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The growth of ICT investment in OECD countries

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Abstract

ICT investment has come to represent a growing portion of total investment. ICT accounts for an increasing share of investment in all sectors. In this paper, a model is estimated forecasts largely predicted the share of ICT investment in non-residential fixed capital formation, as a percentage of totals no-residential fixed formation, total economy, in OECD countries. For the empirical analysis we use data for the period 1990-2003. In this study, we examined the forecasting with the time-series data analysis methods using ordinary least squares (OLS) and specify interesting speed growth of ICT investment in different countries.

Keywords: Investment, ICT, least square method, Forecast

1. Introduction

Information and Communications Technologies cover a widely list of products and services, that list is ever going to expanding. ICT drives a significant function in social change and economic change of society.

ICT investments include investment in computer equipment, communications equipment and software.

The Impact of ICTs on productivity before middle of 1990 was not clear, and it called “productivity paradox” named after Robert Solow (who said ”we see computer everywhere except in the productivity”). During this period time (1980-1990s) empirical research generally did not find relevant productivity improvements associated with ICT investment (Bender, 1986; Lovemann, 1988, Strassmann, 1990).

Nowadays ICT impact on productivity is obvious special for economists.

Investment in physical capital is important for growth. It is a way to expand and renew the capital stock and enable new technologies to enter the production process.

Information and communication technology (ICT) has been the most dynamic component of investment in recent years. ICT shares in total non-residential investment doubled, and in some cases, even quadrupled between 1980 and 2003. In 2002/2003, ICT shares were particularly high in Sweden, Finland, Australia and the United States.

Software has been the fastest growing component of ICT investment. In many countries, its share in non-residential investment multiplied several times between 1980 and 2003. Software’s share in total investment is highest in Denmark, Finland, Sweden and the United

States (OECD, 2006).

2. Investment in ICT

The rapid growth in ICT investment has been fuelled by a rapid decline in the relative prices of computer equipment and growing scope for the application of ICT (Jorgenson, 2001). The benefits of lower ICT prices have been felt across the OECD, as both firms investing in these technologies and consumers buying ICT have benefited from lower prices. The lower prices of ICT are only one of the drivers of investment; however, firms have also invested in ICT as it offers large potential benefits (Pilat et al, 2003).

The ICT investment boom did not start at the same time in every country. The United States has been strongly investing in ICT equipment since the eighties. Two stages can be distinguished. The first one is linked to the development and diffusion of personal computers at the beginning of the eighties. The second one is linked to the emergence of the Internet from the middle of last decade (Baudchon , 2002)

3. Theories of Least Square Method

The least square method—a very popular technique—is used to compute estimations of parameters and to fit data. It is one of the oldest techniques of modern statistics as it was first published in 1805 by the French mathematician Legendre in a now classic memoir. But this method is even older because it turned out that, after the publication of Legendre's memoir, Gauss, the famous German mathematician, published another memoir (in 1809) in which he mentioned that he had previously discovered this method and used it as early as 1795. A somewhat bitter anteriority dispute followed (a bit reminiscent of the Leibniz-Newton controversy about the invention of Calculus), which, however, did not diminish the popularity of this technique. Galton used it (in 1886) in his work on the heritability of size which laid down the foundations of correlation and (also gave the name) regression analysis. Both Pearson and Fisher, who did so much in the early development of statistics, used and developed it in different contexts (factor analysis for Pearson and experimental design for Fisher).

Nowadays, the least square method is widely used to find or estimate the numerical values of the parameters to fit a function to a set of data and to characterize the statistical properties of estimates. It exists with several variations: Its simpler version is called ordinary least squares (OLS), a more sophisticated version is called weighted least squares (WLS), which often performs better than OLS because it can modulate the importance of each observation in the final solution. Recent variations of the least square method are alternating least squares (ALS) and partial least squares (PLS) (Abdi ,2003)

The method of linear least squares may be used to determine the best constants in a given form of equation and also for establishing the best form of equation for a given set of data. The best constants are first evaluated for each form of equation under consideration. The best form of equation is then that for which the average of the squares of the deviations is the least. (Hougen and Watson, 1959)

Unfortunately this method has a number of defects. (Seinfeld and Lapidus, 1974) Foremost among these is the fact that few rate equations of any complexity occur in the desired linear form. As a result the rate equation must be linearized or rearranged to be handled by this method. Thus the original distribution of errors are not preserved (Hopper et al, 2001)

The principle of least squares aids in determining the line that best describes the trend of the data. The principle states that a line of best fit to a series of values is a line the sum of the squares of the deviations (the differences between the line and the actual values) about which will be a minimum. There can be only one line having this qualification.

Advantages:

a. Results obtained under the method are definite and independent of any subjective estimate on the part of the statistician.

b. The resulting equation is in convenient form for extrapolation (extension into future or past).

Disadvantages:

The method is based on the assumption that the data follows a trend that can be expressed by a mathematical equation.

In numerical descriptions, such as a time series of numbers, a secular trend is the long-term upward or downward trend in the numbers, as opposed to a smaller cyclical variation with a periodic and short-term duration.

4. Review of Empirical Studies

Bhattacharry M. N. university Queensland in Australia in the paper "Forecasting the demand for telephone in Australia" Jstore 1974,no 23, a time series developed for forecasting the demand for telephone in Austria and use linear least squares method.

Clopper Almon in the book "The Craft of Economic Modeling" (University of Maryland, 2001) explain Economic models and concepts of Least squares regression for forecasting.

Halber White in "Economic prediction using neural networks: the case of ibm daily stock returns" (Neural Networks, 1988., IEEE International Conference on, On page(s): 451-458 vol.2) used the Method of Least squares and wrote:" the method of least squares (equivalently, back-propagation) is adequate for testing the efficient markets hypothesis, it is not necessarily the method that one should use if interest attaches to building a network for market trading purposes. Such networks should be evaluated and trained using profit and loss in dollars from generated trades, not squared forecast error. Learning methods for this criterion are under development by the author."

Kazimierz Z. Poznanski in the article "Diffusion performance of major steel-making countries: alternative econometric tests", (Journal Economics of Planning, Issue Volume 23, Number 2 / January, 1990, Publisher Springer Netherlands,) compare the speed of diffusion in major steel-making countries. This is a cross-system analysis, involving industrial market countries (Western Europe, the United States, Canada, and Japan), quasi-market economies (selected newly industrializing countries, India), and the central planning states (the Soviet Union and Eastern Europe). The study reveals that at least in this, significant case, the latter countries are clearly inferior, i.e. slower.

The article seeks the most accurate measure of speed of diffusion of one radical steel innovation, the oxygen process. The speed is estimated by regressing a logistic function not applied to the steel industry to date. Parameters of a logistic function are estimated first with linear least squares methods and then with nonlinear (or iterative) least squares, to establish which offers more accurate estimation than the widely used linear approach. It is shown that the iterative method produces a better statistical fit.

Agnar Ho¨skuldsson in "Stable solutions of linear dynamic models" (Journal of Chemometrics, 2000; 14: 401–421) present a new approach to analyse dynamic models. It is based on the H-principle of mathematical modelling. The key issue is to identify the covariance matrices involved and solve the set of equations by steps, where at each step we optimize the selection of the covariance. The advantage of the procedure is that updating of model estimates in linear least squares, biased estimation and Kalman filtering can be achieved in a stable and secure manner.

5. Data

This section provide a short description of OECD data- share of ICT investment in non-residential fixed capital formation, as a percentage of total no-residential fixed formation, total economy, which is used in following analysis. We use time series data and apply Secular trend with lowest square for forecasting. We use data from Economic, Environmental and Social Statistics OECD 2006. We have three categories of data:

-The data are for six countries (Austria, France, Japan, New Zealand, Norway and Spain) from 1990 until 2002

-The data for other 14 OECD countries from 1990 until 2003

-The data for South Korea from 1995 until 2003

We have separate calculation for these three groups.

Estimates of investment levels and shares of ICT investment in GDP and in total non residential Gross Fixed Capital Formation (GFCF) permit the comparison of ICT investment across countries. The OECD estimates are based on national data and Groningen Growth and Development Centre Total Economy Growth Accounting Database, total GFCF and GDP are based on estimates from the OECD Annual National Accounts.

ICT has three components: information technology equipment (computers and related hardware), communications equipment and software. Software includes acquisition of pre-packaged software, customized software and software developed in house.

The investment shares are percentages of each country's gross fixed capital formation, excluding residential construction.

6. Empirical Results and Discussion

6.1 The test result

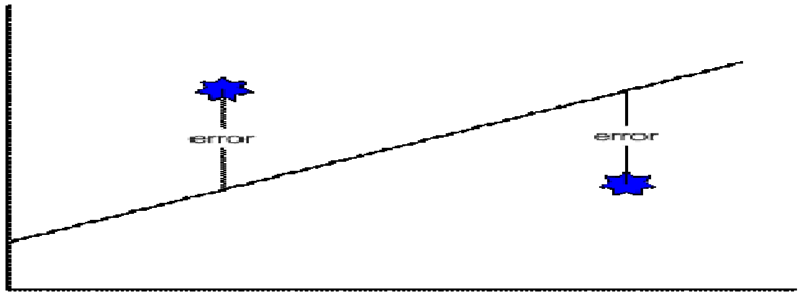

Figure 1: Errors in Line model

We need an agreement here that our best line model is really the optimum line. The best line model is the line model that minimizes the sum of error. We know some error is positive and some of the error is negative. The sum of error may be zero. If we sum all the error, we may get many lines. The most common agreement among scientist and engineers, mathematician and statistician is a criterion that the best line model should minimize the sum square error. When we square the error, regardless it is positive or negative, the number become positive (Teknomo, 2006).

6.2 Discussion of the Result

ICT shares in total non-residential investment doubled, and in some cases, even quadrupled between 1980 and 2003. In 2002/2003, ICT shares were particularly high in Sweden, Finland, Australia and the United States.

To predict the ICT investment (Y value) for the year 2010, we can name the slope, intercept and next year cells and then compute

the prediction = next year * slope + intercept.

In our result, slop of our prediction and intercept are positive. It means our ICT investment will increase every year. For example we have for Australia in year 2010:

Australia2010 =0.9392*(2010-1996) + 21.613 =34.8

As we see in figure below, in year 2015, the ICT investment in U.S.A, Finland, Sweden and Australia will be very high in compare with other OECD countries. In other hand, ICT investment in Austria, Portugal and Greece will be very low.

Time series based on historical data allows us to estimate the relationships that existed in the past. As we intended to use the econometric results to drive a forecasting model, we always kept in mind the need to identify relationships that are likely to be fundamental to future trends, as well as relationships that were fundamental in the past.

Our result shows that growth of investment is not %100 percent related with the value of ICT investment in 2002. For example in 2002, the value of ICT investment in Korea is little than in Belgium and Canada but in 2015 the growth in Korea is more than other two countries. Japan has in 2002 has investment little than Denmark, France, Germany, Spain and Italy, but its growth in 2015 is more than these countries. It means that calculation the intercept and slop for prediction are very sensible to supply data and their growth in our collection data.

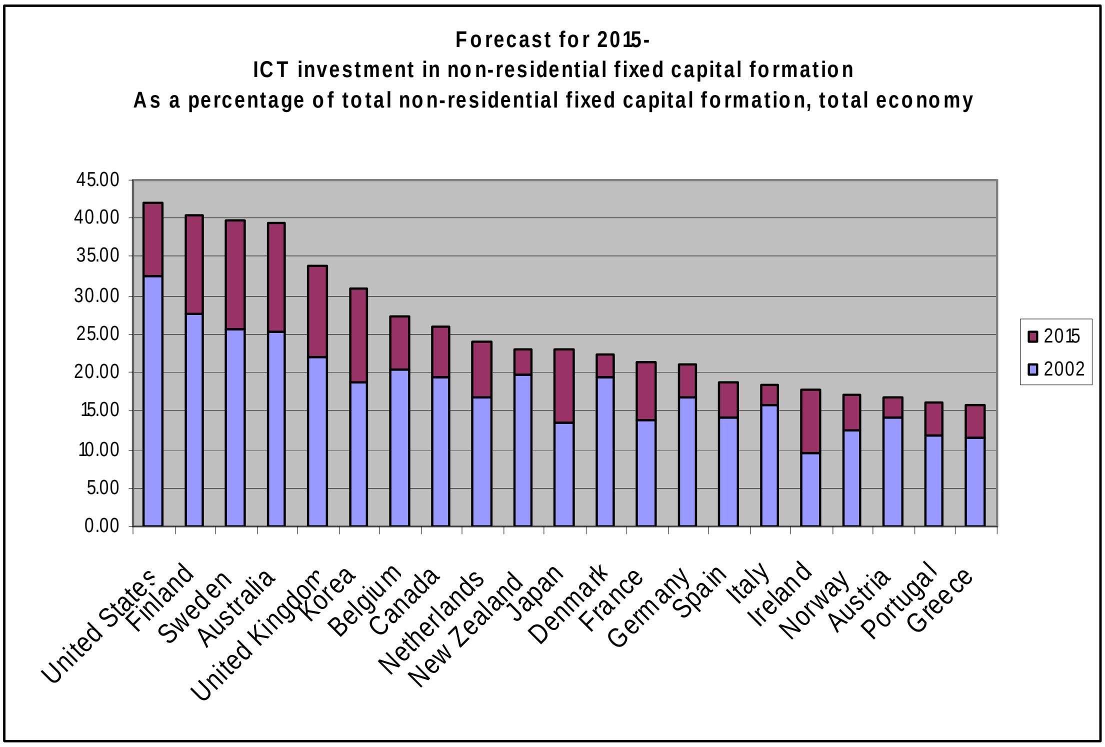

Figure 2: Forecast of ICT Investment

The table below shows growing of share of ICT investment in non-residential fixed capital formation, as a percentage of total no-residential fixed formation, total economy, in year 2015 compare with the data of 2002. The maximum grow is for Australia and Sweden with 14.16 and 14.12 percent. Italy and Austria have minimum grow with 2.88 percent.

Table 1: Growth of share of ICT investment

Countries	2015	Grow after 2002
United States	41.99	9.57
Finland	40.26	12.62
Sweden	39.65	14.12
Australia	39.5	14.16
United Kingdom	33.93	11.89
Korea	30.78	11.97
Belgium	27.32	6.98

Canada	26.07	6.73
Netherlands	24.05	7.28
New Zealand	23.1	3.52
Japan	23.0	9.39
Denmark	22.47	3.08
France	21.3	7.64
Germany	20.95	4.07
Spain	18.6	4.54
Italy	18.55	2.88
Ireland	17.61	7.97
Norway	17.1	4.50
Austria	16.86	2.88
Portugal	16.23	4.31
Greece	15.85	4.39

7. Conclusion

This paper predicts the growth of share of ICT investment in non-residential fixed capital formation, as a percentage of total non-residential fixed formation, total economy, in OECD countries and discuses and compare these growth between OECD countries over the next years.

The relationship between information and communications technology (ICT) and productivity has been extensively debated over the last three decades.

Information and communications technology investment includes investment in computer equipment, communications equipment and software. It is important to note that ICT investment does not include silicon chips embodied in other goods.

ICT shares in total non-residential investment doubled, and in some cases, even quadrupled between 1980 and 2003. In 2002/2003, ICT shares were particularly high in Sweden, Finland, Australia and the United States.

The paper also demonstrates that in some countries with strong growth in ICT investment the 1990-2002, will lead continually this boost. Our estimate shows the United States will comprise highest investment in ICT in 2015 and the role of ICT strategy in Korea and Japan will manipulate their speed growth.

In this study, we examined the forecasting with the time-series data analysis methods using ordinary least squares (OLS). Our result indicates that speed of growth of investment in different countries is not similar and is not %100 percent related with the recent value of ICT investment. It means that calculation the intercept and slop for prediction are very sensible to supply data and their growth in our collection data.

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