum_{j=1}^{n} \beta_j y_{rj}^{t+1}$ r=1,... s
$\sum_{j=1}^{n} \beta_j x_{ij}^{t} \le x_{ik}^{t}$ i=1,... m	$\sum_{j=1}^{n} \beta_j x_{ij}^{t+1} \le x_{ik}^{t+1}$ i=1,... m
$\beta_j \ge 0$ j=1,... n	$\beta_j \ge 0$ j=1,... n
$\left[D_o^{t+1}(x_k^t, y_k^t)\right]^{-1} = max\theta$	$\left[D_o^{t}(x_k^{t+1}, y_k^{t+1})\right]^{-1} = max\theta$
$\theta y_{rk}^{t} \le \sum_{j=1}^{n} \beta_j y_{rj}^{t+1}$ r=1,... s	$\theta y_{rk}^{t+1} \le \sum_{j=1}^{n} \beta_j y_{rj}^{t}$ r=1,... s
$\sum_{j=1}^{n} \beta_j x_{ij}^{t+1} \le x_{ik}^{t}$ i=1,... m	$\sum_{j=1}^{n} \beta_j x_{ij}^{t} \le x_{ik}^{t+1}$ i=1,... m
$\beta_j \ge 0$ j=1,... n	$\beta_j \ge 0$ j=1,... n

In DEA models, the efficiency value is called the efficiency (EFF) when obtained with constant return to scale assumption, while it is called the pure efficiency (PEFF) when obtained with the variable return to scale assumption. Rational difference of these two efficiencies is called the scale efficiency (SE). The relation between these effectiveness values are as follows (Ulucan & Karacabey, 2002):
EFF = PEFF * SE.

For the calculation of the values/changes of PEFF and SE with distance functions, similar to ones as in DEA models, constraint of convexity, which is the summation of density values equal to 1, ($\sum_{j=1}^{n} \beta_j = 1$), has to be added to LP models given above (Fare et al., 1994). Ratio of $D_o^{t+1}(x^{t+1}, y^{t+1})$ ve $D_o^{t}(x^{t}, y^{t})$ distance functions obtained by the addition of convexity constraint, gives the pure efficiency change (PEFFCH), EFFCH/PEFFCH ratio gives the scale efficiency change (SECH). PEFFCH and SECH investigate respectively the administrative efficiency and whether the decision units work or not in an appropriate scale (Kaya & Aktan, 2011; Tosun & Aktan, 2010).

4.0 APPLICATION

4.01 PURPOSE OF THE RESEARCH AND DATA

This study is tried to be investigated by MPI method how the 20 enterprises in information technologies are affected from 2007 crisis, that are in the Fortune 500 list published in the US and whose data can be achieved. The list of 2011 is taken to be the criteria for the selection of the enterprises; assessments are made for 6 years data between 2005 and 2010. Win4DEAP software package is used for the calculations of productivity changes. In financial accounts, liabilities are used as input while total income and net profit are used as output (Table 1). The data is taken from annual reports that they have published in the website of the company each year.

Table 1: Inputs and outputs used in the study

Inputs	Outputs
Short-term liabilities	Total income
Long-term liabilities	Net profit
Shareholders' equity	

4.02 EMPRICAL RESULTS

EFFCH, TECHCH and MPI of the enterprises between 2005 and 2010 are given respectively in table 2, 3 and 4 with ascending/descending/invariant number of enterprises and geometric mean of each period.
In terms of sector average EFFCHs of enterprises decreased in first 2 periods, increased in the following 2 periods and decreased again in the last period (Table 2). In period 2005-2006 (that is the exchange of 2006 with respect to 2005) average EFFCHs of enterprises decreased by 7.4%, maximum increase occurred in SAIC, maximum decrease experienced in Yahoo. In the period of 2006-2007 while the decrement continues, ratio of decrement is in average 2.5%. In this period, the maximum increment occurred in Xerox while the maximum decrement happened in Harris. Beginning from 2007 the

enterprises starting to recover, increased their efficiencies 2.8% in average. In this period, while IBM provides the maximum increment, Automatic Data Processing provides the maximum decrement in terms of EFFCH. In 2008-2009 period average increment (1.9%) has continued. In this period, maximum increment and maximum decrement were seen respectively in Apple and Qualcomm. In the last two periods, highest increment in Apple and maximum decrement in Qualcomm occurred. In spite of the increment in the last two periods, there has been a decrement of 6.9% in average between 2009 and 2010. In 2010 while the maximum increment occurred in Hewlett-Packard, Oracle is the enterprise whose EFFCH decreased the most.

Table 2: Efficiency changes (EFFCH)

DMU	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010
Cisco System	0.754	0.925	1.098	0.843	0.764
Harris	0.896	0.754	1.241	0.963	1.082
Qualcomm	0.943	1.06	0.943	0.563	0.894
Automatic Data Processing	1.280	0.916	0.692	1.53	0.834
Computer Sciences	0.884	0.875	1.129	1.191	0.824
SAIC	1.486	1	0.968	1.034	1
IBM	1.088	1.084	1.307	1	1
Amazon.com	1	1	1	1	1
Google	1	1	1	1	1
Yahoo	0.624	0.812	1.178	1.04	0.983
Intel	0.656	0.996	1.152	0.972	1.064
Texas Instruments	1	1	1	1	1
Western Digital	1	1	1	1	1
Apple	0.734	1.09	0.905	1.645	0.905
Dell	1	1	1	1	1
Hewlett-Packard	0.888	1.105	0.952	1.112	1.151
Xerox	0.901	1.142	0.915	0.9	0.830
Microsoft	1	1	1	1	1
Oracle	0.809	0.918	1.122	1.116	0.631
Danaher	0.940	0.922	1.136	0.919	0.835
Mean	**0.926**	**0.975**	**1.028**	**1.019**	**0.931**
EFFCH>1	3	5	8	7	3
EFFCH= 1	6	7	6	7	8
EFFCH<1	11	8	6	6	9

The production frontier of enterprises shifted down according to previous period based on average apart from the period before crisis (2006) and the last year (2010) (Table 3). In period 2005-2006 average of production technologies of enterprises increased 10.7%; maximum increment was in Dell, only decrement was seen in Amazon.com. In the period 2006-2007 that covers the year 2007, which was the beginning of crisis, decrement in the production frontier was 1.7%. In this period while in Microsoft the highest increase was realized, largest decline happened in Google. In period 2007-2008 when the crisis was felt intensely in the world there was a decrease of 10.4%. In this period, while the largest increase took place IBM, the largest technological decrease occurred in Western Digital. The continuing decline in the 2008-2009 periods was realized as 10.2%. During this period, the largest increase in 2 enterprises (Computer Sciences and SAIC) was experienced, while the largest decline was in Automatic Data Processing. In the last period the TECHCHs of enterprises that started to recover had an average increase of 9.1%. In this period, Cisco System was the company that increased its TECHCH at most, while on the other hand Dell was the company having the largest decrement.

Table 3: Technical changes (TECHCH)

DMU	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010
Cisco System	1.123	1.119	0.942	0.891	1.286
Harris	1.072	1.01	1.01	0.957	1.160
Qualcomm	1.007	0.994	0.599	0.942	1.179
Automatic Data Processing	1.140	1.074	0.988	0.682	1.082

Computer Sciences	1.061	1.006	0.912	1.114	1.118
SAIC	1.102	1.003	0.893	1.114	1.030
IBM	1.099	0.961	1.342	0.805	1.042
Amazon.com	0.777	0.715	0.981	0.849	1.038
Google	1.316	0.62	0.762	1.01	0.984
Yahoo	1.035	0.989	0.751	0.845	1.004
Intel	1.095	1.038	0.897	0.888	1.244
Texas Instruments	1.238	1.032	0.915	0.854	1.249
Western Digital	1.163	1.086	0.452	0.846	1.126
Apple	1.185	1.054	0.822	0.831	1.228
Dell	1.360	0.792	1.042	0.893	0.634
Hewlett-Packard	1.073	0.948	0.99	0.943	0.893
Xerox	1.051	1.036	0.943	1.099	1.180
Microsoft	1.092	1.235	1.103	0.723	1.137
Oracle	1.152	1.135	0.956	0.912	1.282
Danaher	1.131	1.036	1.028	0.909	1.162
Mean	**1.107**	**0.983**	**0.896**	**0.898**	**1.091**
TECHCH>1	19	13	5	4	17
TECHCH<1	1	7	15	16	3

In terms of periods MPIs followed a similar pattern to TECHCHs (Table 4). MPIs of enterprises increased average of 2.5% in 2005-2006 period and 1.6% in period 2009-2010, in the other periods they decreased respectively of 4.1%, 7.9% and 8.4%. In 2005-2006 SAIC, in 2006-2007 Microsoft, in 2007-2008 Harris, in 2008-2009 Apple, in 2009-2010 Intel were the companies that had the largest increase in factor productivity, in the same periods respectively Intel, Google, Western Digital, Qualcomm and Dell were the companies that their factor productivity decreased the most.

Table 4: MPI changes (M_o)

DMU	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010
Cisco System	0.847	1.035	1.034	0.751	0.982
Harris	0.960	0.762	1.254	0.921	1.255
Qualcomm	0.950	1.054	0.565	0.53	1.054
Automatic Data Processing	1.459	0.984	0.683	1.043	0.903
Computer Sciences	0.939	0.881	1.029	1.327	0.921
SAIC	1.637	1.003	0.864	1.152	1.030
IBM	1.196	1.042	1.754	0.805	1.042
Amazon.com	0.777	0.715	0.981	0.849	1.038
Google	1.316	0.62	0.762	1.01	0.984
Yahoo	0.646	0.803	0.885	0.879	0.987
Intel	0.718	1.034	1.033	0.863	1.323
Texas Instruments	1.238	1.032	0.915	0.854	1.249
Western Digital	1.163	1.086	0.452	0.846	1.126
Apple	0.870	1.149	0.744	1.368	1.112
Dell	1.360	0.792	1.042	0.893	0.634
Hewlett-Packard	0.952	1.048	0.943	1.049	1.028
Xerox	0.947	1.183	0.863	0.989	0.980
Microsoft	1.092	1.235	1.103	0.723	1.137
Oracle	0.932	1.042	1.073	1.017	0.809
Danaher	1.062	0.955	1.168	0.835	0.970
Mean	**1.025**	**0.959**	**0.921**	**0.916**	**1.016**
M_o>1	9	12	9	7	11
M_o<1	11	8	11	13	9

Changes of mean values of MPIs and its components of enterprises are given in table 5 with respect to periods. Taking 5 periods into account and investigating their geometric mean, it is seen that MPI and its all components reduced. In every period in terms of decrement/increment, MPI change and TECHCH followed a similar pattern. Except for first and last periods, SECH average of enterprises in each period

increased; the average of their PEFFCH unchanged in 2008-2009, but increased in 2007-2008, it decreased in the other periods.

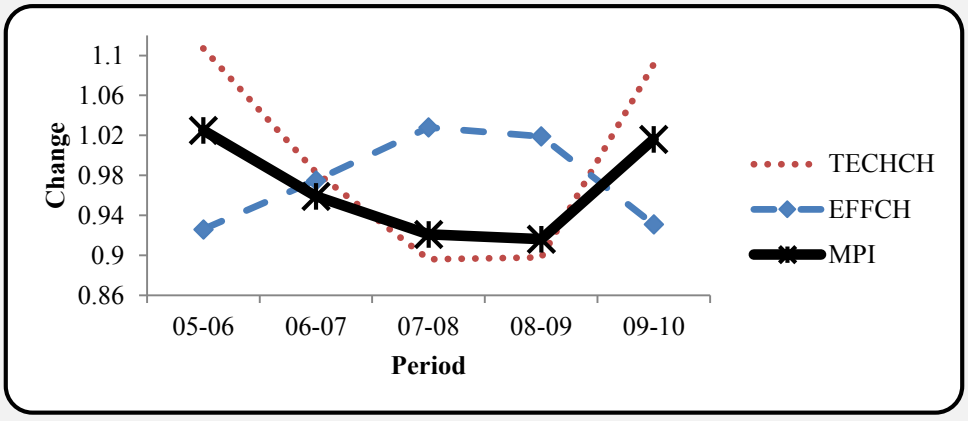
Table 5: Changes of enterprises mean values of MPI and its components

	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	Mean
EFFCH	0.926	0.975	1.028	1.019	0.931	**0.975**
TECHCH	1.107	0.983	0.896	0.898	1.091	**0.991**
PEFFCH	0.978	0.964	1.020	1.000	0.958	**0.984**
SECH	0.947	1.011	1.008	1.019	0.972	**0.989**
M_0	**1.025**	**0.959**	**0.921**	**0.916**	**1.016**	**0.966**

Moreover, in respect to mean values of enterprises, the following results are obtained:

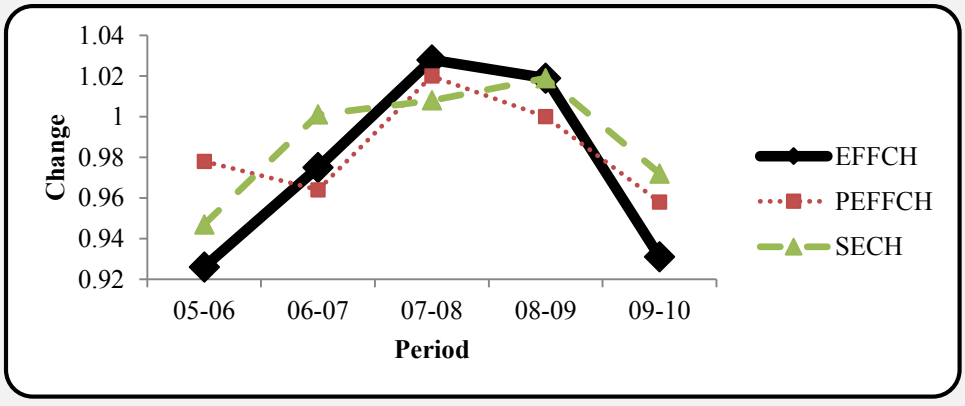
- Enterprises mean values of MPIs increased in 2006 that was the last year before the crisis and in 2010 that the effects of crisis started to decline.
- Enterprises mean values of MPIs decreased between 2007 and 2009 when the crisis felt intensely in the world.
- In each period MPI and TECHCH showed a similar trend. Since the rates of TECHCH were higher than in EFFCH, it can be said that for each period change in MPI is mainly due to TECHCH (Figure 1).

Figure 1: Changes in MPI and components



Particularly in 2008 and 2009 years that the crisis were experienced intensely it can be said that the companies had spent efforts on: work in appropriate scale by increasing their SEs; increase administrative efficiency by increasing their PEFFs (Figure 2).

Figure 2: Changes in EFFCH and components



5.0 CONCLUSION

Results of this study show that, the economic crisis, which began in the US and spread quickly around the world and reached a global extent, affected the enterprises operating in information technologies

industry negatively. However, it can be said that the effect, in terms of sector average, was not a very large extent. Additionally, it is monitored that the managements of enterprises had not remained unresponsive to the crisis. Moreover, companies struggled for compensating their efficiency losses caused by TECHCHs by way of increasing their EFFCHs. One can also see that companies both tried to work optimum scale level by way of increasing their scale efficiencies and struggled to increase administrative efficiency by increasing their pure efficiencies, and in the end they obtained positive results.

Enterprises in the information technologies industry are companies that work heavily in technology and can sustain their existence only with significant research-development investments and innovative inventions. In normal market conditions production technology in the sector (production frontier) is expected to change in a positive direction. As known, TECHCH encompasses the policies of the production process, regulations and effect of the environment as well as the technological advances. In this context, it seems possible to say that global financial policies and the crisis psychology may effect on the decline in TECHCHs of companies operating in the global dimension. It can also be said that the reason of positive TECHCHs with respect to company and year is the new technology/product that the corresponding enterprise has launched.

MPI is a numerical method based on database. In this sense, it is obvious that adding/removing new enterprises to the analysis or selecting different inputs and outputs cause different results in the information technologies sector which has a broad framework.

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