Analyzing the Influences of GDP and ICT in Indonesian Industrial Structural Changes Using Statistical Analysis: 1990-2005

Ubaidillah Zuhdi[1,2*], Shunsuke Mori[1], Kazuhisa Kamegai[1]

[1]Department of Industrial Administration, Tokyo University of Science, Japan

[2]School of Business and Management, Institut Teknologi Bandung, Indonesia

Abstract. *The purpose of this study is to analyze the influences of Gross Domestic Product (GDP) and Information and Communication Technology (ICT) in structural changes of Indonesian industrial sectors from 1990-2005. In this study, the former component is represented by growth of GDP per capita while telephone lines per 100 people explain the latter one. These components are explanatory variables used in this study. We employ statistical tool in investigating the influences, namely Constrained Multivariate Regression (CMR) model. Likelihood Ratio Test (LRT) method is used in order to test the statistical significance of this model. In this study, we focus on (1) trade, (2) business services, and (3) personal and household services sectors. We then do the deeper analysis, microscopic analysis, for these sectors. The results showed that above variables, in analysis period, gave significant influences on structural changes of analyzed sectors. Besides, in these sectors, the influences given by explanatory variables generated the different patterns.*

Keywords: *GDP, ICT, Industrial Structural Changes, CMR, LRT, Indonesia*

1. Introduction

According to Lewis and Hildreth (2012), Gross Domestic Product (GDP) is a tool to determine the economic performance of specific country during a set time period. Association for Investment Management and Research (AIMR) (2003) argued that the real GDP is a comprehensive tool to measure the well-being and health of an economy. On the other hand, Gutierrez, Glassman, Landefeld, and Marcuss (2007) explained about GDP as follows:

"*GDP is one of the most comprehensive and closely watched economic statistics: It is used by the White House and Congress to prepare the Federal budget, by the Federal Reserve to formulate monetary policy, by Wall Street as an indicator of economic activity, and by the business community to prepare forecasts of economic performance that provide the basis for production, investment, and employment planning.*"

Meanwhile, in recent years, the role of Information and Communication Technology (ICT) on economic activities of specific country is important. This role observed in micro and macro levels. In former level, we can see that now almost every day people in the world use internet. Kramer, Jenkins, and Katz (2007) emphasized the role of ICT in latter level as follows:

"*Unbound from the structures of the PTT days, ICT has become the foundation of every sector of every economy, everywhere. The reason for this are, by now, fairly well-known, but demand brief repetition here. Information and communications technologies reduce transactions costs and thereby improve productivity; offer immediate connectivity-voice, data, visual-improving efficiency, transparency, and accuracy; substitute for other, more expensive means of communicating and transacting, such as physical travel; increase choice in the marketplace and provide access to otherwise unavailable goods and services; widen the geographic scope of potential markets; and channel knowledge and information of all kinds*"

There are many previous study discussed about GDP and ICT. For example, Gu, Terefe, and Wang (2012) analyzed the effect of the capitalization of expenditures of Research and Development (R&D) on GDP and growth of labor productivity in Canada since 1981. Jordaan (2013) investigated the relationship between nominal GDP and nominal interest rate which the object of study was South Africa. Zuppo (2012) focused on making a hierarchy of applications and definitions of ICT. Zuhdi, Mori, and Kamegai (2012) compared the role of ICT sectors in national economic structural changes of Indonesia and Japan by using Structural Decomposition Analysis (SDA), one of tools in Input-Output (IO) analysis. Besides, Zuhdi, Mori, and Kamegai (2013) analyzed the influences of ICT in structural changes of particular Japanese industrial sectors from 1985-2005 using statistical analysis.

The study discusses the role of GDP and ICT in industrial structural changes of specific country, which both components are simultaneously presented as explanatory variables, however, is still thin. The kind of study is important because it can open the opportunity in increasing the economic growth of industrial sectors of analyzed country. This study is conducted in order to fulfill this gap.

The purpose of this study is to analyze the influences of GDP and ICT in structural changes of industrial sectors of specific country. The object of this study is Indonesia. The analysis period of this study covers 1990-2005. We develop a statistical tool in order to achieve the objective. This tool investigates the influences reflecting the properties of IO activity vector. This paper is arranged as follows. The methodology of this study is explained in chapter 2. Chapter 3 describes the calculation results and analysis related to these results. Chapter 4 explores the conclusions and suggested further researches from this study.

2. Methodology

The methodology of this study which is referring to Zuhdi, Mori, and Kamegai (2013) can be explained as follows. First, we do the process of aggregation for 1990, 1995, and 2005 Indonesian IO tables in order to get same number on industrial sectors. The number of Indonesian industrial sectors for 1990, 1995, and 2005 was 161, 172, and 175, respectively. These numbers are aggregated into 159 sectors. The adjustment process is also done for 2005 IO table of Indonesia. This process aims to get proper data for this table. Detail description of aggregated sectors is displayed in appendix.

Second, we do the calculation in order to get IO coefficient matrices for each year in analysis period. Miller and Blair (2009) mentioned that the calculation uses following equation:

$$a_{ij} = \frac{z_{ij}}{X_j} \qquad (1)$$

where a_{ij}, z_{ij}, and X_j are input needed to produce one unit of production of industry j from industry i, inter-industry sales by sector i to sector j, and total production of sector j, respectively. Further, a_{ij} represents IO coefficient from sector i to sector j.

Third, we calculate the influences of explanatory variables used in this study, growth of GDP per capita and telephone lines per 100 people, in Indonesian industrial structural changes. The former variable explains GDP while the latter one is a representation of ICT. The changes are represented by the dynamic changes in IO coefficient vectors extracted from IO tables. In order to conduct this calculation, we develop a Constrained Multivariate Regression (CMR) model.

The data of above variables are obtained from the website of The World Bank. As with main data, these variables data represent the data of 1990, 1995, and 2005. The detail description of CMR model is described as follows. In the beginning, we define the years of analysis, 1990, 1995, and 2005 as T. We then define the data represents Indonesian industrial structural changes, IO coefficient matrices, as $a(t)$ t = 1…T. Further, in above calculation, the vectors of IO coefficient are used. In other words, this model is applied to each industrial sector of Indonesia through IO coefficient of the sector. The explanatory variables used can be described as $x(k,t)$ k = 1…k. The following mathematical model, representation of CMR model, is employed as an elaboration of $a(t)$:

$$a(i,t) = b0(i) + \sum_k b(i,k) \times x(k,t) + e(i,t)$$

$$a(i,t) \geq 0, \quad \sum_i a(i,t) = 1.0 \, . \qquad (2)$$

where *b0(i)* and *b(i,k)* explain the regression coefficients of model. Since coefficients are non-negative and these summations should be unity by definition, constraints among estimators are imposed. *e(i,t)* describes the difference of original and estimated values. By least square method, $\min.\sum_i\sum_t e(i,t)^2$, one can obtain the parameters. In this study, the calculation is separately conducted for each explanatory variable.

Fourth, we test the statistical significance of estimators in the fitted model using Likelihood Ratio Test (LRT) method. This method is based on calculation of $-N(\ln S - \ln S_0)$, where N and S are the total amount of data and the results of performance function optimization, respectively. N is given by $K \times M \times T$ where K, M, and T are number of sectors which give input for discussed sector(s), number of discussed sector(s), and number of periods, respectively. The degree of freedom is given by (K-1)×M×(number of removed explanatory variables). The statistical significance of an explanatory variable is given by $-N(\ln S - \ln S_0)$, which follows a χ2 distribution. In this study, we take 0.05 as the level of significance. Therefore, we use the 0.05 level of χ2 distribution in applying this method. As with previous calculation, this test is also separately conducted for each explanatory variable.

The value of degree of freedom used in this study is 159×1×1 = 159. The cutoff score for statistical significance in this study is $\chi 2_{0.05}$ (159) = 189.14. More specifically, we use this score in investigating the statistical significance of the explanatory variables on analyzed sectors, trade, business services, and personal and household services. A particular explanatory variable is called to give significant influence on specific sector if its significance score is greater than the cutoff score. In this study, six null hypotheses are used to emphasize the results of the method. These are:

- **Hypothesis 1:** Growth of GDP per capita had no influence on structural changes of Indonesian trade sector from 1990 to 2005
- **Hypothesis 2:** Growth of GDP per capita had no influence on structural changes of Indonesian business services sector from 1990 to 2005
- **Hypothesis 3:** Growth of GDP per capita had no influence on structural changes of Indonesian personal and household services sector from 1990 to 2005
- **Hypothesis 4:** Telephone lines had no influence on structural changes of Indonesian trade sector from 1990 to 2005
- **Hypothesis 5:** Telephone lines had no influence on structural changes of Indonesian business services sector from 1990 to 2005
- **Hypothesis 6:** Telephone lines had no influence on structural changes of Indonesian personal and household services sector from 1990 to 2005

Previous calculation steps can be simplified as follows. In the beginning we describe the original data of 3 points period of IO coefficient matrices of 159 Indonesian industrial sectors as an *A(t,i,j)*. The vectors of explanatory variables, *Ex_x(k,t)*, are used as a source of influences for the data. We use CMR model in order to calculate the influences of these variables on Indonesian industrial structural changes in analysis period. We then describe the influenced original IO coefficient matrices as an estimated IO coefficient matrices, *A_est(t,i,j)*. In this study, General Algebraic Modeling System (GAMS) software, software for analyzing high-level modeling system for optimization and mathematical programming (GAMS, n.d.), is used in order to conduct the calculation. The test using LRT method which focuses on specific sectors is done in the next step. The purpose of this test is to know the statistical significance of estimators in the fitted model.

Fifth, we do the deeper analysis, microscopic analysis, which focuses on analyzed sectors. The reason of choosing these sectors is because the explanatory variables used in this study seem to give direct impact to the transaction activities occurred in the sectors. The term of "microscopic" shows this analysis focuses on more detail aspects. We calculate the standard deviation for original IO coefficients of these sectors as a first step of this analysis. The calculation for estimated IO coefficients is ignored because the results of this calculation generally follow previous one. The purpose of this calculation is to know the magnitude of changes of original IO coefficients on analysis period. For each focused sector, we choose top ten from these coefficients which have highest standard deviation value. These top ten coefficients represent inputs which the changes are dynamic. From these coefficients we choose one which have increasing pattern as a source of analysis. The coefficient of variation and amount of correlation (R) are used in order to get deeper insight related to influences of above variables in analyzed sectors. As with previous calculation and test, this analysis is also separately conducted for each explanatory variable. After finishing the analysis, we describe the conclusions of this study and further researches which are suggested from this study.

3. Results and Analysis

3.1. The Results of LRT Calculation

Table 1 describes the summary of LRT calculation which evaluates the CMR model. From information in this table, we can assert that both explanatory variables used in this study significantly influenced the structural changes of analyzed sectors from 1990-2005. Based on this phenomenon, we reject all null hypotheses.

Table 1. Summary of LRT calculations (null model as a base)

No.	Explanatory variable	Influence on trade sector	Influence on business services sector	Influence on personal and household services sector
1	Growth of GDP per capita	Significant	Significant	Significant
2	Telephone lines per 100 people	Significant	Significant	Significant

3.2. Microscopic Analysis

3.2.1. Trade Sector

Table 2 describes top ten original IO coefficients of trade sector viewed from value of standard deviation on the period between 1990 and 2005. From information in this table, the most dynamic input is input from building and land rent, sector number 149. For investigating the influences of both explanatory variables in micro level, we choose $a_{141,137}$, IO coefficient describes input from road transport sector to trade sector, as a source of analysis. We select this coefficient because it had increasing pattern in analysis period.

Table 2. Top ten original IO coefficients of trade sector viewed from value of standard deviation (1990–2005)

No.	Input-output coefficient	Value of standard deviation	Value of mean
1	$a_{149,137}$	0.0239	0.0372
2	$a_{150,137}$	0.0124	0.0209
3	$a_{141,137}$	0.0098	0.0211
4	$a_{146,137}$	0.0071	0.0133
5	$a_{132,137}$	0.0062	0.0110
6	$a_{92,137}$	0.0060	0.0134

7	$a_{147,137}$	0.0056	0.0304
8	$a_{130,137}$	0.0039	0.0129
9	$a_{138,137}$	0.0039	0.0086
10	$a_{57,137}$	0.0038	0.0126

3.2.1.1. Influence of GDP per Capita Growth on Trade Sector

This section explains more detail the influence of growth of GDP per capita on trade sector in period of analysis. Figure 1 explains the changes of $a_{141,137}$ from 1990-2005. Numbers in this figure, also in other figures, represents the analysis years, namely 1990, 1995, and 2005, respectively. Table 3 shows the coefficient of variation of both original and estimated values of this coefficient and correlation of both values on the same period. From these results we can observe that our model well follow historical changes. In other words, we can say that, during 1990-2005, above explanatory variable had strong influence in $a_{141,137}$.

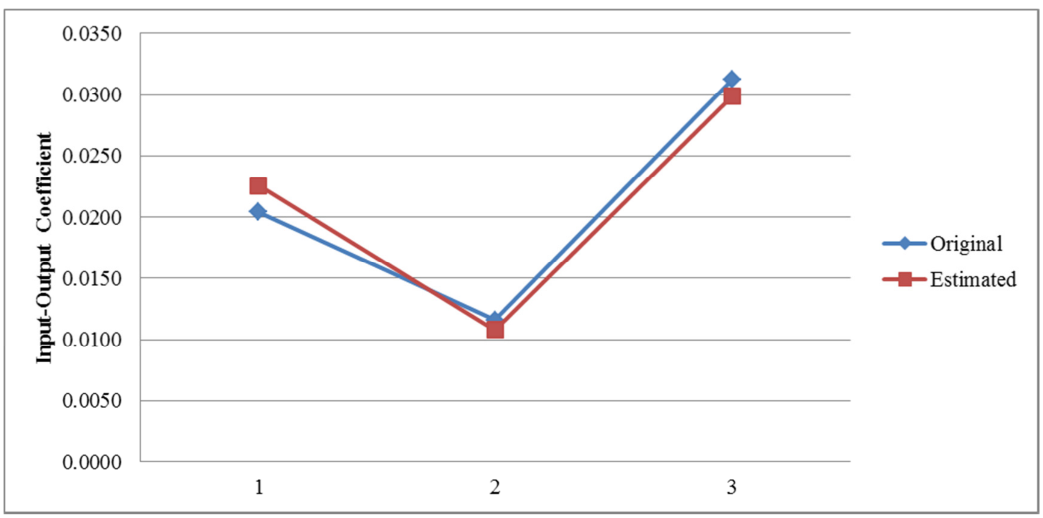

Figure 1. The changes of $a_{141,137}$ from 1990-2005, influenced by growth of GDP per capita

Table 3. Coefficient of variation of both original and estimated values of $a_{141,137}$ and correlation (R) of both values (1990–2005), influenced by growth of GDP per capita

Coefficient of variation		Correlation
Original	Estimated	
0.466	0.458	0.981

Above phenomenon shows that, especially during 1995-2005, GDP per capita growth has supported the relationship between road transport and trade sectors. Following explanation gives more detail information regarding the phenomenon. GDP is usually used as a tool of national economic measurement. One country is called to have a good trend in economy if its GDP growth is high. The growth of GDP per capita of Indonesia in 1995-2005, compared with 1990-1995, had a decreasing pattern. This situation should give a negative impact to above relationship. However, this impact did not appear in above period. This fact indicate that, from 1995-2005, the decreasing of GDP per capita growth has strengthened the connection of above sectors.

3.2.1.2. Influence of Telephone Lines on Trade Sector

This section explains more detail the influence of telephone lines on trade sector in period of analysis. Figure 2 explains the changes of $a_{141,137}$ from 1990-2005. Table 4 shows the coefficient of variation of both original and estimated values of this coefficient and correlation of both values on the same period. From these results we can observe that our model well follow historical changes. In other words, we can say that, during 1990-2005, above explanatory variable had strong influence in $a_{141,137}$.

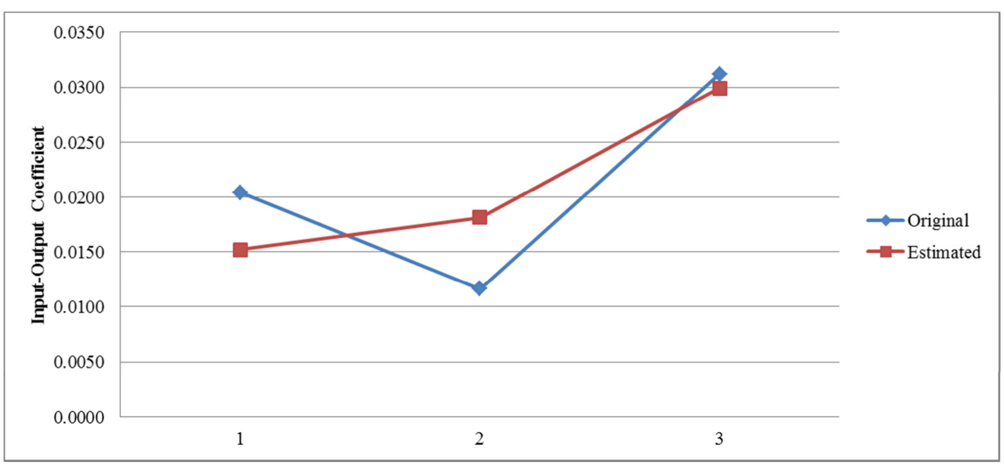

Figure 2. The changes of $a_{141,137}$ from 1990-2005, influenced by telephone lines

Table 4. Coefficient of variation of both original and estimated values of $a_{141,137}$ and correlation (R) of both values (1990–2005), influenced by telephone lines

Coefficient of variation		Correlation
Original	Estimated	
0.466	0.370	0.793

Above phenomenon shows that, during 1990-2005, telephone lines have supported the relationship between road transport and trade sectors. Following explanation gives more detail description regarding this condition. ICT device, including telephone, makes the communication between two or more persons more smoothly. The impact of this situation is to increase the quality and quantity of relationship between them. This logic can be used in industrial level. Indonesia had an increasing pattern in telephone lines from 1990-2005. This fact explains the phenomenon.

3.2.2. Business Services Sector

Table 5 describes top ten original IO coefficients of business services sector viewed from value of standard deviation on the period between 1990 and 2005. From information in this table, the most dynamic input is input from banking and other financial intermediaries, sector number 147. For investigating the influence of GDP per capita growth in micro level, we choose $a_{152,150}$, IO coefficient describes input from education services sector to business services sector, as a source of analysis. On the other hand, $a_{152,150}$, IO coefficient explains input from general government sector to business services sector, is used to analyze the influence of telephone lines. We select these coefficients because of its increasing pattern in analysis period.

Table 5. Top ten original IO coefficients of business services sector viewed from value of standard deviation (1990–2005)

No.	Input-output coefficient	Value of standard deviation	Value of mean
1	$a_{147,150}$	0.0264	0.0727
2	$a_{157,150}$	0.0104	0.0287

3	$a_{156,150}$	0.0061	0.0035
4	$a_{144,150}$	0.0059	0.0135
5	$a_{149,150}$	0.0058	0.0133
6	$a_{158,150}$	0.0053	0.0095
7	$a_{138,150}$	0.0045	0.0095
8	$a_{152,150}$	0.0044	0.0091
9	$a_{151,150}$	0.0043	0.0025
10	$a_{137,150}$	0.0037	0.0161

3.2.2.1. Influence of GDP per Capita Growth on Business Services Sector

This section explains more detail the influence of growth of GDP per capita on business services sector in period of analysis. Figure 3 explains the changes of $a_{152,150}$ from 1990-2005. Table 6 shows the coefficient of variation of both original and estimated values of this coefficient and correlation of both values on the same period. From these results we can observe that our model well follow historical changes. In other words, we can say that, during 1990-2005, above explanatory variable had strong influence in $a_{152,150}$.

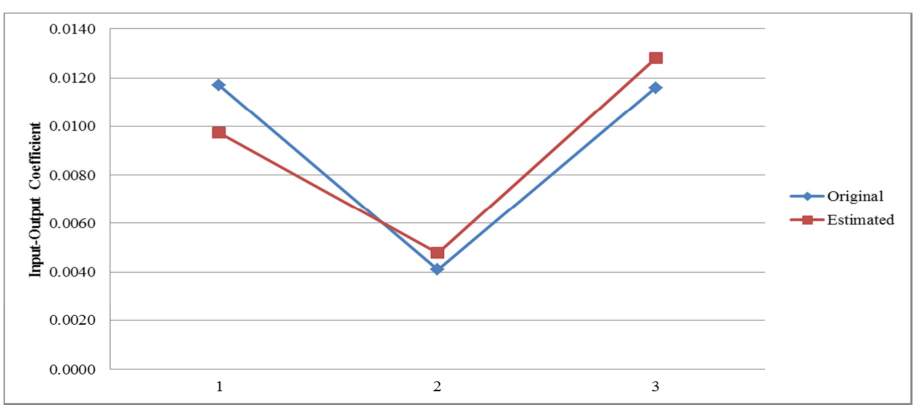

Figure 3. The changes of $a_{152,150}$ from 1990-2005, influenced by growth of GDP per capita

Table 6. Coefficient of variation of both original and estimated values of $a_{152,150}$ and correlation (R) of both values (1990–2005), influenced by growth of GDP per capita

Coefficient of variation		Correlation
Original	Estimated	
0.477	0.445	0.921

Above phenomenon shows that, especially during 1995-2005, GDP per capita growth gave a positive support to the relationship between education services and business services sectors. This phenomenon is unique because the growth of GDP per capita of Indonesia in 1995-2005, compared with 1990-1995, had a decreasing pattern. This situation supposedly has a negative impact to above relationship. However, this impact did not appear in above period. This fact indicate that, from 1995-2005, the decreasing of GDP per capita growth has accelerated the connection of above sectors.

3.2.2.2. Influence of Telephone Lines on Business Services Sector

This section explains more detail the influence of telephone lines on business services sector in period of analysis. Figure 4 explains the changes of $a_{151,150}$ from 1990-2005. Table 7 shows the coefficient of variation of both original and estimated values of this coefficient and correlation of both values on the same period. From these results we can observe that our model well follow historical changes. In other words, we can say that, during 1990-2005, above explanatory variable had strong influence in $a_{151,150}$.

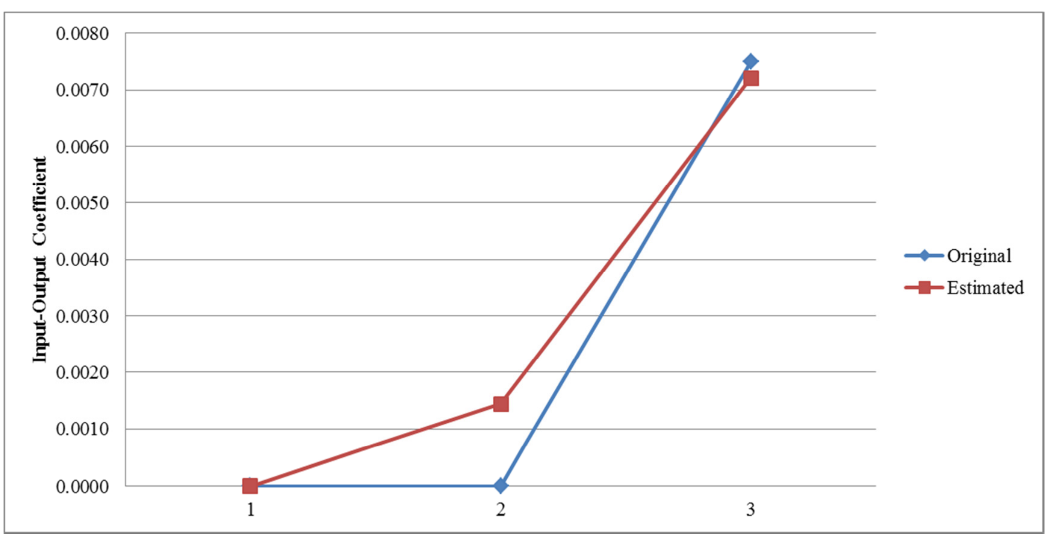

Figure 4. The changes of $a_{151,150}$ from 1990-2005, influenced by telephone lines

Table 7. Coefficient of variation of both original and estimated values of $a_{151,150}$ and correlation (R) of both values (1990–2005), influenced by telephone lines

Coefficient of variation		Correlation
Original	Estimated	
1.732	1.323	0.982

Above phenomenon indicates that, during 1990-2005, telephone lines have strengthened the relationship between general government and business services sectors. Following explanation gives more detail information regarding this situation. ICT device, including telephone, makes the connection between two or more parties better. The consequence of this condition is to improve the quality and quantity of relationship between them. This logic can be applied in the level of industrial sector. Indonesia had an increasing pattern in telephone lines from 1990-2005. This fact supports the phenomenon.

3.2.3. Personal and Household Services Sector

Table 8 describes top ten original IO coefficients of personal and household services sector viewed from value of standard deviation on the period between 1990 and 2005. From information in this table, the most dynamic input is input from textile, sector number 65. For investigating the influences of both explanatory variables in micro level, we choose $a_{146,158}$, IO coefficient describes input from communication services sector to personal and household services sector, as a source of analysis. We select this coefficient because it had increasing pattern in analysis period.

Table 8. Top ten original IO coefficients of personal and household services sector viewed from value of standard deviation (1990–2005)

No.	Input-output coefficient	Value of standard deviation	Value of mean
1	$a_{65,158}$	0.0205	0.0245
2	$a_{149,158}$	0.0137	0.0542
3	$a_{130,158}$	0.0114	0.0300

4	$a_{64,158}$	0.0106	0.0123
5	$a_{150,158}$	0.0106	0.0165
6	$a_{146,158}$	0.0100	0.0097
7	$a_{116,158}$	0.0076	0.0051
8	$a_{137,158}$	0.0076	0.0113
9	$a_{92,158}$	0.0057	0.0045
10	$a_{152,158}$	0.0046	0.0029

3.2.3.1. Influence of GDP per Capita Growth on Personal and Household Services Sector

This section explains more detail the influence of growth of GDP per capita on personal and household services sector in period of analysis. Figure 5 explains the changes of $a_{146,158}$ from 1990-2005. Table 9 shows the coefficient of variation of both original and estimated values of this coefficient and correlation of both values on the same period. From these results we can observe that our model well follow historical changes. In other words, we can say that, during 1990-2005, above explanatory variable had strong influence in $a_{146,158}$.

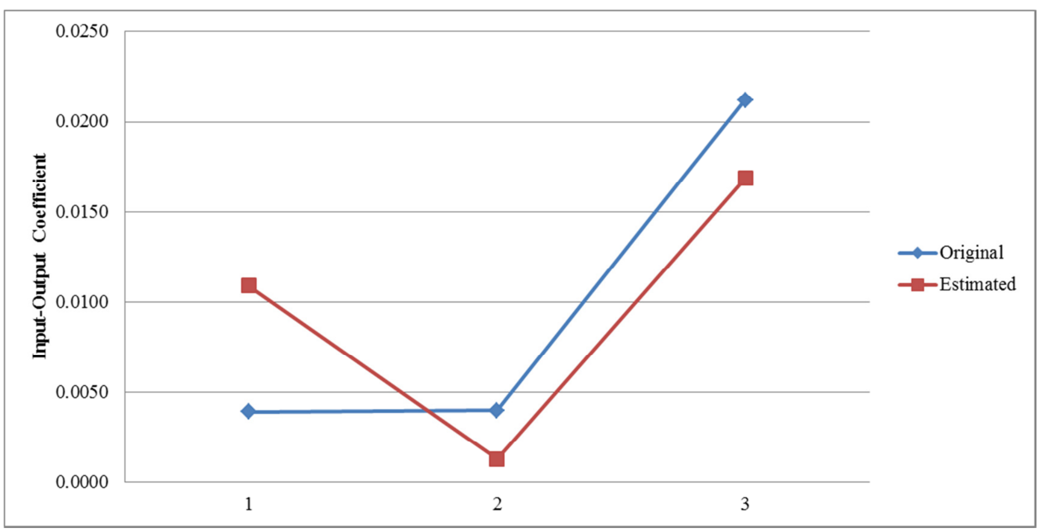

Figure 5. The changes of $a_{146,158}$ from 1990-2005, influenced by growth of GDP per capita

Table 9. Coefficient of variation of both original and estimated values of $a_{146,158}$ and correlation (R) of both values (1990–2005), influenced by growth of GDP per capita

Coefficient of variation		Correlation
Original	Estimated	
1.027	0.811	0.788

Above phenomenon shows that, especially during 1995-2005, GDP per capita growth gave a positive endorsement to the relationship between communication services and personal and household services sectors. This is a peculiar phenomenon because usually the positive support is given by the increasing growth of GDP per capita. Above growth of Indonesia in 1995-2005, compared with 1990-1995, had a decreasing pattern. This situation should give a negative contribution to above relationship. However, this impact did not appear in above period. This fact indicate that, from 1995-2005, the decreasing of GDP per capita growth has invigorate the connection of above sectors.

3.2.3.2. Influence of Telephone Lines on Personal and Household Services Sector

This section explains more detail the influence of telephone lines on personal and household services sector in period of analysis. Figure 6 explains the changes of $a_{146,158}$ from 1990-2005. Table 10 shows the coefficient of variation of both original and estimated values of this coefficient and correlation of both values on the same period. From these results we can observe that our model well follow historical changes. In other words, we can say that, during 1990-2005, above explanatory variable had strong influence in $a_{146,158}$.

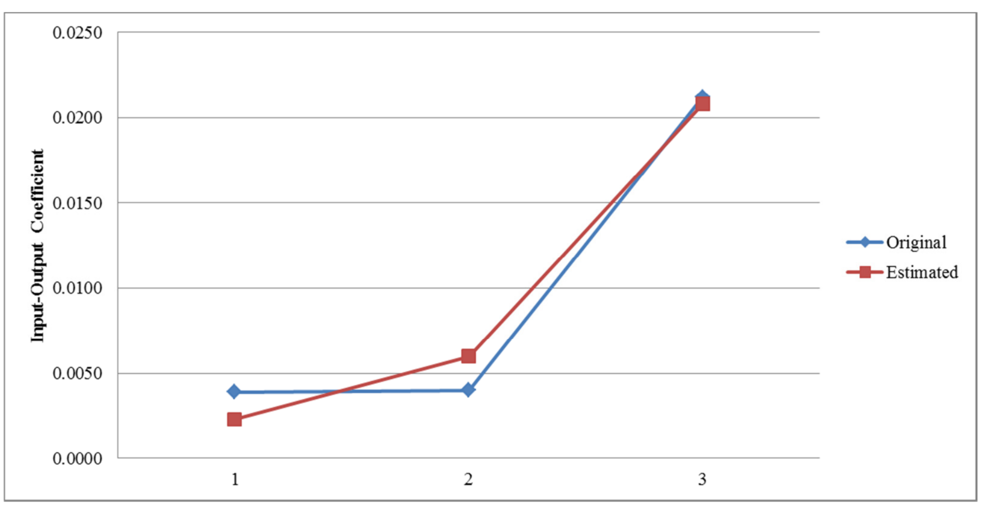

Figure 6. The changes of $a_{146,158}$ from 1990-2005, influenced by telephone lines

Table 10. Coefficient of variation of both original and estimated values of $a_{146,158}$ and correlation (R) of both values (1990–2005), influenced by telephone lines

Coefficient of variation		Correlation
Original	Estimated	
1.027	1.010	0.983

Above phenomenon shows that, during 1990-2005, telephone lines have endorsed the relationship between communication services and personal and household services sectors. Following explanation gives more detail description regarding this circumstance. ICT device, including telephone, makes one person easier to conduct the communication to another one. This situation will increase the quality and quantity of relationship between them. This logic can be adopted in industrial level. From 1990-2005, the amount of telephone lines of Indonesia was increasing. This fact explains why the phenomenon happened.

4. Conclusions and Further Research

This study analyzed the influences of GDP and ICT in the changes of structural of Indonesian industrial sectors from 1990-2005. In this study, GDP was represented by growth of GDP per capita while telephone lines per 100 people explained the ICT. Both of these represented explanatory variables used in this study. This study focused on three Indonesian industrial sectors, namely (1) trade, (2) business services, and (3) personal and household services sectors. CMR model was employed as an analysis tool. LRT method was used in order to test the statistical significance of estimators in the fitted model. This study also conducted hypothesis testing in order to emphasize the results of this method. We then did deeper analysis, microscopic analysis, which focused on analyzed sectors. The standard deviation calculation, coefficient of variation, and correlation were used in order to get deeper understanding related to the influences of above variables in these sectors.

The results showed that above variables, in analysis period, gave significant influences on structural changes of analyzed Indonesian industrial sectors. Based on the values of statistical significance, structural changes of all analyzed sectors got stronger influence from telephone lines than GDP per capita growth. The results also showed that, in analyzed sectors, the influences given by explanatory variables generated the different patterns. More specifically, the influence from growth of GDP per capita produced decreasing-increasing pattern for the sectors while increasing trend appeared from the influence of telephone lines.

This study could analyze the influences of GDP and ICT in structural changes of Indonesian industrial sectors from 1990-2005, especially focusing on the structural changes of ICT related sectors. The scope of this study, however, should be expanded further. This argument is especially based on the limited analysis period. This study only used three points period for analysis. Therefore, adding the period of analysis is a suggestion from this study when conducting the further research.

Finally, performing the international comparison in this topic is also suggestion for further research from this study. The comparison between developing and developed countries is a good example. More specifically, the comparison between this and previous studies, e.g. to focus on contrasting the results of influences of ICT on structural changes of national industrial sectors, will be interesting future work. This comparison will describe the characteristics of industrial structural changes of compared countries.

References

Lewis, C. W., & Hildreth, W. B. (2012). *Using the Gross Domestic Product to Measure the Role and Size of Government (Exercise)*. Available at http://global.oup.com/us/companion.websites/9780199859214/student/chapter7/pdf/usinggross.pdf. [accessed 22 March 2014].

AIMR. (2003). *The Top 10 Economic Indicators: What to Watch and Why*. Available at http://www.rbcpa.com/economic_fundamentals.pdf. [accessed 22 March 2014].

Gutierrez, C. M., Glassman, C. A., Landefeld, J. S., & Marcuss, R. D. (2007). *Measuring the Economy: A Primer on GDP and the National Income and Product Accounts*. Available at http://www.bea.gov/national/pdf/nipa_primer.pdf. [accessed 22 March 2014].

Kramer, W. J., Jenkins, B., & Katz, R. S. (2007). *The Role of the Information and Communications Technology Sector in Expanding Economic Opportunity*. Available at http://www.hks.harvard.edu/m-rcbg/CSRI/publications/report_22_EO%20ICT%20Final.pdf. [accessed 22 March 2014].

Gu, W., Terefe, B., & Wang, W. (2012). *The Impact of R&D Capitalization on GDP and Productivity Growth in Canada*. Available at http://www.statcan.gc.ca/pub/11-626-x/11-626-x2012016-eng.pdf. [accessed 22 March 2014].

Jordaan, J. C. (2013). *Impact of Interest Rate Changes on South African GDP and Households: A Combined Macroeconomic and Social Accounting Matrix Modelling Approach*. Available at http://www.unisa.ac.za/contents/faculties/service_dept/docs/Sabview_17_3_Chap%207.pdf. [accessed 22 March 2014].

Zuppo, C. M. (2012). Defining ICT in a boundaryless world: The development of a working hierarchy. *International Journal of Managing Information Technology*, *4(3)*, 13-22.

Zuhdi, U., Mori, S., & Kamegai, K. (2012). Analyzing the role of ICT sector to the national economic structural changes by decomposition analysis: The case of Indonesia and Japan. *Procedia-Social and Behavioral Sciences*, *65*, 749-754.

Zuhdi, U., Mori, S., & Kamegai, K. (2013). Analysis of Influences of ICT on Structural Changes in Japanese Commerce, Business Services and Office Supplies, and Personal Services Sectors Using Multivariate Analysis: 1985–2005. *The Asian Journal of Technology Management*, *6(2)*, 102-111.

Miller, R. E., & Blair, P. D. (2009). *Input–Output Analysis: Foundations and Extensions–2nd Ed*. New York: Cambridge University Press. ISBN: 978 0 521 51713 3.

The World Band. (2014). *Indonesia*. Available at http://data.worldbank.org/country/indonesia. [accessed 18 March 2014].

GAMS. (n.d.). *Welcome to the GAMS home page!*. Available at http://www.gams.com/. [accessed 12 November 2013].

Appendix

Industrial sectors of Indonesia used in this study

Sector No.	Sector Name
1	Paddy
2	Maize
3	Cassava
4	Other root crops include sweet potatoes

5	Groundnut
6	Soybeans
7	Other beans
8	Vegetables
9	Fruits
10	Cereals and other food crops
11	Rubber
12	Sugarcane
13	Coconut
14	Oil palm
15	Fiber crops
16	Tobacco
17	Coffee
18	Tea
19	Clove
20	Other estate crops
21	Other agriculture
22	Livestock and livestock product except fresh milk
23	Fresh milk
24	Poultry and its product
25	Other livestock raising
26	Wood
27	Other forest product
28	Sea fish and other sea products
29	Inland water fish and its product
30	Coal
31	Crude oil
32	Natural gas and geothermal
33	Tin ore
34	Nickel ore
35	Bauxite ore
36	Copper ore
37	Gold and silver ore

38	Other mining
39	Crude salt
40	Quarrying, all kinds
41	Meat and entrails of slaughtered animal
42	Processed and preserved meat
43	Dairy products
44	Canning and preserving of fruits and vegetables
45	Drying and salting of fish
46	Processed and preserved fish
47	Copra, animal oil and vegetables oil
48	Rice
49	Wheat flour
50	Other flour
51	Bakery product and the like
52	Noodle, macaroni and the like
53	Sugar
54	Peeled grain, chocolate and sugar confectionery
55	Milled and peeled coffee
56	Processed tea
57	Soya bean products
58	Other foods
59	Animal feeds
60	Alcoholic beverages
61	Non-alcoholic beverages
62	Tobacco products
63	Cigarettes
64	Yarn and cleaning kapok
65	Textile
66	Made up textile goods except wearing apparel
67	Knitting mills
68	Wearing apparel
69	Manufacture of carpet, rope, twine and other textile
70	Leather tanneries and leather finishing

71	Manufacture of footwear and leather products
72	Sawmill and preserved wood
73	Manufacture of plywood and the like
74	Wooden building components
75	Manufacture of furniture and fixtures mainly made of wood, bamboo and rattan
76	Manufacture of other products mainly made of wood, bamboo, rattan and cork
77	Manufacture of non-plastic plait
78	Pulp
79	Paper and cardboard
80	Paper and cardboard products
81	Printing and publishing
82	Basic chemical except fertilizer
83	Fertilizer
84	Pesticides
85	Synthetic resins, plastic and fiber
86	Paints, varnishes and lacquers
87	Drugs and medicine
88	Native medicine
89	Soap and cleaning preparation
90	Cosmetics
91	Other chemical products
92	Petroleum refineries products
93	Liquefied of natural gas
94	Smoked and crumb rubber
95	Tire
96	Other rubber products
97	Plastic products
98	Ceramic and earthenware
99	Glass products
100	Clay and ceramic structural products
101	Cement
102	Other non-ferrous products
103	Basic iron and steel

104	Basic iron and steel products
105	Non-ferrous basic metal
106	Non-ferrous basic metal products
107	Kitchen wares, hand tools and agricultural tools
108	Furniture and fixed primarily made of metal
109	Structural metal products
110	Other metal products
111	Prime movers engine
112	Machinery and apparatus
113	Electric generator and electrical motor
114	Electrical machinery and apparatus
115	Communication, electronic equipment and apparatus
116	Household electronics appliances
117	Other electrical appliances
118	Battery and storage battery
119	Ship and its repair
120	Train and its repair
121	Motor vehicle except motor cycle
122	Motor cycle
123	Other transport equipment
124	Aircraft and its repair
125	Measuring, photographic and optical equipment
126	Jewelry
127	Musicals instruments
128	Sporting and athletics goods
129	Other manufacturing industries
130	Electricity and gas
131	Water supply
132	Residential and non-residential buildings
133	Construction on agriculture
134	Public work on road, bridge and harbor
135	Construction and installation on electricity, gas, water supply and communication
136	Other construction

137	Trade
138	Restaurant
139	Hotel
140	Railway transport
141	Road transport
142	Sea transport
143	River and lake transport
144	Air transport
145	Services allied to transport
146	Communication services
147	Banking and other financial intermediaries
148	Insurance and pension fund
149	Building and land rent
150	Business services
151	General government
152	Education services
153	Health services
154	Other community services
155	Private motion picture and its distribution
156	Amusement, recreational and cultural services (private)
157	Repair shop n.e.c
158	Personal and household services
159	Other goods and services n.e.c

n.e.c.: Not elsewhere classified