Technological Change and ICTs in OECD countries

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ABSTRACT

The motivation of the study is to form a ground for further research on the issue of the effect of electronic commerce on economic variables that has been supported by empirical models. In this respect, a considerable part of the study is devoted to the discussion of the building significant relationship between technology, electronic commerce and the fundamentals of the real economy. As a result of both the conceptual part and the analytical part, two important conclusions were drawn. The first one is that technological change is increasingly gaining special emphasis especially with the rising arguments on the issue of "New Economy". The second important point is that technological change and electronic commerce are in relation with the most important variables of the real economy like gross domestic product, investment, trade balance and also R&D expenditures.

Keywords: Technological Change, ICTs, E-commerce, employment, macroeconomics, OECD.

JEL Codes : 033, M54

1. INTRODUCTION

Growth of electronic commerce and especially Information and Communication Technologies (ICT), which formed an infrastructure for the progress of usage of electronic commerce, has become an important interest area especially for the OECD countries and subsequently for the developing countries. This stems from the fact that evolution of information technologies plays an important role for the development dynamics and the basic macroeconomic fundamentals of the countries that utilize these technologies. Macroeconomic fundamentals refer to the variables that affect the working of the whole economy. Examples to some of those variables are; growth rate of GDP, unemployment, investment, exports, imports, inflation and productivity. However, there is a problem related with the difficulties of the measurement of the net effect of these technologies on the macroeconomic fundamentals in question. The reason why this measurement is so difficult is that, newly developing technologies are at a very early stage and therefore researchers could not form a coherent statistical background for the purpose of developing valid relationships between the impacts of these new technologies and the variables of economic sphere. The insufficiency of measurement is notably evident for the case of electronic commerce usage.

The economic literature specifically related to the results of the technological change that has been evolved especially in the second half of 1990s puts considerable emphasis on the effects of electronic commerce and Information and Communication Technologies (ICT) on the productivity, growth, unemployment, and in general, market economy of the specific countries that utilizes these technologies intensively. Especially, when electronic commerce is considered, as the concept is historically not too old for most of the OECD countries, there are various studies trying to determine the measurement process related to the usage of electronic commerce and the impacts that can be observed along with the wider usage of this technology. It is not surprising to see insufficient amount of studies that try to test the impacts of electronic commerce on economy utilizing econometric tools, as statistics related with electronic commerce differ with the source and may fail to be accurate at this early stage. However, there are recent studies, which try to measure the effect of widening usage of electronic commerce especially on price competitiveness related with the widening usage of business-to-consumer electronic commerce, as business-to-consumer electronic commerce is most commonly used in online retail shopping.

There are various empirical studies based on the possible effects of new-technologies on the skill-composition of labor and the effects on productivity, growth and other economic variables especially for the manufacturing industry. The reason why these studies are generally applied for the manufacturing industry is related with the availability of data for the manufacturing sector and difficulty of measurement in the services industry. This study also aims to measure the effects of technological change and the usage of electronic commerce on the economic variables like productivity, growth and trade, for the manufacturing industry and the telecommunications sector.

The literature on the relation between technology and employment situation can be analyzed through various channels. The first channel was related to the concept of skill-biased technological change.[1] Accordingly many studies have found that technological change has increased skill demand and required new work practices. This change will have an effect on the labor market so that in some sectors where new skills are required with the adoption of new technologies there will be job creation. On the other hand, in sectors that do not use high technology it is most probable that there will be job destruction. In this framework, what is most important is the net effect of the gross job creation and gross job destruction.

The second channel of the literature survey was related to the issue of the effect of technological change on wages.[2] Recent studies suggested that wage increases for workers using advanced technology are much greater than workers that do not use high technology. Most studies considered above found out that skill-biased technological change leads to an increase in the relative demand for high-skilled workers and in this framework pushes the wages of workers in the high-tech industry.

Short-run impacts of the skill-biased technological change on the labor and product markets with the assumption of perfect competition have been listed briefly in Brown and Campbell (2000). Accordingly, the most effect is related to rising returns to skill. The authors explained this phenomena as; if a firm experiences a technological shock that increases the demand for high-skilled workers relative to the supply of high-skilled workers in the economy, then wages for high-skilled workers increase relative to that of low-skilled workers. In this way, the return to education will have increased, and

[1] For a detailed discussion of this literature see for example Nelson and Phelps (1966), Wallace (1989), Berman, Bound and Griliches (1994), Colecchia and Papaconstantinou (1996), Bresnahan, Brynjolfsson and Hitt (1999), Berman, Bound and Machin (1998), Sanders and Weel (2000), Berman and Machin (2000), Roed and Nordberg (2000), Greenan, Mairesse and Bensaid (2001).

even high-skilled workers in other firms that do not experience a technological shock will receive higher wages in the short run (Brown and Campbell, 2000:4).

To sum up, it is commonly accepted that in the short run technological change has an effect on the skill requirements of the workers, that causes job flows between different industries. These job flows are more volatile in the high-tech sectors especially when the manufacturing industry is concerned. Also these shifts create wages of the workers that uses advanced technology to increase. However, although short-run effects are signals gross shifts in the employment levels, long-term net effects needs further study which is beyond the scope of this study.

Within this framework, the motivation of the study is to form a ground for further research on the issue of the effect of electronic commerce on economic variables that has been supported by empirical models. In this respect, a considerable part of the study is devoted to the discussion of the building significant relationship between technology, electronic commerce and the fundamentals of the real economy.

2. Technological Change, E-Commerce, and Macroeconomic Fundamentals in OECD Countries

The main objective of the empirical part of this study is twofold. The first one is to test whether there is a significant relationship between different types of technological change indicators and macroeconomic fundamentals of the OECD countries, and the second objective is to test if there is a relationship between information technology or more specifically electronic commerce usage variables and the macroeconomic fundamentals in question. These macroeconomic fundamentals cover variables like productivity, growth, trade, investment, which have an effect on the working of the whole economy in general. Within this framework, if a significant relationship between the technological change, electronic commerce and economic variables is set properly, and then comes the examination of the direction of this relationship. In this chapter of the study, for the objective of setting a clear relationship between the electronic commerce and technological change indicators, and variables like productivity, growth, trade and R&D expenditure, data of total manufacturing industry for a panel of OECD countries is utilized for the period between 1970 to 1997. The relationship is set within the framework

[2] The examples of such studies are Krueger (1993), Goldin and Katz (1998), Murphy, Riddell and Romer (1998), Chennells and Reenen (1999), Bartel and Sicherman (1999), Galor and Moav (2000)

of two Ordinary Least Square (OLS) models and panel data estimation procedure has been utilized for the regression equations.

2.1. The Data, Variables, and the Models

Three data source is utilized within the framework of this study. What is common to all three databases is that, they are in annual frequency and belong to selected OECD countries. These data sets are ANBERD (Analytical Business Enterprise Research and Development) database, which aims to provide a consistent dataset for the international comparison of official business enterprise R&D. The database is designed by OECD Secretariat to supply researchers time-series data on industrial R&D expenditures for 14 of the largest R&D performing OECD countries for the 1973-1998 period. One of the most important characteristic of this dataset is that, the time-series data is compatible with the data provided by OECD, STAN database, which is the second data source utilized within the framework of this paper.

- STAN database aims at providing researchers with time-series data that is compatible with national accounts of 22 OECD countries. It covers 49 manufacturing industries for six variables with annual data for the period 1970 and 1997.

The third important database for the empirical part of this study is OECD Telecommunications Database, which provides time-series data covering 29 OECD countries, from 1970-97 where available. Telecommunications database contains both telecommunication and economic indicators such as telecommunications infrastructure, revenues, expenses and trade in telecommunications equipment. The indicators that have been exploited from this database are access lines per total staff in telecommunications services, Internet hosts per total staff in telecommunications services, total PTO revenue per employee in US dollars, total PTO investment per employee in US dollars, trade balance in telecommunications equipment per total staff and GDP per capita in US dollars.

In this section of the study variables of the two models will be explained in detail.[3] Starting with the first model, it can be noted that first model aims to build a relationship between two different technological change variables and productivity, trade, investment, and R&D variables.

[3] Explanations for the variables of both models has been illustrated in Appendix .

The first model can be specified as:

$$\Delta PT_{it} = \alpha_0 + \alpha_1 \Delta PT_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta PR_{it} + \alpha_9 \Delta PR_{i,t-1} + \varepsilon_{it} \ldots\ldots\ldots\ldots$$

Taking into consideration the technological change variables, which are dependent variables of the model, the first dependent variable is the number of national patent applications according to the relationship of the patentee to patent office that can be considered as partial proxy measures of the output of R&D in the form of inventions (OECD, 2001). Second dependent variable is the inventiveness coefficient that is found by dividing number of resident patent applications by population. In the equation that has been specified above, the dependent variable is set as patents. However, as will be considered in the coming parts of this chapter, inventiveness ratio is the other dependent variable of the first model.

When the independent variables are pondered, the first variable, investment, is defined as gross fixed capital formation per number engaged. Productivity variable is defined as value added per number engaged. R&D variable is defined as R&D expenditures for the total manufacturing industry per number engaged. The last variable is trade balance that can be defined as exports minus imports per number engaged for the total manufacturing industry.[4]

The expected relationship between the dependent variables of the first model, namely the patents and inventiveness ratio, and the independent variables can be summarized briefly. Considering the relationship between the technological change and investment, it is expected that the two variables have a positive relationship. The same positive relationship is again expected between the technological change variables and productivity and R&D expenditures. Considering the relationship between trade balance and technological change, it can be stated that, the expected sign is dependent on the position of balance of net exports and net imports. In other words, the relationship between the technological change and the trade balance of a country very much depends on whether the country is a net exporter or a net importer of the technology in question.

[4] All the variables related to the first model are for the total manufacturing industry.

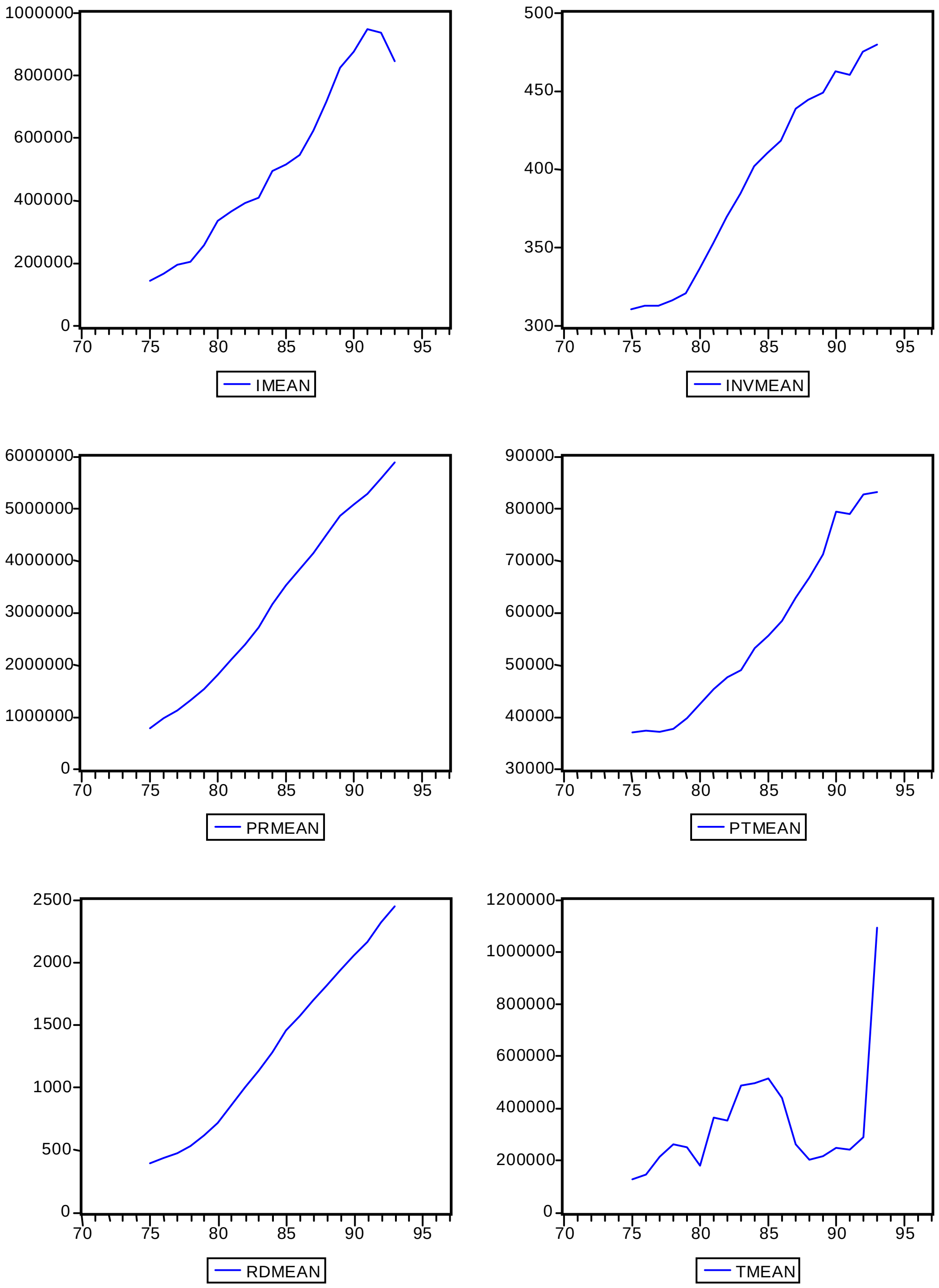
Table 1: *Descriptive Statistics of the Variables of First Model[5], Covering 14 OECD Countries, 1977-1973 (in US dollars)*

	I	INV	PR	PT	RD	T
Mean	516402.5	392.7	3191190.0	56152.9	1310.9	336631.8
Median	17673.8	272.0	102365.3	29073.0	1015.9	4745.0
Maximum	10278991.0	2715.4	67298762.0	383926.0	5021.3	14589261.0
Minimum	451.8	39.3	3613.4	3761.0	99.2	-1326689.0
Std. Dev.	1652182.0	492.2	10386725.0	73639.5	1038.9	1274133.0
Std.Dev/Mean	3.2	1.3	3.3	1.3	0.8	3.8
Skewness	4.3	3.4	4.4	2.7	1.3	6.4
Kurtosis	22.2	14.9	22.7	10.8	4.7	63.0
Observations	266.0	266.0	266.0	266.0	266.0	266.0
Cross sections	14.0	14.0	14.0	14.0	14.0	14.0

In Table 1, descriptive statistics of the variables of the first model are given in detail for panel of countries.[6] There are a total of 266 common observations for 14 countries. It is easily observed that there are huge differences between the minimum and maximum numbers of the variables, which is though to be originating from the long period of the database that includes 19 years. One thing should be noted that, the descriptive statistics above are for balanced data that covers the period utilized in the model according to balanced data estimation. The mean of variables can be observed easily from Figure 1, which graphs time period means of the variables. Another important point related to the descriptive statistics of the variables is that, in the models that has been estimated for analysis, first differences of the series have been utilized in general.

[5] Fourteen industrialized countries that have been utilized for the first model is Australia, Canada, Denmark, Spain, Finland, France, Germany, Italy, japan, Netherlands, Norway, Sweden, United Kingdom and United States.

Figure 1: *Time Period Means of the Variables of First Model, 1975-1993*



When Figure 1 is examined, it can be observed that for the investment variable, year 1991 is a turning point and after that point investment per number employed stars to show a declining trend for the panel of 14 countries. Except trade variable, this turning point is not obvious in other variables. In general for all the variables there is an upward

[6] Explanations for the variables takes place in Appendix.

trend. Considering the trade data, between the period 1985 and 1992 we observe a declining trend, but after 1992 there is a sharp increase, which can be explained with increasing positive trade balance of the 14 countries for the manufacturing industry.

When we analyze other descriptive statistics for the first model briefly (Table 1), it can be observed that all the series of the first model have positive skewness. The skewness of a symmetric distribution, such as the normal distribution, is zero. Positive skewness means that the distribution has a long right tail. Considering the kurtosis statistics, if the kurtosis exceeds 3, the distribution is peaked (leptokurtic) relative to the normal, and it is clear that for all the series kurtosis statistics are greater than 3.

Another statistics that should be analyzed is the ratio of standard deviation to mean, which shows the volatility of the data. For all of the variables except R&D series, this ratio is greater than 1, which signals to the volatility of the time period data. If all the variables are analyzed within the framework of this ratio, between the years 1973 and 1986 value of this ratio increases for nearly all the variables with the exception of R&D and trade series. This situation points to an increasing variation beginning with the year 1973, till the middle of 1980s. Figure 1 shows that variation decreases starting from 1973 for R&D data and also increases after middle of 1980s for trade data.

Table 2: *Descriptive Statistics of the Variables of First Model Covering 3 Developing Countries of OECD[7], 1976-1997 (in US dollars)*

	I	INV	PR	RD	T	PT
Mean	2685398.00	190.37	47606.52	4823.35	0.00	21440.50
Median	80.59	5.94	66450.34	1646.75	-0.01	9078.00
Maximum	9162378.00	639.69	75646.67	12774.67	0.17	60575.00
Minimum	0.00	2.49	461.79	1156.69	-0.13	1226.00
Std. Dev.	4218563.00	292.37	36548.68	5301.40	0.11	25767.96
Std.Dev/Mean	1.57	1.54	0.77	1.10	-241.96	1.20
Skewness	0.79	0.79	-0.67	0.76	0.29	0.73
Kurtosis	1.74	1.74	1.50	1.68	1.74	1.73
Observations	6.00	6.00	6.00	6.00	6.00	6.00
Cross sections	3.00	3.00	3.00	3.00	3.00	3.00

In Table 2 descriptive statistics of the variables of the first model are given for 3 developing countries. As can be seen from the table, there are only 6 observations for 3 cross section variables. Mean values of the variables are significantly high with the exception of trade data. Considering the variation ratio, it can be easily observed that the numbers are slightly higher than 1 with the exception of trade variable, which means that the series do not show great volatility for the period in question.[8]

Within the framework of this study, the second model aims to build a relationship between two different dependent variables, which are substituted as an indicator for the usage of electronic commerce, and economic fundamentals as growth, investment, revenue, trade and R&D.

The second model can be specified as:

$$\Delta A_{it} = \alpha_0 + \alpha_1 \Delta A_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta R_{it} + \alpha_9 \Delta R_{i,t-1} + \alpha_{10} \Delta G_{it} + \alpha_{11} \Delta G_{i,t-1} + \varepsilon_{it} \ldots\ldots\ldots\ldots$$

Starting with the dependent variables, in the first part of the study it has been stated that OECD countries have started to collect data for the measurement of first stage of electronic commerce (Figure 2). Within this framework, Internet hosts and number of access lines figures[9] are utilized as dependent variables for this study. In the equation above, access lines has been illustrated as the dependent variable. These two variables, access lines and Internet hosts are related to the telecommunications infrastructure available in a country and indicate the measurement of first stage of electronic commerce.

Considering the independent variables, the first variable, growth, is defined as Gross Domestic product per capita in US dollars. Investment variable in this model can be defined as total postal telecommunication investment per total employee in the telecommunication services in US dollars. Revenue variable is the total postal telecommunication revenue per employee in US dollars. R&D data is total expenditures for the manufacturing industry per number of employees in telecommunication services. The last variable is trade balance in communications equipment.

The expected relationship between the dependent variables of the second model, namely the number of access lines and Internet hosts, and the independent variables can be summarized briefly. Considering the relationship between the access

[7] Three developing countries in question are, Korea, Mexico and Turkey.
[8] But, this low level of volatility may be related to the short span of data available for the developing countries. Therefore, interpretations on the levels of variation ratio should be considered with care.
[9] This data is extracted from OECD Telecommunications database.

lines, Internet hosts and GDP, it is expected that the two variables have a positive relationship. It is expected that the growth of the economy requires more infrastructure related with the usage of telephone lines, which will increase the number of access lines. Internet usage will also increase with growing economy. In the model GDP per capita is utilized as a proxy as this proxy is a better measure of wealth of the country. The same positive relationship is again expected between access lines, Internet hosts and productivity and R&D expenditures. Considering the relationship between trade balance and access lines and Internet hosts, again it can be stated that, the expected sign is dependent on whether the country is a net exporter or net importer of goods in the telecommunications sector.

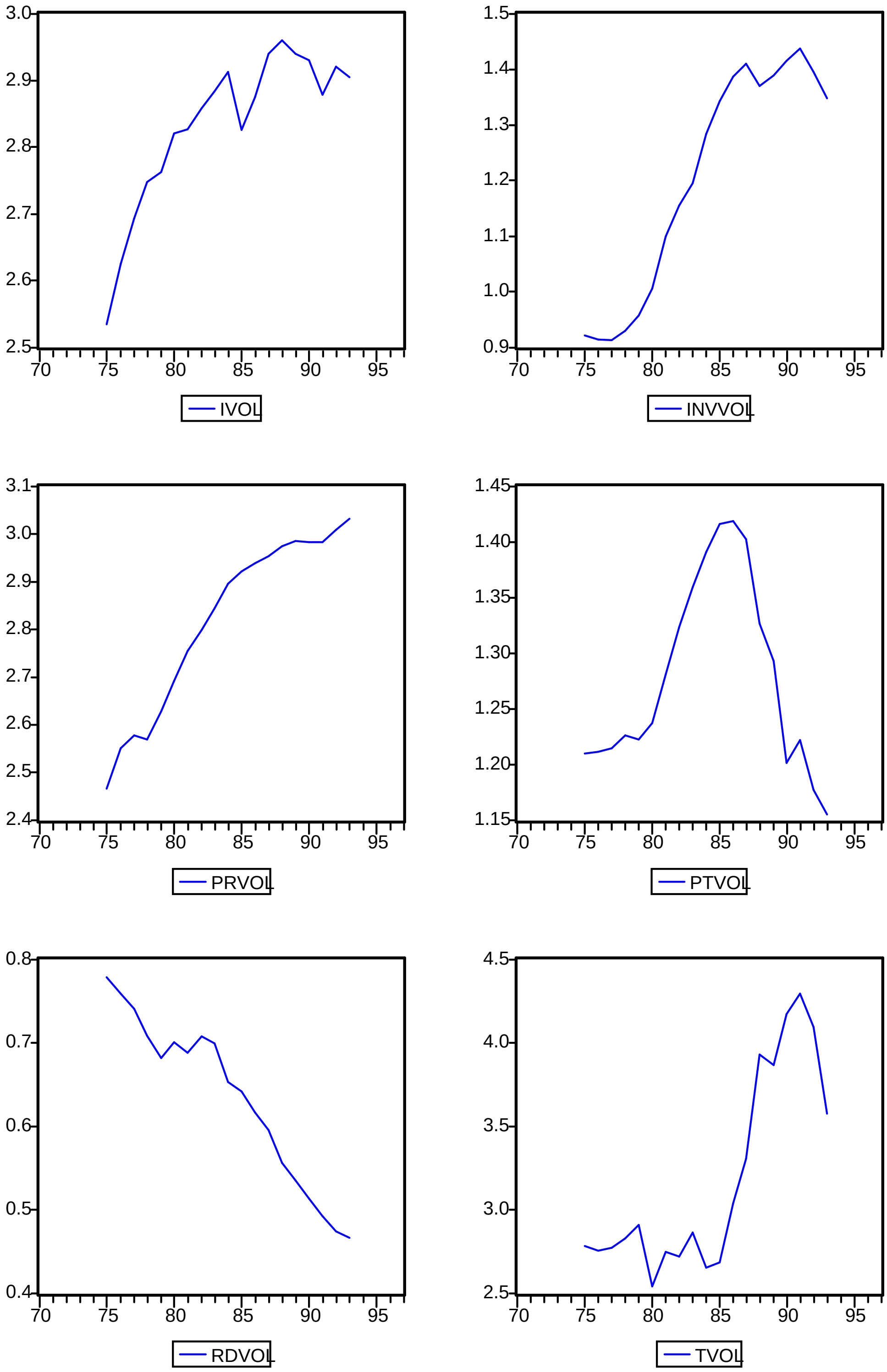
Table 3: *Descriptive Statistics of the Variables of Second Model Covering 15 Industrialized Countries of OECD*[10]*, 1982-1993 (in US dollars)*

	A	G	I	IH	R	RD	T
Mean	167.1	21440.1	41411.0	0.4	148384.4	64529.9	2142.6
Median	168.3	21226.6	32782.2	0.3	137722.8	54955.8	-5116.7
Maximum	259.4	34331.9	97859.7	1.8	287780.8	194011.9	70970.9
Minimum	77.4	12217.4	16913.7	0.0	93665.4	13359.1	-31379.7
Std. Dev.	45.5	5076.0	22180.0	0.4	39186.7	45293.6	22718.8
Std.Dev/Mean	0.3	0.2	0.5	1.0	0.3	0.7	10.6
Skewness	0.0	0.3	1.1	1.3	1.1	1.3	1.5
Kurtosis	2.3	2.6	3.2	3.9	4.9	4.5	4.4
Observations	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Cross sections	15.0	15.0	15.0	15.0	15.0	15.0	15.0

In Table 3 descriptive statistics of the variables for the second model are given in detail for a panel of 15 OECD countries. There are a total of 45 common observations for 15 countries.

[10] To 14 countries of the first model, Ireland is included.

Figure 2: *Time Period SD/Mean of the Variables of First Model, 1975-1993*



Considering the descriptive statistics of the second model, it can be observed that the differences between the minimum and maximum numbers of the variables are not so big as the first model, which is thought to be related to the shorter span of time for the second model. The database of the second model is form the OECD telecommunications data, for this reason it covers the period between 1980 and 1997. Again, the descriptive statistics above are for balanced data that covers the period utilized in the estimation of the model.

When we analyze other descriptive statistics briefly, it can be observed that, except number of access lines and growth variable, all the series of the second model has positive skewness. Considering the kurtosis statistics, if the kurtosis exceeds 3, the distribution is peaked (leptokurtic) relative to the normal, and it is clear that, with the exception of number of access lines and growth variables, kurtosis statistics are greater than 3. Considering coefficient of variation, except trade balance series, this ratio is smaller or equal to 1 signaling to the stability of time period data.

Table 4: *Descriptive Statistics of the Variables of Second Model Covering 3 Developing Countries of OECD[11], 1987-1996 (in US dollars)*

	A	G	I	IH	R	RD	T
Mean	233.5	5152.5	29162.1	0.5	107906.7	2996.4	16.6
Median	209.7	3558.9	17284.7	0.4	124070.7	244.9	4.9
Maximum	324.5	10253.3	79197.9	1.8	202293.2	9467.1	56.8
Minimum	152.8	2787.8	5753.6	0.0	24410.6	12.1	-1.1
Std. Dev.	72.3	3054.7	27143.1	0.5	60955.1	4324.1	21.6
Std.Dev/Mean	0.3	0.6	0.9	1.1	0.6	1.4	1.3
Skewness	0.4	1.0	0.9	1.8	-0.1	0.7	0.9
Kurtosis	1.4	2.3	2.3	5.1	1.9	1.6	2.4
Observations	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Cross sections	3.0	3.0	3.0	3.0	3.0	3.0	3.0

If the descriptive statistics for 3 developing countries are examined in detail, it can be observed that, data is much smoother and the statistics are more stable, that is though to be related to the restricted number of observations covering only three years, this can be monitored from Table 4.

[11] Mexico, Korea and Turkey.

Table 5: *Descriptive Statistics o the Variables of Second Model Covering 18 Countries of OECD[12], 1982-1997 (in US dollars)*

	A	G	I	IH	R	RD	T
Mean	181.0	20037.4	41739.1	1.8	162796.5	60190.1	6833.4
Median	177.5	20619.3	37041.0	0.7	158734.7	52108.2	-1190.9
Maximum	324.5	41059.1	156325.0	19.5	461387.3	237293.1	177823.5
Minimum	77.4	2181.1	5508.8	0.0	24298.7	8.5	-36045.3
Std. Dev.	52.2	8780.8	25572.4	3.2	70079.2	50148.6	36986.9
Std.Dev/Mean	0.3	0.4	0.6	1.8	0.4	0.8	5.4
Skewness	0.5	-0.3	1.8	3.4	1.3	1.3	3.0
Kurtosis	3.2	2.9	8.1	16.0	7.5	5.0	12.6
Observations	107.0	107.0	107.0	107.0	107.0	107.0	107.0
Cross sections	18.0	18.0	18.0	18.0	18.0	18.0	18.0

In Table 5 descriptive statistics of the variables are given in detail for all the countries in question. There are a total of 107 common observations for 18 countries. For the second model covering all of the countries, balanced data could not be utilized as developing countries lack data needed to be common with the industrialized countries. Therefore, when the descriptive statistics are calculated, common data is utilized for the 18 countries.

When we analyze all descriptive statistics briefly, again it can be observed that, except the trade balance variable, all the series are smooth and seems stable over the period of 1970s till the end of 1990s.

2.2. Cross Correlations and Scatter plots for both Models

In this section of the study, preliminary empirical evidence on the relationship between technological change, investment, productivity, trade balance and R&D expenditures, within the framework of the first model, is provided. This analysis is also prepared for the second model with variables of electronic commerce usage and growth, revenue, investment, trade balance and R&D expenditures.

Before considering the analysis for the both models, both of the models will be illustrated with all of the dependent variables. In this respect first model is

[12] 15 industrialized countries and 3 developing countries together.

$$\Delta PT_{it} = \alpha_0 + \alpha_1 \Delta PT_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta PR_{it} + \alpha_9 \Delta PR_{i,t-1} + \varepsilon_{it} \ldots\ldots$$

where the dependent variable is patents. If first model is illustrated with the dependent variable of inventiveness ratio, the model becomes,

$$\Delta INV_{it} = \alpha_0 + \alpha_1 \Delta INV_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta PR_{it} + \alpha_9 \Delta PR_{i,t-1} + \varepsilon_{it} \ldots\ldots$$

For the first model, the data related to all the variables have been utilized from the OECD STAN database, and the R&D data is from the ANBERD database. For the second model, the database is from the OECD telecommunications data, and the second model can be written as,

$$\Delta A_{it} = \alpha_0 + \alpha_1 \Delta A_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta R_{it} + \alpha_9 \Delta R_{i,t-1} + \alpha_{10} \Delta G_{it} + \alpha_{11} \Delta G_{i,t-1} + \varepsilon_{it} \ldots\ldots$$

$$\Delta IH_{it} = \alpha_0 + \alpha_1 \Delta IH_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta R_{it} + \alpha_9 \Delta R_{i,t-1} + \alpha_{10} \Delta G_{it} + \alpha_{11} \Delta G_{i,t-1} + \varepsilon_{it} \ldots\ldots$$

where Access Lines is the dependent variable of the first equation, and the Internet Hosts is the dependent variable of the second equation. The independent variables do not change.

Starting with the first model, Table 6 provides an overview of the relationships between the six variables for the 14 OECD countries (see footnote 22) that has been mentioned above. When patent applications are regarded as dependent variable, it can be observed that there is a strong positive correlation between production and R&D expenditures. In Table 6, the values in parenthesis are the t-values related with the cross correlations, and for investment also, the correlations are quite strong. Negative correlations are only observed with the trade balance variable. For the inventiveness ratio, which is the other dependent variable of the first model, the correlations are a bit lower than the first dependent variable, but when the t-values are considered, these correlations are again strongly significant for all of the 14 countries. Only trade balance variable is insignificant for some of the countries.

Table 6: *Correlation Coefficients of the Variables of First Model Covering 14 Countries of OECD, 1970-1997*

	Australia	Canada	Denmark	Spain	Finland	France	Germany	Italy	Japan	Netherlands	Norway	Sweden	UK	US
Dependent Variable= Patent Applications														
Patent Applications-Productivity	0.93 (11.59)	0.89 (8.94)	0.88 (8.29)	0.92 (10.50)	0.73 (4.89)	0.97 (18.28)	0.97 (18.28)	0.88 (8.49)	0.98 (22.57)	0.97 (18.28)	0.89 (8.94)	0.94 (12.63)	0.97 (18.28)	0.96 (15.71)
Patent Application-Investment*	0.92 (10.50)	0.74 (4.92)	0.71 (4.39)	0.97 (17.39)	0.72 (4.64)	0.91 (10.06)	0.93 (10.73)	0.95 (12.91)	0.93 (10.73)	0.83 (6.31)	0.78 (5.71)	0.96 (14.55)	0.98 (21.47)	0.95 (13.61)
Patent Applications-Trade Balance*	-0.95 (-13.61)	-0.25 (-1.15)	0.86 (7.54)	-0.87 (-7.89)	0.77 (5.40)	0.09 (0.40)	0.55 (2.95)	0.84 (6.92)	0.36 (1.73)	0.22 (1.01)	-0.76 (-5.23)	0.89 (8.73)	-0.79 (-5.76)	-0.78 (-5.57)
Patent Applications-R&D*	0.95 (13.94)	0.93 (11.59)	0.93 (11.32)	0.96 (15.33)	0.86 (7.72)	0.99 (31.39)	0.98 (20.30)	0.81 (6.33)	0.97 (18.28)	0.96 (15.33)	0.82 (6.57)	0.97 (17.39)	0.93 (11.59)	0.9 (9.46)
Dependent Variable= Inventiveness Ratio														
Inventiveness Ratio-Productivity	0.66 (4.03)	0.62 (3.62)	0.83 (6.65)	0.49 (2.51)	0.94 (12.63)	0.47 (2.44)	0.81 (6.33)	0.88 (8.49)	0.97 (18.28)	0.03 (0.14)	0.84 (7.09)	-0.55 (-3.02)	-0.86 (-7.72)	0.84 (7.09)
Inventiveness Ratio-Investment*	0.66 (3.93)	0.59 (3.27)	0.66 (3.83)	0.53 (2.72)	0.89 (8.73)	0.51 (2.72)	0.57 (2.94)	0.95 (12.91)	0.92 (9.96)	0.2 (0.87)	0.74 (5.04)	-0.85 (-6.85)	-0.79 (-5.61)	0.84 (6.92)
Inventiveness Ratio-Trade Balance*	-0.62 (-3.53)	-0.5 (-2.58)	0.85 (7.22)	-0.57 (-3.10)	0.69 (4.26)	-0.28 (-1.30)	0.58 (3.18)	0.83 (6.65)	0.42 (2.07)	-0.19 (-0.87)	-0.74 (-4.92)	-0.28 (-1.30)	0.54 (2.87)	-0.62 (-3.53)
Inventiveness Ratio-R&D*	0.61 (3.53)	0.6 (3.44)	0.82 (6.41)	0.6 (3.35)	0.87 (8.09)	0.41 (2.01)	0.74 (4.54)	0.81 (6.33)	0.94 (12.63)	0.14 (0.63)	0.79 (5.90)	-0.61 (-3.36)	-0.82 (-6.57)	0.75 (5.20)

* per PTO employee

Source: OECD, STAN database.

Table 7: *Correlation Coefficients of the Variables of Second Model Covering 15 Countries of OECD, 1980-1997*

Dependent Variable=Access Lines*	Australia	Canada	Denmark	Spain	Finland	France	Germany	Irland	Italy	Japan	Netherlands	Norway	Sweden	UK	US
Access Lines-Total Revenue[1] n=18	0.96 (13.7)	0.95 (12.17)	0.94 (11.02)	0.92 (9.39)	0.9 (8.26)	0.94 (11.02)	0.97 (15.96)	0.99 (28.07)	0.97 (15.96)	0.94 (11.02)	0.93 (10.12)	0.93 (10.12)	0.88 (7.71)	0.97 (15.96)	0.99 (28.07)
Access Lines-Total Investment[1] n=18	0.85 (6.45)	0.74 (4.40)	0.73 (4.27)	0.68 (3.71)	0.81 (5.53)	0.78 (4.99)	0.77 (4.83)	0.81 (5.53)	0.66 (3.51)	0.94 (11.02)	0.79 (5.15)	0.61 (3.08)	0.86 (6.74)	0.81 (5.53)	0.9 (8.26)
Access Lines-GDP per capita n=18	0.9 (8.26)	0.81 (5.53)	0.89 (7.81)	0.88 (7.41)	0.72 (4.15)	0.92 (9.39)	0.93 (10.12)	0.99 (28.07)	0.9 (8.26)	0.98 (19.70)	0.86 (6.74)	0.84 (6.19)	0.72 (4.15)	0.87 (7.06)	0.99 (28.07)
Access Lines-R&D[1] n=18	0.97 (15.96)	0.97 (15.96)	0.97 (15.96)	0.96 (13.7)	0.9 (8.26)	0.99 (27.18)	0.94 (9.54)	0.96 (13.7)	0.96 (13.7)	0.98 (19.70)	0.86 (6.53)	0.98 (19.70)	0.92 (8.78)	0.99 (28.07)	0.97 (15.96)
Access Lines-Trade Balance[1] n=18	-0.93 (-8.77)	-0.22 (-0.90)	-0.78 (-4.83)	-0.6 (-3.00)	0.77 (4.83)	0.27 (1.12)	-0.17 (-0.69)	0.77 (4.83)	-0.68 (-3.71)	0.59 (2.83)	-0.81 (-5.35)	-0.73 (-4.27)	0.59 (2.92)	0.76 (4.68)	-0.39 (-1.69)
Dependent Variable=Internet Hosts[1]															
Internet Hosts-Total Revenue n=7	0.93 (5.66)	0.95 (6.80)	0.9 (4.62)	0.88 (4.14)	0.92 (5.25)	0.74 (2.46)	0.8 (2.98)	0.96 (7.67)	0.92 (5.25)	0.72 (2.32)	0.81 (3.09)	0.81 (3.09)	0.6 (1.68)	0.95 (6.80)	0.98 (11.01)
Internet Hosts-Total Investment n=7	0.95 (6.80)	0.7 (2.19)	0.83 (3.33)	-0.19 (-0.43)	0.87 (3.95)	-0.32 (-0.76)	-0.37 (-0.89)	0.98 (11.01)	-0.46 (-1.16)	0.64 (1.86)	-0.05 (-0.11)	0.69 (2.13)	-0.69 (-2.13)	0.98 (11.01)	0.99 (15.69)
Internet Hosts-GDP per capita n=7	0.82 (3.20)	0.4 (0.98)	0.76 (2.62)	0.13 (0.29)	0.48 (1.22)	0.56 (1.51)	0.52 (1.36)	0.93 (5.66)	0.27 (0.63)	0.14 (0.32)	0.66 (1.96)	0.84 (3.46)	0.14 (0.32)	0.94 (6.16)	0.97 (8.92)
Internet Hosts-R&D n=7	0.58 (1.59)	0.93 (5.66)	0.91 (4.91)	0.91 (4.91)	0.94 (6.16)	-0.53 (-1.25)	-0.8 (-1.33)	0.9 (4.62)	0.88 (4.14)	0.93 (5.66)	0.95 (6.09)	-0.05 (-0.11)	0.83 (2.58)	0.74 (2.46)	0.99 (15.69)
Internet Hosts-Trade balance n=7	-0.99 (-7.02)	0.24 (0.55)	-0.96 (-6.86)	-0.12 (-0.27)	0.85 (3.61)	0.9 (4.62)	0.98 (11.01)	0.65 (1.91)	-0.51 (-1.33)	-0.93 (-5.06)	-0.47 (-1.06)	-0.27 (-0.63)	0.98 (11.01)	0.98 (11.01)	0.45 (1.13)

[1] per PTO employee

In Table 7, correlations between the variables of the second model, electronic commerce usage and growth, revenue, investment, trade balance and R&D

expenditures are demonstrated.[13] When we consider first dependent variable that is the access lines, correlations between the dependent variable and total revenue, total investment and GDP is quite high and positive. The t values in the parenthesis are also significant for nearly all of the countries. Only the correlations between access lines and trade balance is negative for most of the countries. Again the t-values are significant at the 0.95 level. For the Internet hosts variable, which is the other dependent variable of the second model, the correlations are again strongly significant for all of the 14 countries, but this time negative correlations are observed between the Internet hosts and total investment and R&D for some countries. However, these negative correlations, which can be observed from Table 7, are statistically insignificant at the 0.95 level.

2.3. Estimation of Models and Diagnostic Tests

In this study, to scrutinize the effects of technological change and usage of electronic commerce on various macroeconomic variables, two models are estimated that is in line with the panel data estimation techniques. Within the framework of this study, the term "panel data" refers to the pooling of observations on a cross-section of selected OECD countries over a time period of around 20 years. Advantages and disadvantages of panel data can be listed as follows (Baltagi, 1995).

Starting with the benefits of using panel data, the first one is related to the controlling for individual heterogeneity. Panel data suggest that individuals, firms, states or countries are heterogeneous. Time series and cross-section studies not controlling for this heterogeneity run the risk of obtaining biased-results (Baltagi, 1995:3). The second benefit is that, panel data give more informative data, more variability, less collinearity among the variables, more degrees of freedom and more efficiency.

The third advantage is the argument that panel data are better to study the dynamics of adjustment. For example, in measuring unemployment, cross-sectional data can estimate what proportion of the population is unemployed at a point in time. Repeated cross-sections can show how this proportion changes over time. Only panel data can estimate what proportion of those who are unemployed in one period remain unemployed in another period (1995:5). Last two benefits of the panel data as described in Baltagi (1995) are related to the identification and measurement superiority of panel data and the models with panel data allowing construction and testing of more

[13] These variables are the variables of the second model, which examines the relationship between two proxies for the electronic commerce usage and the macroeconomic fundamentals like GDP, trade and

complicated behavioral modals when compared with purely cross-section or time series data.

The most important limitation related to the panel data includes the problem of data collection and designing the panel surveys. To give an example, there was a data problem in this study especially with the data related to the estimation of second model, which is related to the telecommunications database of OECD. If explained in detail, when the Internet hosts data is included in the second model as a dependent variable, it is not possible to make a balanced panel estimation, especially when three developing countries are included as cross-section, due to lack of data on annual terms. To make balanced estimation every cross-section has to have same number of common observations.

If the panel data regression is explained theoretically, it can be shown that the regression has a double subscript on its variables, i.e.

$$y_{it} = \alpha + X_{it}^{'}\beta + u_{it} \qquad i = 1,...,N; \quad t = 1,...,T \qquad (1)$$

with i denoting households, individuals, firms, countries, etc., and t denoting time. In other words, the i subscript denotes the cross-section dimension whereas t denotes the time-series dimension. α is a scalar, β is $K \times 1$ and X_{it} is the it th observation on K explanatory variables. Most of the panel data applications utilize a one-way error component model for the disturbances, with

$$u_{it} = \mu_i + \nu_{it} \qquad (2)$$

where μ_i denotes the unobservable individual specific effect and ν_{it} denotes the remainder disturbance. One thing should be noted that, μ_i is time-invariant and it accounts for any individual specific effect that is not included in the regression. The remainder ν_{it} varies with individuals and time and can be thought of as the usual disturbance in the regression (Baltagi, 1995:9).

In vector form (1) can be written as

---

investment.

$$y = \alpha\iota_{NT} + X\beta + u = Z\delta + u \qquad (3)$$

where y is $NT \times 1$, X is $NT \times K$, $Z = [\iota_{NT} X]$, $\delta' = (\alpha', \beta')$ and ι_{NT} is a vector of ones of dimension NT. Also, (2) can be written as

$$u = Z_{\mu}\mu + \nu \qquad (4)$$

where $u' = (u_{11},...,u_{1T},u_{21},...,u_{2T},...,u_{N1},...,u_{NT})$ with the observations stacked such that the slower index is over individuals and the faster index is over time (Baltagi, 1995:10).

For the fixed effects model case, the μ_i are assumed to be fixed parameters to be estimated and the remainder disturbances stochastic with ν_{it} independent and identically distributed IID$(0,\sigma_{\nu}^2)$. The X_{it} are assumed independent of the ν_{it} for all i and t. For example, any panel which is made up of time series observations over a group of countries which are brought together either through membership to an organization like the OECD or geographical designation, such as the Middle East countries, may be investigated by using a fixed effects model (Erlat, 1997:11).

The disturbances given by (6.4) can be substituted into (3) to get

$$y = \alpha\iota_{NT} + X\beta + Z_{\mu}\mu + \nu = Z\delta + Z_{\mu}\mu + \nu \qquad (5)$$

and then perform ordinary least squares to get estimates of α, β and μ.

Within the framework of the theoretical analysis of panel data that has been illustrated above two models will be scrutinized in detail in the remaining part of this section.

<u>Estimation and Diagnostic Tests of the First Model (Without Dummies)</u>

The model related to the variables effecting technological change can be specified as

$$\Delta PT_{it} = \alpha_0 + \alpha_1 \Delta PT_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta PR_{it} + \alpha_9 \Delta PR_{i,t-1} + \varepsilon_{it} \quad (6)$$

where all the variables are listed in Appendix. As stated before, in the first model, data from the OECD STAN database has been employed. For the first model 4 different estimations have been realized. The first estimation covers 14 industrialized countries of the OECD and all the variables are included in the model that can be seen in equation 6. In this model the dummies related to the panel of 14 countries are not included, in other words, this first estimation is not fixed effects model. The results of the estimation are given in Table 8.

Table 8: *Estimation Results of the Variables of First Model Covering 14 Countries of OECD, 1977-1993*

Dependent Variable: ΔPT
Method: Pooled Least Squares
Sample(adjusted): 1977 1993
Included observations: 17 after adjusting endpoints
Balanced sample
Total panel observations 238
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	684.5781	393.7843	1.738460	0.0835
ΔPT(-1)	0.553444	0.123347	4.486874	0.0000
ΔRD	9.031394	3.366628	2.682623	0.0078
ΔRD(-1)	-4.957325	4.595603	-1.078710	0.2819
ΔT	-0.000412	0.000589	-0.700506	0.4843
ΔT(-1)	0.001011	0.001135	0.891121	0.3738
ΔPR	0.001267	0.001072	1.182171	0.2384
ΔPR(-1)	-0.001900	0.001522	-1.248741	0.2130
ΔI	-0.002329	0.003330	-0.699473	0.4850
ΔI(-1)	0.006443	0.004470	1.441256	0.1509

R-squared	0.343780	Mean dependent var	2698.895
Adjusted R-squared	0.317876	S.D. dependent var	4898.165
S.E. of regression	4045.433	Sum squared resid	3.73E+09
Log likelihood	-1957.033	F-statistic	13.27159
Durbin-Watson stat	2.453559	Prob(F-statistic)	0.000000

According to the t values of the results, only two variables are significant at the 5 percent level. These variables are the first lag of the dependent variable and the R&D

expenditures. Accordingly, the number of patents at period *t* is determined by the number of patents that has been realized one year before *(t-1)*. The positive relationship between the first lag of patents and the variable itself signals a first order autoregressive process. When the result of the estimation that has been demonstrated in Table 8 is examined, it is observed that R&D expenditures are significant also. The positive relationship between the number of patents and the R&D expenditures is expected. The number of patents is a proxy for the level of technological change. In this respect high levels of R&D expenditures should cause an improvement in the level of technological change.

For the reliability of the estimation results diagnostic tests of the regression should be analyzed statistically. Within the framework of statistical significance three different diagnostic tests should be taken into consideration. These three diagnostic tests can be described as:

1. Tests for serial collinearity

2. Tests for heteroskedasticity

3. Tests for serial correlation

The program that has been utilized for the estimation of the parameters of the first and the second model[14] does not give estimation results if the variables of the model has serious collinearity problem. In this respect, as long as the coefficients can be estimated, it is for sure that the estimation does not have a serious collinearity problem. One of the most common problems that can be observed for the panel data is the heteroskedasticity problem. The model given by equations (1) and (2) assumes that the regression disturbances are homoskedastic with the same variance across time and individuals. This may be a restrictive assumption for panels, where the cross-sectional units may be of varying size and as a result may exhibit different variation. Assuming homoskedastic disturbances when heteroscedasticity is present will still result in consistent estimates of the regression coefficients, but these estimates will not be efficient (Baltagi, 1995:77).

For the estimation equation that has been demonstrated in Table 8 and also for the coming equations that will be analyzed in the remaining part of this chapter the heteroskedasticity problem has been solved by White Heteroskedasticity-Consistent Standard Errors & Covariance estimation, which is one of the properties of the program utilized for the estimation. In this respect, all the estimation equations that will be considered in the remaining part will not include the problem of heteroskedasticity.

The last diagnostic test, namely the serial correlation problem will not be considered for the equations due to the fact that autocorrelation is not so common for the panel data. It is assumed that the equations do not have autocorrelation problem. Despite this assumption the Durbin Watson statistics are illustrated at the end of each table that covers the estimation results.

Table 9: *Estimation Results of the Variables of First Model Covering 14 Countries of OECD, 1977-1993 (Only the Significant Variables)*

Dependent Variable: ∆PT

Method: Pooled Least Squares

Sample(adjusted): 1977 1993

Included observations: 17 after adjusting endpoints

Balanced sample

Total panel observations 238

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	502.6355	354.6602	1.417231	0.1577
∆PT(-1)	0.536149	0.118895	4.509414	0.0000
∆RD	6.391379	2.742905	2.330150	0.0206

R-squared	0.325126	Mean dependent var	2698.895
Adjusted R-squared	0.319382	S.D. dependent var	4898.165
S.E. of regression	4040.965	Sum squared resid	3.84E+09
Log likelihood	-1928.830	F-statistic	56.60651
Durbin-Watson stat	2.466202	Prob(F-statistic)	0.000000

The second estimation that is demonstrated in Table 9 shows only the relationship between dependent variable, which is again patents and the significant variables[15]. This time, again it seems that there is a relation between the dependent variable and the first lag of it, and R&D expenditures.

[14] Eviews Version 3.0 has been exploited for the estimation results.

[15] In the framework of all the estimations considered above, the significance is related to the t-values that has been listed in Table 8. Here all the variables that are considered significant at the 90 percent level have been analyzed.

The result of the estimation, which has been put forward by Table 9 signals that technological change should increase with increasing R&D expenditures of the manufacturing sector. If we consider the relationship of unemployment with the result of this estimation we may say that, the employment level should increase in sectors of manufacturing industry in which the level of R&D expenditures are relatively high. But according to the preliminary analysis that has been carried out in the fourth chapter of the study, in sectors of manufacturing industry, where the levels of R&D expenditures are high relatively, the employment has fallen significantly between the years 1973 and 1997.

The third estimation is realized for 3 developing countries, i.e. Mexico, Turkey and South Korea and with all of the variables of equation (6). The results of the estimation are again listed in Table 10.

Due to the result of the estimation covering three countries, technological change is not related with any of the variables considered above. This result can be easily observed with the help of Table 10, as the t-values of all the variables are insignificant.

Table 10: *Estimation Results of the Variables of First Model Covering 3 Developing Countries of OECD, 1991-1997*

Dependent Variable: ∆PT

Method: Pooled Least Squares

Sample(adjusted): 1991 1997

Included observations: 7 after adjusting endpoints

Total panel observations 11

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3005.386	6436.574	0.466923	0.6865
∆PT(-1)	0.306141	0.261651	1.170034	0.3625
∆PR	-0.516849	1.629668	-0.317150	0.7812
∆PR(-1)	-1.354801	0.960707	-1.410213	0.2939
∆I	0.000295	0.014528	0.020316	0.9856
∆I(-1)	0.017376	0.022136	0.784948	0.5147
∆RD	7.884235	16.90202	0.466467	0.6868
∆T	43373.89	91195.96	0.475612	0.6812
∆T(-1)	-26618.06	52225.65	-0.509674	0.6610
R-squared	0.875707	Mean dependent var		8667.364
Adjusted R-squared	0.378537	S.D. dependent var		11626.39
S.E. of regression	9165.429	Sum squared resid		1.68E+08

Log likelihood	-144.2396	F-statistic	1.761381
Durbin-Watson stat	2.992854	Prob(F-statistic)	0.411921

When the insignificant variables are eliminated one by one from the estimated model that takes place in Table 10, it can be observed that only the first difference of the dependent variable and productivity is left (Table 11).

It can be declared that the model with three developing countries shows an autoregressive process, that is, the level of technological change is related with the previous periods' level of technological change. Also there is a positive relationship between the number of patents and the level of productivity and the first lag of productivity. However, one thing should be noted that the relationship between the number of patents and the productivity at time t-1 is negative. This result is to say that last year's productivity has a negative effect on this year's technological progress.

Table 11: *Estimation Results of the Variables of First Model Covering 3 Developing Countries of OECD, 1977-1997 (Only the Significant Variables)*

Dependent Variable: ∆PT
Method: Pooled Least Squares
Sample(adjusted): 1977 1997
Included observations: 21 after adjusting endpoints
Total panel observations 27
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	786.7770	904.3493	0.869992	0.3933
∆PT(-1)	0.594309	0.180517	3.292255	0.0032
∆PR	0.686367	0.197920	3.467905	0.0021
∆PR(-1)	-0.724116	0.208331	-3.475791	0.0020

R-squared	0.745995	Mean dependent var	4318.667
Adjusted R-squared	0.712864	S.D. dependent var	8576.548
S.E. of regression	4595.753	Sum squared resid	4.86E+08
Log likelihood	-536.4268	F-statistic	22.51643
Durbin-Watson stat	2.222562	Prob(F-statistic)	0.000000

Above, first model has been estimated and analyzed with patents employed as dependent variable. Next, the first model will be estimated, but this time the dependent variable changes to inventiveness ratio coefficient that is found by dividing number of resident patent applications by population. The model is specified as:

$$\Delta INV_{it} = \alpha_0 + \alpha_1 \Delta INV_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta PR_{it} + \alpha_9 \Delta PR_{i,t-1} + \varepsilon_{it} \quad (7)$$

where all the variables are listed in Appendix. For this model again 4 different estimations have been realized. The first estimation covers 14 industrialized countries of the OECD and all the variables are included in the model that can be seen in equation 7. In this model the dummies related to the panel of 14 countries are not included, in other words, this first estimation is not fixed effects model. The results of the estimation are given in Table 12. According to the t values of the results, only one variable is significant at the 5 percent level of significance.

Table 12: *Estimation Results of the Variables of First Model Covering 14 Countries of OECD, 1977-1993*

Dependent Variable: ∆INV

Method: Pooled Least Squares

Sample(adjusted): 1977 1993

Included observations: 17 after adjusting endpoints

Balanced sample

Total panel observations 238

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.719067	3.169994	-0.226836	0.8208
∆INV(-1)	0.511838	0.123123	4.157143	0.0000
∆I	-3.73E-05	3.71E-05	-1.006418	0.3153
∆I(-1)	6.88E-05	5.25E-05	1.309813	0.1916
∆T	-9.02E-06	6.24E-06	-1.444184	0.1501
∆T(-1)	1.01E-05	1.21E-05	0.834112	0.4051
∆RD	0.044038	0.023220	1.896520	0.0592
∆RD(-1)	-0.007225	0.024913	-0.290016	0.7721
∆PR	2.39E-05	1.82E-05	1.315292	0.1897
∆PR(-1)	-2.48E-05	2.08E-05	-1.194998	0.2333

R-squared	0.321245	Mean dependent var	9.829148
Adjusted R-squared	0.294452	S.D. dependent var	36.73179
S.E. of regression	30.85356	Sum squared resid	217042.8
Log likelihood	-869.0465	F-statistic	11.98992
Durbin-Watson stat	2.387644	Prob(F-statistic)	0.000000

There is a positive and significant relationship between inventiveness coefficient and first lag of inventiveness ratio, which is the dependent variable. Again there seems an autoregressive process. Technological change at time t is explained by the technological change at time t-1. In the estimated equation that has been illustrated in Table 12, the R&D expenditures are significant at the 10 percent significance level. The relationship between the inventiveness ratio and the R&D expenditures is positive which is expected.

The second estimation shows only the relationship between dependent variable, which is again inventiveness ratio and the significant variables. This time, only R&D expenditures seem significance in the equation (Table 13).

Table 13: *Estimation Results of the Variables of First Model Covering 14 Countries of OECD, 1977-1993 (Only the Significant Variables)*

Dependent Variable: ΔINV

Method: Pooled Least Squares

Sample(adjusted): 1977 1993

Included observations: 17 after adjusting endpoints

Balanced sample

Total panel observations 238

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.094087	2.927578	0.032138	0.9744
ΔINV(-1)	0.501077	0.121555	4.122218	0.0001
ΔRD	0.041173	0.019348	2.127993	0.0344

R-squared	0.269398	Mean dependent var	9.829148
Adjusted R-squared	0.263180	S.D. dependent var	36.73179
S.E. of regression	31.52991	Sum squared resid	233621.7
Log likelihood	-861.9236	F-statistic	43.32633
Durbin-Watson stat	2.421847	Prob(F-statistic)	0.000000

The third estimation is realized for 3 developing countries, i.e. Mexico, Turkey and South Korea and with all of the variables of equation (7). The results of the estimation could not be given due to the fact that the equation has a serial multicollienarity problem.

The result of the estimation process that has been considered above resulted with the fact that, in OECD countries the level of technological change is in relation with only R&D expenditures. For the 3 developing countries productivity level also has got a positive relationship with the level of technology

<u>First Model (With Dummies)</u>

The model related to the technological change is estimated considering the country-specific dummies. These types of models are named as fixed-effect models in the econometrics literature.

Starting with the model that takes patents as the dependent variable, we can specify the model as:

$$\Delta PT_{it} = \alpha_0 + \alpha_1 \Delta PT_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta PR_{it} + \alpha_9 \Delta PR_{i,t-1} + d_i + \varepsilon_{it} \quad (8)$$

Here d_i refers to the individual country dummies. The only difference between the equation (8) and the before two is that, in equation 8 there are 13 dummies country dummies.

For the first model including country dummy variables 4 different estimations have been realized. The first estimation covers 14 industrialized countries of the OECD and all the variables are included in the model that is included in equation (8). The results of the estimation are given in Table 14. According to the t values of the results, only two variables are significant. There is a positive and significant relationship between patents and R&D expenditures, and first lag of patents, which is the dependent variable. These results are in line with the expected signs of the coefficients of the estimation. It is also observed that the autoregressive process did not change with the inclusion of dummies.

When the dummies for 13 countries are analyzed in detail, it can be observed that individually all of them are significant. On the other hand, these dummies should be jointly significant, that can be measured by Wald test. The Wald test computes the test statistic by estimating the unrestricted regression without imposing the coefficient restrictions specified by the null hypothesis. The Wald statistic measures how close the unrestricted estimates come to satisfying the restrictions under the null hypothesis. If the restrictions are in fact true, then the unrestricted estimates should come close to satisfying the restrictions. In our case, the unrestricted model is the one that has the country dummies, and the restricted model is the model without dummies. When this restriction is tested, it has been concluded that all the dummies are different then zero, i.e., the null hypotheses is rejected. This result of the Wald test points that fixed effects model is much more suitable for the estimation of the first model.

Table 14: *Estimation Results of the Variables of First Model Covering 14 Countries of OECD, 1977-1993*

Dependent Variable: ∆PT

Method: Pooled Least Squares

Sample(adjusted): 1977 1993

Included observations: 17 after adjusting endpoints

Balanced sample

Total panel observations 238

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
∆PT(-1)	0.287759	0.112410	2.559903	0.0111
∆I	-0.001106	0.003758	-0.294214	0.7688
∆I(-1)	0.005122	0.004718	1.085616	0.2787
∆T	-0.000167	0.000646	-0.258973	0.7959
DT(-1)	0.000773	0.001156	0.669262	0.5040
∆RD	8.275103	3.444885	2.402142	0.0171
∆RD(-1)	-5.705879	4.182963	-1.364076	0.1738
∆PR	0.001861	0.001142	1.629975	0.1044
∆PR(-1)	-0.001489	0.001431	-1.040335	0.2992

R-squared	0.450771	Mean dependent var	2698.895
Adjusted R-squared	0.394571	S.D. dependent var	4898.165
S.E. of regression	3811.230	Sum squared resid	3.12E+09
Log likelihood	-1925.904	F-statistic	22.05721
Durbin-Watson stat	2.163479	Prob(F-statistic)	0.000000

Table 15: *Estimation Results of the Variables of First Model Covering 14 Countries of OECD, 1977-1993 (Only the Significant Variables)*

Dependent Variable: ∆PT

Method: Pooled Least Squares

Sample(adjusted): 1977 1993

Included observations: 17 after adjusting endpoints

Balanced sample

Total panel observations 238

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
∆PT(-1)	0.268054	0.111536	2.403302	0.0170
∆RD	5.956317	3.125908	1.905468	0.0579

R-squared	0.435151	Mean dependent var	2698.895
Adjusted R-squared	0.396985	S.D. dependent var	4898.165
S.E. of regression	3803.622	Sum squared resid	3.21E+09
Log likelihood	-1897.493	F-statistic	171.0253
Durbin-Watson stat	2.165128	Prob(F-statistic)	0.000000

The second estimation shows only the relationship between dependent variable, which is again patents and the significant variables (Table 15). The two significant variables are the R&D expenditures and the first lag of the dependent variable. The result does not differ significantly from the model that has been estimated without the country dummies. On the other hand, according to the results of the Wald test the null hypotheses of all the dummies are equal to zero is rejected.

The third estimation is realized for 3 developing countries, i.e. Mexico, Turkey and South Korea and with all of the variables of equation (8). The results of the estimation are not listed due to insignificance of the t-values The R-square of the estimation is higher than the other estimations. Besides, the t-values and the coefficients of the variables are higher than expected. It is thought that these results are related to the multicollinearity problem resulting from the insufficient number of observations.

Table 16: *Estimation Results of the Variables of First Model Covering 14 Countries of OECD, 1977-1993*

Dependent Variable: ∆INV
Method: Pooled Least Squares
Sample(adjusted): 1977 1993
Included observations: 17 after adjusting endpoints
Balanced sample
Total panel observations 238
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
∆INV(-1)	0.222560	0.104810	2.123461	0.0347
∆I	-2.65E-05	3.83E-05	-0.692026	0.4896
∆I(-1)	5.07E-05	5.25E-05	0.966168	0.3349
∆T	-5.95E-06	6.33E-06	-0.940655	0.3478
∆T(-1)	7.02E-06	1.19E-05	0.587558	0.5574
∆RD	0.053832	0.023737	2.267833	0.0242
∆RD(-1)	-0.005409	0.024889	-0.217323	0.8281
∆PR	2.57E-05	1.73E-05	1.484401	0.1390
∆PR(-1)	-1.97E-05	1.93E-05	-1.024335	0.3067

R-squared	0.437988	Mean dependent var	9.829148
Adjusted R-squared	0.380480	S.D. dependent var	36.73179
S.E. of regression	28.91145	Sum squared resid	179712.5
Log likelihood	-836.9588	F-statistic	20.94425
Durbin-Watson stat	2.098771	Prob(F-statistic)	0.000000

As stated before, for developing countries the data is more limited and it is not possible to make a balanced estimation. It should be noted that for all the estimations covering only the three countries there is the problem of degrees of freedom due to lacking data related to some of the variables. For this reason results of the estimations should be interpreted with great care. Another important problem related with the estimation of the model that covers 3 developing countries is that, due to lack of data, the estimation is unbalanced. In other words, when the model is estimated the data of the variables do not belong to common points in time. This situation may also cause a biased estimation.

Above, the model whose dependent variable is patents has been analyzed briefly within the framework of fixed effects model. The same analysis will be made changing the dependent variable to inventiveness coefficient. Again there will be four different estimations, two of them related to 14 countries and the remaining two related to the 3 developing countries. The estimations will be realized according to equation (9), which is specified as:

$$\Delta INV_{it} = \alpha_0 + \alpha_1 \Delta INV_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta PR_{it} + \alpha_9 \Delta PR_{i,t-1} + d_i + \varepsilon_{it} \quad \ldots\ldots(9)$$

The results of the first estimation are illustrated in Table 16. According to the t values of the results, two variables are significant. The first lag of the dependent variable and R&D expenditures are positively related with the technological change. When the dummies for 13 countries are analyzed in detail, individually only the dummy variable related to Japan is significant. When the restriction of the Wald test is tested, it has been concluded that all the dummies are different then zero, i.e., the null hypotheses is rejected. This result of the Wald test points that fixed effects model is much more suitable for the estimation of the first model.

If the insignificant variables are eliminated from the model that has been illustrated in Table 16, the coefficients and the t-values of the new estimation does not change so significantly. The results can be scrutinized from Table 17.

Table 17: *Estimation Results of the Variables of First Model Covering 14 Countries of OECD, 1977-1993 (Only the Significant Variables)*

Dependent Variable: ΔINV
Method: Pooled Least Squares
Date: 10/11/01 Time: 06:17
Sample(adjusted): 1976 1993
Included observations: 18 after adjusting endpoints
Balanced sample
Total panel observations 252
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ΔRD	0.067942	0.022985	2.955934	0.0034
R-squared	0.366102	Mean dependent var		9.417737
Adjusted R-squared	0.328656	S.D. dependent var		35.81174
S.E. of regression	29.34256	Sum squared resid		204053.6
Log likelihood	-866.6261	Durbin-Watson stat		1.603433

Conclusively, it can be stated that for the first model whose dependent variables are the number of patents and inventiveness ratio, only R&D expenditures and the first lag of the dependent variable seem significant when compared with the other independent variables of the model. For 14 industrialized countries of the OECD, the equation states that technological change is related positively to R&D expenditures and the technological change that has occurred one period before.

Second Model (Without Dummies)

This model is related to the specification of the relationship between the electronic commerce usage proxies and the macroeconomic variables. As in the first model, there are two basic equations estimated with two different dependent variables. The dependent variables are the access lines and the Internet hosts. All the variables are explained in detail in Appendix. Starting with the first specification in which the dependent variable has been taken as the Access Lines per number of employee working in the telecommunication sector, the model can be specified as:

$$\Delta A_{it} = \alpha_0 + \alpha_1 \Delta A_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta R_{it} + \alpha_9 \Delta R_{i,t-1} + \alpha_{10} \Delta G_{it} + \alpha_{11} \Delta G_{i,t-1} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots (10)$$

The same procedure that has been applied in the first model will also be applied for this model. The estimation will be realized for two dependent variables within the framework of 15 OECD countries. First dependent variable is the number of access lines per number of employees working in the telecommunications sector. There will be two estimations related to the first dependent variable, in the first estimation all the variables are put in the equation, while, in the second equation only the significant variables will be estimated.

Table 18: *Estimation Results of the Variables of Second Model Covering 15 Countries of OECD, 1982-1993*

Dependent Variable: ΔA
Method: Pooled Least Squares
Sample(adjusted): 1982 1993
Included observations: 12 after adjusting endpoints
Balanced sample
Total panel observations 180
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.831329	0.632268	4.478049	0.0000
ΔA(-1)	0.109115	0.086552	1.260690	0.2092
ΔG	-0.003071	0.000479	-6.411036	0.0000
ΔG(-1)	0.000418	0.000459	0.909635	0.3643
ΔI	0.000245	0.000113	2.179893	0.0307
ΔI(-1)	-0.000299	0.000112	-2.664469	0.0085
ΔR	0.000479	7.38E-05	6.488521	0.0000
ΔR(-1)	-2.49E-05	7.05E-05	-0.353588	0.7241
ΔRD	0.000678	0.000128	5.288323	0.0000
ΔRD(-1)	-0.000369	0.000135	-2.724865	0.0071
ΔT	8.89E-05	8.03E-05	1.107581	0.2696
ΔT(-1)	0.000210	0.000115	1.822263	0.0702
R-squared	0.582388	Mean dependent var		6.225673
Adjusted R-squared	0.555045	S.D. dependent var		7.423441
S.E. of regression	4.951803	Sum squared resid		4119.420
F-statistic	21.29888	Durbin-Watson stat		1.987577
Prob(F-statistic)	0.000000			

According to Table 18 that illustrates the estimation results, most of the independent variables have t-statistics that are significant at 90 percent. However, there are unexpected signs related with the coefficients. The most unexpected relation is the negative relationship between the gross domestic product and the number of access lines. As can be seen from Table 18 the coefficients of all the variables are exceptionally low.

In Table 19, the estimation for the access lines has been realized for only significant variables; therefore in this table all the variables are significant. However, the coefficients are still near to zero and the sign of the gross domestic product is negative. In second model, trade variable gained significance with a positive sign.

Table 19: *Estimation Results of the Variables of Second Model Covering 15 Countries of OECD, 1982-1993 (Only the Significant Variables)*

Dependent Variable: ΔA
Method: Pooled Least Squares
Sample(adjusted): 1982 1993
Included observations: 12 after adjusting endpoints
Balanced sample
Total panel observations 180
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.341881	0.624634	5.350140	0.0000
ΔG	-0.003160	0.000413	-7.657284	0.0000
ΔI	0.000236	0.000110	2.140088	0.0338
ΔI(-1)	-0.000241	8.52E-05	-2.825980	0.0053
ΔR	0.000485	6.52E-05	7.438843	0.0000
ΔRD	0.000656	0.000122	5.390215	0.0000
ΔRD(-1)	-0.000279	0.000116	-2.399939	0.0175
ΔT(-1)	0.000261	0.000122	2.147325	0.0332

R-squared	0.573292	Mean dependent var	6.225673
Adjusted R-squared	0.555926	S.D. dependent var	7.423441
S.E. of regression	4.946898	Sum squared resid	4209.149
F-statistic	33.01228	Durbin-Watson stat	1.780607
Prob(F-statistic)	0.000000		

The estimation related with the second model that covers the telecommunication sector of the OECD countries will be done changing the dependent variable to Internet Hosts, which is another proxy for the electronic Commerce Usage.

The new equation can be specified as:

$$\Delta IH_{it} = \alpha_0 + \alpha_1 \Delta IH_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta R_{it} + \alpha_9 \Delta R_{i,t-1} + \alpha_{10} \Delta G_{it} + \alpha_{11} \Delta G_{i,t-1} + \varepsilon_{it} \quad \text{.................................}(6.11)$$

The only difference between equation (10) and (11) is that the access lines in equation (10) gives its place to Internet Hosts in equation (11). In Table 20 all the variables have been estimated and with the exception of investment per employee and total revenue per employee all the remaining variables seem significant. In this equation Internet Host and both gross domestic product and the first lag of gross domestic product have a positive relation that is the expected sign. High coefficient of the first lag of the dependent variable in the equation signals an autoregressive process.

Table 20: *Estimation Results of the Variables of Second Model Covering 15 Countries of OECD, 1993-1997*

Dependent Variable: ΔIH

Method: Pooled Least Squares

Sample(adjusted): 1993 1997

Included observations: 5 after adjusting endpoints

Total panel observations 61

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.367107	0.174778	2.100422	0.0409
ΔIH(-1)	0.528332	0.171161	3.086761	0.0033
ΔG	0.000144	7.56E-05	1.908441	0.0622
ΔG(-1)	0.000211	6.74E-05	3.137227	0.0029
ΔI	4.34E-06	1.62E-05	0.267230	0.7904
ΔI(-1)	-5.02E-06	1.27E-05	-0.395109	0.6945
ΔR	-1.42E-05	6.94E-06	-2.046629	0.0461
ΔR(-1)	-6.22E-06	8.52E-06	-0.730493	0.4686
ΔRD	6.89E-05	2.53E-05	2.727162	0.0088
ΔRD(-1)	-6.22E-06	2.20E-05	-0.282176	0.7790
ΔT	-2.46E-05	9.89E-06	-2.483727	0.0165
ΔT(-1)	6.74E-05	8.43E-06	7.993177	0.0000

R-squared	0.790303	Mean dependent var	1.228762
Adjusted R-squared	0.743228	S.D. dependent var	1.596438
S.E. of regression	0.808958	Sum squared resid	32.06628
F-statistic	16.78819	Durbin-Watson stat	1.293887
Prob(F-statistic)	0.000000		

Again Table 20 shows that R&D expenditures do increase with increasing Internet Hosts. Trade per employee variable shows a different pattern when compared with the first lag of itself. Trade balance per employee is in negative relation with the Internet hosts but for the first lag this relationship changes sign.

Table 21 illustrates that when investment variable has been removed from the equation, total revenues per employee gains significance but the sign of the coefficient is negative. Still with 0.5, coefficient of the first lag of the dependent variable is higher than the other coefficients. Moreover, all the other coefficients are ignorably small.

Table 21: *Estimation Results of the Variables of Second Model Covering 15 Countries of OECD, 1993-1997(Only the Significant Variables)*

Dependent Variable: ΔIH

Method: Pooled Least Squares

Sample(adjusted): 1993 1997

Included observations: 5 after adjusting endpoints

Total panel observations 61

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.282014	0.122501	2.302129	0.0253
ΔIH(-1)	0.511206	0.159247	3.210138	0.0023
ΔG	0.000168	6.00E-05	2.799434	0.0071
ΔG(-1)	0.000177	4.14E-05	4.279622	0.0001
ΔR	-1.57E-05	7.96E-06	-1.970515	0.0540
ΔRD	6.96E-05	2.25E-05	3.091030	0.0032
ΔT	-2.28E-05	7.63E-06	-2.990232	0.0042
ΔT(-1)	6.77E-05	8.22E-06	8.239977	0.0000
R-squared	0.784301	Mean dependent var		1.228762
Adjusted R-squared	0.755812	S.D. dependent var		1.596438
S.E. of regression	0.788886	Sum squared resid		32.98408
F-statistic	27.53035	Durbin-Watson stat		1.248045
Prob(F-statistic)	0.000000			

<u>Second Model (With Dummies)</u>

To value whether fixed-effects is more suitable for the second model equation 12 has been estimated,

$$\Delta A_{it} = \alpha_0 + \alpha_1 \Delta A_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta R_{it} + \alpha_9 \Delta R_{i,t-1} + \alpha_{10} \Delta G_{it} + \alpha_{11} \Delta G_{i,t-1} + d_i + \varepsilon_{it} \quad (12)$$

where, d_i equals to individual dummies of the OECD countries in question. The results of the estimation are given in Table 22. When the table is examined it is easily observed that the results do not differ much from the model that has been estimated without the country dummies. One thing should be noted that, although first lag of the dependent variable is not significant in the equation

Table 22: *Estimation Results of the Variables of Second Model Covering 15 Countries of OECD, 1982-1993*

Dependent Variable: ΔA

Method: Pooled Least Squares

Sample(adjusted): 1982 1993

Included observations: 12 after adjusting endpoints

Balanced sample

Total panel observations 180

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ΔA(-1)	0.017479	0.083541	0.209229	0.8345
ΔG	-0.002999	0.000425	-7.063282	0.0000
ΔG(-1)	0.000317	0.000453	0.700250	0.4847
ΔI	0.000215	0.000102	2.114723	0.0358
ΔI(-1)	-0.000333	0.000112	-2.969771	0.0034
ΔR	0.000494	6.57E-05	7.524129	0.0000
ΔR(-1)	1.08E-05	7.24E-05	0.148841	0.8818
ΔRD	0.000722	0.000115	6.260643	0.0000
ΔRD(-1)	-0.000203	0.000137	-1.481403	0.1402
ΔT	9.59E-05	7.74E-05	1.239546	0.2167
ΔT(-1)	0.000241	0.000120	2.006487	0.0463
R-squared	0.631759	Mean dependent var		6.225673
Adjusted R-squared	0.571979	S.D. dependent var		7.423441
S.E. of regression	4.856660	Sum squared resid		3632.421
F-statistic	26.42039	Durbin-Watson stat		2.093489
Prob(F-statistic)	0.000000			

To understand whether we should use dummies in this model or not, individual and joint significance of all the dummies has been tested. Individually all the t-statistics of all the dummies are considerably small and could not be able to pass the critical levels for the significance. On the other hand, the result of the Wald test could not be able to reject the null hypotheses that all the dummies are equal to zero. The meaning of these results shows that the dummies are insignificant individually and jointly. Therefore, it can be concluded that this model does not need a type of fixed-effects estimation procedure. As expressed before, there are very small differences between the results of the equations with dummies and without dummies.

When the insignificant variables are eliminated from equation (12), the remaining variables have been listed in Table 23. The variables considered in the table do not much differ from the model without the dummies. Here again the coefficient of the gross domestic product has a negative sign. Considering the significance of the country dummies, individually nearly most of them seem significant due to small values of t-statistics. Besides, results of the Wald test shows that the null hypotheses that all the dummy variables are jointly equal to zero has been rejected, which means that the dummies are jointly significant.

Table 23: *Estimation Results of the Variables of Second Model Covering 15 Countries of OECD, 1982-1993 (Only the Significant Variables)*

Dependent Variable: ΔA
Method: Pooled Least Squares
Sample(adjusted): 1982 1993
Included observations: 12 after adjusting endpoints
Balanced sample
Total panel observations 180
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ΔG	-0.003038	0.000376	-8.082357	0.0000
ΔI	0.000211	0.000102	2.066590	0.0401
ΔI(-1)	-0.000293	8.38E-05	-3.502008	0.0006
ΔR	0.000502	6.01E-05	8.355183	0.0000
ΔRD	0.000643	0.000112	5.735067	0.0000
ΔT(-1)	0.000294	0.000130	2.254231	0.0253
R-squared	0.621545	Mean dependent var		6.225673
Adjusted R-squared	0.573941	S.D. dependent var		7.423441
S.E. of regression	4.845517	Sum squared resid		3733.167
F-statistic	52.22591	Durbin-Watson stat		1.994643
Prob(F-statistic)	0.000000			

The model with the dependent variable of Internet Hosts is specified as:

$$\Delta IH_{it} = \alpha_0 + \alpha_1 \Delta IH_{i,t-1} + \alpha_2 \Delta I_{it} + \alpha_3 \Delta I_{i,t-1} + \alpha_4 \Delta T_{it} + \alpha_5 \Delta T_{i,t-1} + \alpha_6 \Delta RD_{it} + \alpha_7 \Delta RD_{i,t-1} + \alpha_8 \Delta R_{it} + \alpha_9 \Delta R_{i,t-1} + \alpha_{10} \Delta G_{it} + \alpha_{11} \Delta G_{i,t-1} + d_i + \varepsilon_{it} \quad \text{.........................} (13)$$

where d_i refers to the country specific dummies. The same analysis has been carried out for equation (13) and the results are given in Table 24 and 25.

Table 24 shows that, inclusion of country dummies does not change the significance of the variables. In the fixed-effects model that has been estimated for the dependent variable Internet hosts, it can be observed that the first lag of the GDP growth, R&D expenditures, first lag of the trade balance and the first lag of the dependent variable are positively related with the proxy for the electronic commerce usage.

Table 24: *Estimation Results of the Variables of Second Model Covering 15 Countries of OECD, 1993-1997*

Dependent Variable: ΔIH

Method: Pooled Least Squares

Sample(adjusted): 1993 1997

Included observations: 5 after adjusting endpoints

Total panel observations 61

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ΔIH(-1)	0.465592	0.104716	4.446218	0.0000
ΔG	8.34E-05	6.11E-05	1.365877	0.1767
ΔG(-1)	0.000124	5.19E-05	2.396145	0.0195
ΔI	1.98E-05	1.31E-05	1.509811	0.1359
ΔI(-1)	2.14E-05	1.24E-05	1.721168	0.0900
ΔR	-8.62E-06	5.67E-06	-1.519600	0.1335
ΔR(-1)	-1.06E-06	8.78E-06	-0.120467	0.9045
ΔRD	8.46E-05	2.30E-05	3.683138	0.0005
ΔRD(-1)	1.37E-05	2.32E-05	0.591058	0.5565
ΔT	-9.26E-06	1.04E-05	-0.891486	0.3760
ΔT(-1)	8.44E-05	1.26E-05	6.694131	0.0000
R-squared	0.881487	Mean dependent var		1.228762
Adjusted R-squared	0.796834	S.D. dependent var		1.596438
S.E. of regression	0.719577	Sum squared resid		18.12270
F-statistic	26.03253	Durbin-Watson stat		1.938317
Prob(F-statistic)	0.000000			

The results of the individual t- tests and Wald tests also show that the dummies are individually and jointly insignificant. However, when the insignificant variables are eliminated from the model the dummies become jointly significant and the model turns to fixed effects one.

Table 25: *Estimation Results of the Variables of Second Model Covering 15 Countries of OECD, 1993-1997 (Only the Significant Variables)*

Dependent Variable: ΔIH

Method: Pooled Least Squares

Sample(adjusted): 1993 1997

Included observations: 5 after adjusting endpoints

Total panel observations 64

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ΔIH(-1)	0.636386	0.107636	5.912395	0.0000
ΔI(-1)	3.47E-05	1.14E-05	3.053660	0.0031
ΔRD	9.23E-05	1.77E-05	5.206015	0.0000
ΔT(-1)	0.000109	1.32E-05	8.271032	0.0000

R-squared	0.835901	Mean dependent var	1.263062
Adjusted R-squared	0.770261	S.D. dependent var	1.581622
S.E. of regression	0.758088	Sum squared resid	25.86139
F-statistic	76.40826	Durbin-Watson stat	1.682589
Prob(F-statistic)	0.000000		

One thing should be kept in mind when considering the Internet Hosts as the dependent variable. The data period starts from 1980 and lasts till 1997. Nearly all the variables have full data but as Internet Host data has not got an old history, therefore, it does start form the year 1991. This problem with the Internet Host data caused an unbalanced estimation and changed the coefficient of variables. Within this framework, when interpreting the results of the estimations that include Internet Hosts as the dependent variable, the bias in the data should be given a special emphasis.

3. Overview of the Results

In this study basically two models have been estimated. The first model, which utilized OECD, STAN dataset, has two dependent variables which has been taken as the proxies for technological change. These two dependent variables in question are the number of patents and the inventiveness ratio. The second model, which utilizes OECD telecommunications dataset has two dependent variables also, namely access lines per employee and Internet Hosts per employee. The dependent variables of the second model have been considered as a proxy for electronic commerce usage. Besides, the two models have been estimated with country specific dummies and without them to see how the coefficients of the other variables change. Also, the dummies have been tested if they are individually and jointly significant to decide on if the models in question are of the type fixed-effects or not.

For the first model, it has been found that fixed-effects type of modeling is much more suitable as an estimation procedure. Within this framework, for the industrialized countries, R&D expenditures and the first lag of the technological change variable is very important for the model. The coefficients of both R&D expenditures and first lag of the technological change variable is positive, which is in line with the expectations. For the first model, it has been observed that inventiveness ratio is better for showing the relationship between the technological change and variables like investment R&D and productivity.

For the second model it has been observed that when the country dummies are included in the model, the results do not change significantly, and most of the time the results of the Wald test could not be able to reject the null hypotheses that all the dummies are equal to zero. Due to that reason, it has been concluded that fixed effects model is not much suitable for the second model.

The results of the second model showed that, when access lines per employee has been taken as a proxy for the electronic commerce usage the coefficient of the gross domestic product becomes negative. However, when Internet Hosts have been considered as a proxy for electronic commerce, this time, the coefficient of the total revenue becomes negative. In general the coefficients of the other variables are positive but they are very small.

It is difficult to interpret why the coefficient of the gross domestic product becomes negative when access lines have been taken as a dependent variable. However negative relation between the total revenue and the Internet Hosts can be explained briefly. Nearly all the companies related with the online sales like Amazon.com could not be able to make revenues. The sector related to the online retail sales or telecommunication services revenues are not so high, as the usage is limited to a small number of communities and it is very difficult and costly to supply secure environment for the sales. Therefore the negative sign of the revenue coefficient is not surprising.

Conclusively, it can be argued that for both of the models it has been observed that technological change variables are positively related with R&D expenditures for both of the models. This signals to the fact that R&D expenditures are significant for both increasing technological change and the increasing usage of the electronic commerce. Other important point was that, both the investment and the trade balance variable were most of the time insignificant in the equations that have been considered above. Especially for the first model, the effect of the trade on technological change was negligible. The same conclusion was also true for the investment variable.

4. Concluding Remarks

Following the recent developments in the usage of electronic commerce and the increasing discussion on the effects of technological change on the economic environment of both industrialized and the developing countries, this study aimed at discovering significant relations between technological change, electronic commerce and economic variables like productivity, growth, trade and investment. In addition, while scrutinizing the effects of technological change and usage of electronic commerce on the economy, special emphasis was given to the issue of employment effects of technological change.

Within this framework, the conceptual framework related to the electronic commerce and the Information and Telecommunication Technologies have been employed for the aim of preparing a ground for the empirical part of the study. The literature survey was related with the issue of the relationship between the technology and labor markets. According to a wide array of studies on the effects of technological change on the labor market, it has been concluded that, in the short term technological change causes unemployment in some sectors of the economy causing job flows between the different sectors. However, in the long run, net effect of these job flows gain importance. In other words, especially for the long-term effects of electronic commerce usage on employment is crucial to scrutinize. Hence, data shortages, and the insufficient number of empirical studies for the employment effect of electronic commerce on employment make the issue complicated.

Before considering the relationship between technological change, electronic commerce and the economic variables, the issue of the employment level in the high-tech sectors of the manufacturing industry has been analyzed for the selected OECD countries for the period between 1973 and 1997. The results showed that in most of the countries that has been scrutinized, there was a decline in the employment level for the manufacturing industry, but this decline was much more serious in the high-tech sectors of the manufacturing industry.

For a preliminary analysis on the relationship between the technological change, electronic commerce usage and the economic variables, correlation coefficient and the scatter plots has been carried out in great detail before the estimation of the models for the empirical part. Correlation coefficients illustrated a strong relationship between the technological change variables and productivity, investment, GDP growth and R&D expenditures. Only, the relationship between the trade balance and the technological change was weaker than the other variables in question. Considering scatter plots, most of them illustrated a significant and positive relationship between the technological change and electronic commerce usage and the economic variables. In this respect, preliminary analysis on the issue was signaling to healthy estimation results for the two different models that will be analyzed in the last part of the study.

As a result of both the conceptual part and the analytical part, two important conclusions were drawn. The first one is that technological change is increasingly gaining special emphasis especially with the rising arguments on the issue of “New Economy”. In this framework, technological change has various effects on the general equilibrium of the economy of both industrialized and developing countries. It has been argued in this paper that, technology causes shifts in employment levels related with the “skill-biased technological- change” and the shift of employment to services sector. The employment decline is much more significant in the high-tech sectors of the manufacturing industry within the last 20 years.

The second important point is that technological change and electronic commerce are in relation with the most important variables of the real economy like gross domestic product, investment, trade balance and also R&D expenditures. The two models that have been estimated for building the relationship between technology and these variables in question resulted with positive interaction between the technological change, electronic commerce and growth of gross domestic product, productivity, trade balance and R&D expenditures in general. However some of the coefficients related with the estimations are insignificant. There seem individual differences between the OECD countries with respect to their technological change variables band the level of their electronic commerce usage. This divergence between the countries imply a fixed-effects type of panel data estimation procedure with respect to the estimation of the two specific models that have been described within the study.

Conclusively, it should be always kept in mind that, it is not possible to put all the dynamic relations between the technological change and the main aggregate of the economy with the help of only the economic models. Especially for the issue of electronic commerce, which do not have a healthy database. Electronic commerce is at an early stage of its improvement, and therefore to put forward direct relationships with the help of empirical study is a challenging task. However, it is expected that as the technological level of the OECD countries will improve and the usage of Internet and electronic commerce will accelerate, the studies on the issue will be more advanced with the help of a strong data background on the technology related variables.

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APPENDIX

Variables of the First Model

PT Patent Applications
INV Inventiveness Ratio
PR Productivity
I Investment
RD Research and Development Expenditures
T Trade Balance
ΔPT First Difference of Patent Applications
ΔINV First Difference of Inventiveness Ratio
ΔPR First Difference of Productivity
ΔI First Difference of Investment
ΔRD First Difference of Research and Development Expenditures
ΔT First Difference of Trade Balance

Variables of the Second Model

A Access Lines per PTO employee
G Gross Domestic Product per capita, in US dollars
I Total PTO investment per employee, in US dollars
IH Internet Hosts per PTO employee
R Total PTO revenue per employee, in US dollars
RD R&D expenditures per PTO employee
T Trade Balance in Communications Equipment per PTO employee
ΔA First Difference of Access Lines per PTO employee
ΔG First Difference of GDP per capita, in US dollars
ΔI First Difference of Total PTO investment per employee, in US dollars
ΔIH First Difference of Internet Hosts per PTO employee
ΔR First Difference of Total PTO revenue per employee, in US dollars
ΔRD First Difference of R&D expenditures per PTO employee
ΔT First Difference of Trade Balance in Communications Equipment per PTO employee