An Analysis of the Relationships between IT Investments and the Industrial Structure Change in Japan using Input-Output Tables - Historical Analysis and Future Projection

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Abstract
The effects of IT on the environment and the economy have broadly been discussed. However, most of the case studies were descriptive due to the lack of data and methods. This paper proposes a method to evaluate the industry structure changes based on the Input-Output analysis developing an extended multivariate analysis. Revising our previous work, we provide the future projection including the estimation of the historical software investments. The results demonstrate the significant contributions of IT in the structural changes in Japan’s economy.

1. Introduction
There have been developed some investigations focusing on the effects of the rapid penetration of Information Technologies (IT) on the macro economy. Department of Commerce [1998] investigated that the contribution of IT to the US productivity growth is around 30-50%. Ministry of Economy and Industry in Japan [2000] reports 2.5 million employees will be created by IT in the next five years while 2.7 million workers may lose their jobs in main industry, 800 thousand people of which are replaced by IT penetration. METI pointed out that IT could create jobs, but industry and employment structure must change rapidly. Japan Center for Economic Research [2000] estimates the products of IT industry is already 92.9 trillion yen in 1997 which is around 18.8% of total GDP and will come to 126 trillion yen, 23.8% of GDP, in 2004.

However, these works have discussed mainly the impacts on whole economy and the

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impacts of IT on the industry structure changes have not been discussed explicitly. The authors provided empirical analysis on the effects of IT based on the historical Input-Output tables proposing a new method as an expansion of multivariate analysis (Yoda and Mori [2001]).

In this paper, we extend our previous work in the following manner: first, we estimate the historical software investment by industry sector to compare its effect with that of hardware. Second, investment coefficient vector of the certain industry is explicitly estimated applying the extended principal component for regression analysis (Extended PCR). Finally, we give the future projection of the structural changes.

2. The Method - Extended Principal Component for Regression (Extended PCR)

We focus on the industry structure changes caused by IT penetration. For this purpose, a method to analyze the relationship between the input data vectors and the output vectors is required. In this view, both traditional RAS method and the regression analysis are insufficient. We employ the extended multivariate method named extended principal component for regression analysis (Extended PCR), which was introduced by the author (Yoda et al [2001]). This method is formulated as follows: Let the number of sectors and the number of explanatory variables be N (n=1..N) and M (m=1..M) respectively. t denotes the period (t=1..T). \( \mathbf{a}_n \) (n×1) and \( \mathbf{b}_m \) (m×1) vectors denote the input coefficient vector of the industry sector n (dependent variable vector) and explanatory variable vector at period t, respectively. \( \mathbf{a}_n \) is non-negative and holds that the sum of the coefficients equals to unity. We assume a linear relationship model between \( \mathbf{a}_n \) and \( \mathbf{b}_m \) using intermediate variable \( \mathbf{z}_{pt} \) and estimation error term \( \mathbf{e}_m \).

\[
\mathbf{a}_n = \mathbf{c}_{0n} + \sum_p \mathbf{z}_{pt} \mathbf{c}_{pn} + \mathbf{e}_n
\]

\[
z_{pt} = \beta_{pn} \mathbf{b}_m, \quad \sum_n a_n = 1, \quad \mathbf{a}_n \geq 0, \quad \mathbf{\beta}_{pn} = 1 \quad (p = 1..P)
\]

Where P (p=1..P) represents the number of aggregated explanatory factors. Then we estimate the parameter vectors \( \mathbf{c}_{pn} \) (p=0…P) and \( \beta_{pn} \) minimizing the sum of errors,

\[
\text{min.} \sum_t \mathbf{e}_m^T \mathbf{e}_m
\]

Employing non-linear optimization technique, one can obtain the estimators.

3. The Data sources: Input-Output Tables and Software Investments

Similar to our previous work (Yoda and Mori [2001]), we extract the input coefficient
vectors from Japan IO tables for 1980-1997 aggregating the industry sectors into sixty-five. IT investment categories are (1) copy machines, (2) word processors, (3) other office equipments, (4) computers, (5) computer peripherals, (6) wired communication appliances, and (7) wireless communication appliances. Due to the data availability, we aggregate the investment coefficient sectors into the twenty-seven groups similar to our previous work. Historical software investments for 1985-1998 of the whole economy are distributed among sectors based on the 1995 data.

4. Simulation Results

4.1 IT investment coefficients and Input coefficients – analysis of structure changes

Firstly, we apply the extended PCR to the estimation of distribution share of the seven IT categories among 27 industry groups. We then applied the extended PCR to the historical input coefficients of 65 industry sectors to evaluate the structural change employing GDP, the hardware investments of seven IT equipments with and without software investments for 1985-1998. We also calculate their projected values until 2002. Figure 1 compares the historical series and their estimates for four industry sectors. These figures suggest that (1) extended PCR generates fairly well fitness and (2) estimates with software investments represent the historical changes better than those without software.

4.2 Statistical test of the estimators

Statistical significant test is indispensible to evaluate the contribution of IT investments. We applied a likelihood ratio test to see it comparing the reference case employing GDP and IT investments as explanatory variables with the case excluding GDP and the case excluding IT investments. The test results represent that IT investments are statistically significant with 95% reliability for all sectors.

4. Conclusion

Applying an extended PCR, we analyzed the relationships between IT investment and the industry structure change and estimated the projected Input-Output tables with 65 sectors. The results provide the assessments of the contribution and impacts of IT equipments under the ongoing structural changes of economies. This research is financially supported by the Japan Foundation Center for Global Partnership.
Figure 1 Historical input-output coefficients and their estimates – based on GDP and IT hardware investments with and without software investments

References