The Telecommunications (ICT) Investment and Economic growth(GDP):

A causality analysis-case study of Sweden

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Abstract

This research paper investigates the causality issue between economic growth rate (GDP) and Information and Communication Technology (ICT) investment in Sweden by applying modern time series techniques. It mainly covers time series analyses of 30 years of Sweden data (1980-2009). During that period, development in Information and communication technology (ICT) infrastructure of Sweden was an evolutionary process based on innovation and technological knowledge. Telecommunication revolution which occurred and developed on the basic idea that economic change can be explained as co-evolution of technologies, institutions and development blocks (such as investment). The other way of describing it as an analysis of a long wave based on telecommunication technological revolution and key factor involved the share of investment in it. Standard tests of Unit roots, Cointegration and Granger Causality tests are presented. The main reason of such study is the assessment of ICT investment influence directly on economic growth. The results provide an interesting aspect that ICT investment share can possibly be a contributing factor to telecommunications infrastructure development but it cannot be as a whole sufficient enough for stimulating economic growth (GDP).It is found that one way causality running from ICT investment to economic growth (GDP) but only at one year lagged values not at other higher lagged values. The lack of long run relationship may be due to the inadequacy in reflecting the full effect of ICT investment in other complementary segments. The other complementary factors of ICT 's infrastructure are quite essential as well in describing economic growth and development level.

Key word;   Economic Development, Long wave- Technological revolution,

Telecommunication (ICT) investment, GDP , Granger Causality, Unit root, Co-integration.

** *The terms ICT, TINV and telecommunications have same meanings and are used in proxy to each other***

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Saqib Masood

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Introduction

The basic scenario of infrastructure consists of those structural elements of economy which facilitate the flow of goods and services between buyers and sellers. These elements are communications and transport (roads, railways, airports, telephones etc.), housing, sewerage, power systems etc. The development of these infrastructural elements regarded as a prerequisite of economic growth. Telecommunication infrastructure is basically formed by fixed line telephones, mobiles & wireless technology, fiber and wireless internet services but telecommunications infrastructure is different from traditional ones because it is not only necessary for the interaction between individuals but also for productive units within countries and exchange of inventions and innovation across the borders as well. The idea is actually strengthen the knowledge, innovation and competitiveness of productive units of an economy with international research and innovation environments which facilitate exchange of innovation and knowledge. In this regard the foreign direct investment exchanges firm-specific advantages such as acquired innovational knowledge, technology, patents or trade-marks (Pearce 1986, p. 204)

The world has almost become a global village and this reality is becoming more and more visible in everyday life by the use of advance and innovative telecommunication technology. Economic activities are now much more dependent on the use of advanced telecommunication technology. The better usage of technology to communicate is very much important for any economic activity. Now a day any economic system strongly based on continuous availability of information and technology. Telecommunication technology according to ITU (2000): "Any transmission, emission or reception of signs, signals, writing, images and sound or intelligence of any definition applies to at least two different kinds of communicating at a distance, traditional telecommunications and broadcasting"

Telecommunication technology is a powerful tool to exchange information among economic agents and may therefore influence economic progress in any sector of the economy. Telecommunication infrastructure has direct and indirect effects on economic growth. It directly attracts foreign direct investment through which inflow of foreign capital increases in the country. Foreign companies and service providers invest in country which leads to new employment opportunities and competitive market environment. Indirectly, "telecommunications structure reduces transaction costs of numerous markets in the economy which leads to higher aggregate output and growth". The development of telecommunications

structure lowers communication costs which results in (1) reduce resource allocation decision costs (2) quality and quantity of information expand (3) increase arbitrage opportunities so that financial markets become more efficient (Norton, 1992 p. 177).

Maddan and Savage (1998) & Roller and Waverman (2001) studied the strong association between telecommunication investment and economic growth but the question of casual relationship between these two variables arises attention to further investigations. The causal relationship means that economic growth lead to raise telecommunication investment as well as contrary telecommunication investment lead to economic growth. The investment naturally accelerates infrastructure development and technology. Technology improvements belongs to investment enhancement which is a natural phenomena but key thing is no doubt development in particular sector can be achieved but influence on overall economic growth is also crucial.

The direction of causation between telecommunication investment and economic growth can be one or two directional or both shows independent behavior to each other. The existence of unidirectional causality from telecommunication investment to growth may suggest that if lowers the telecom investment could lead to fall in economic growth. On the other hand if unidirectional causality running from growth to telecommunication investment it may be suggested that at lowering the telecommunication investment may result in small or no change in economic growth (Yoo and Jung, 2001). Andrew hardy (1980) and Cronin (1991) investigated the causality relationship between telecommunication investment and growth for the Us economy they observed bi-directional causality in their analysis. These previous studies on causality relationship establish basis for my research problem, causality analysis of the Swedish economy.

Sweden is the country with most population of the Nordic region 9.475 million which almost covers 40% of the region population. Sweden has real GDP growth rate 4.4 % (CIA, 2011) and is one of the most advanced nations in the world of ICT (Information and communication technologies). According to ITU(information technology union) annual ICT report 'Measuring the Information Society 2011', rank the Sweden as the 2nd world's most advanced ICT economy, followed by Iceland, Denmark and Finland. The investment in ICT is also comparatively high in Sweden compared to the other Nordic countries. According to OECD, up till 2010 the share of ICT investment in Sweden's gross fixed capital formation is 24.74%.

ICT investment generally has a positive effect on productivity growth in the economy but actual relationship is quite complex to describe because of multi factors involving in it. ICT investment giving rise to productivity growth actually depends upon the measure used, labor or total factor productivity. Labor productivity is defined as the ratio of real output to labor input measured as either hours worked or men employed. Total factor productivity or Multifactor productivity is defined as the ratio of output to all inputs used in production. ICT investment is increased in economy which consequently enhances ICT capital stock and capital intensity or capital/labor ratio. ICT investment can directly contribute to total factor productivity and thereby to labor productivity. The total effect of ICT investment on overall productivity growth is not so simple or precise. It can be said that due capital deepening telecommunications high growth rate become possible. My research paper focuses on this fact that high ICT investment is the only reason for high growth rate or it happens differently in case of Sweden.

This ICT investment share covers three main components of telecommunication infrastructure that is information technology equipment (computers, and related hardware); communications equipment; and software. The ICT products and services are highly connected and inter linked with one another so there exist crucial compatibility between each ICT infrastructure component. The rapid technological progress of information and communication technology infrastructure is mainly attributed to strong ICT investment. This rapid progress also put extra competitive pressure on the production of ICT products and services which also attributed to general fall in ICT prices. On one side ICT prices fall while on the other hand scope and application of ICT goods and services encourage ICT investment.

The reason of selecting Sweden in my case study because of technology revolution in telecommunication infrastructure especially during the last three decades. I think differently in this scenario because investment role can be sufficient in telecommunication development but increase or decrease in investment may not have direct influence on overall economic growth rate. This study focus on the role of three things that is ICT investment, telecommunication infrastructure development and economic growth rate. Investment developed the technology and infrastructure but the question is has it direct influence or causation on GDP growth rate or both operated independently in Sweden's telecommunication revolution .The objective of this paper is to examine the significance, direction and strength of casual relationship between telecommunication investment (ICT) and economic growth.

Structure of the Master Thesis

This paper consists of different sections as in the beginning with the introduction of the study. Then second section is most important thing that is research problem and hypothesis statement of the study. In the third section rigorous theoretical framework is formed, based on different theories and conceptual understandings. In the fourth section evolution and historical background of telecommunication sector of Sweden will be discussed precisely. Fifth section tries to cover the study of different past and most recent literatures related to my topic. In next after that data and methodology of this study will be presented which will describe the econometric model, tools and tests going to be used for this study.

The sixth section will show all the empirical findings of the study. In the last concluding remarks try to sum up all the study in context with empirical results and policy implication. Finally, the last section includes references, both printed, databases and unpublished articles used in this thesis. Appendix showing the list of key figures and tables used in this paper

Research problem

The main focus of this study is to examine and analyze the causality relationship between telecommunications (ICT) investment and economic growth rate of Sweden. In most previous studies, it was just simply assumed that when telecommunication investment increases it will have a multiplier effect on economic growth. This assumption was usually made without investigating causal relationship. No doubt investment has its own contribution in any developed telecommunication structures. The question arises here to what extent investment in ICT does contribute to GDP growth rate of any economy in the perspective of stimulating and increasing telecommunication infrastructure development. Sweden. On that basis, I constructed my research question as stated below,

"Does there exist any causality between telecommunications investment and economic growth rate or independence of both these variables can be suggested in the case of Sweden? The granger causality explains the fact that what happens one variable changes increase or decrease and that change also cause the similar sense and direction of change in other variable as well.

Hypothesis statement:

Null Hypothesis

The share of ICT investment does not (Granger) cause real GDP growth rate and vice versa

Alternative Hypothesis

The share of ICT investment does (Granger) cause real GDP growth rate and vice versa

Delimitation

The study of this paper is limited to a time series causality analysis of 30 years of Sweden data (1980-2009). I took time series into consideration here because traditionally such series taken to be trend cycles and were strongly associated with the concepts of secular evolution, the business cycle, the seasonal or irregular variation and transitory influences. Time series data and tools are incorporated in my analysis because generally both variables GDP growth rate and ICT investment reported for a particular instance in time. Because of temporal structure both variables limited by time, which allows me to test the stationary of data before further analysis. Such time series analysis will not only eliminate problem of spurious regression but also make empirical findings more consistent.

Theoretical framework:

Schumpeter's Theory of Economic Development.

According to Schumpeter (1911), development is defined in a sense when new goods are introduced which are not available for consumers before and to produce these new goods new scientific methods of manufacturing introduced. Moreover new established market appeared which also do not exist before. The supply of raw material to production organizations also become competitive so that newly founded industry like to create the monopoly position or breaking of a monopoly.

This theory explained the concept of entrepreneurs; individuals whose function is to carry out new combinations of production. It is not necessary that these individuals include all heads of firms or managers who may operate that business. The fundamental idea was put here to distinguish between entrepreneurs and capitalist. According to J.B. Say: "the entrepreneur's function is to combine the productive factors, to bring them together. Since this is a performance of a special kind only when the factors are combined for the first time-while it is merely routine work if done in the course of running a business" (Schumpeter, [1911] 1973, p.76)

The role of entrepreneurs in economic development contributes as how fast and slowly capital grows and related to the phenomenon of innovations and change. Entrepreneurs give more importance to the growth in terms of technical progress, innovations and supply of labor. Schumpeter identifies entrepreneurial profit as prime motivator_ "the premium put upon successful innovation". When other participants see this high profit they also start imitating the innovation. The entrepreneurs tries to preserve high profits for as long as possible, through patents, innovation processes, so "aggression directed against actual and would be competitors". Economic development is qualitative, in the form of qualitative improvements of the economic process, while growth is quantitative, in the form of more factor inputs. Economic growth and investment both are quantitative elements but their linkage is also very crucial which targeted in this study.

Schumpeter's explanation of why demand and supply have grown more or less at the same rate would be that supply adjusted to demand while demand in turn reflected the activities and investments of the entrepreneur. Entrepreneurs increase the productivity and capital formation

of any economy and try to bring economic development thorough innovations. Carrying out new combinations, command over means of production and employing of different resources are the fundamentals of the theory of economic development.

The Theory of Innovation

We can simply define innovation as the setting up or creation of a new production function which consists of new combinations of new products, processes, types of organization, sources of supply, and markets. In a technological sense, the marginal productivity of each factor changes. It does not mean every coefficient of production is necessarily increased or decreased.

Innovation deals with the behavior of these coefficients. He also defines innovation with reference to cost function or total costs. Whenever a quantity of product is produced with smaller costs while prices of factors did not change at all there might be some sort of innovation occurs. We can say that "all the marginal cost curves destroyed and replaced by new ones, then there is innovation. And if prices of factors are not constant but change independently then the one firm's cost curves is analogous to the effect of innovation. They break off and new ones emerge instead" (Schumpeter, [1939]1964,p.62-71).

In connection to cost analysis, he sets up some assumptions and observations as well. Firstly newly constructed plants or re-structuring the old ones can be the cause of any small or big innovation. But this assumption is restricted in the sense, not every new plant embodies an innovation; sometimes some smaller addition in the existing plant of production shows the sign of innovation occurring. This phenomenon is important but difficult to estimate. The second assumption is that every innovation embodied in a firm founded for the purpose. It was thought valuable that a new production function can be generated when the new firms founded with a definite purpose. This fact urges the newly build firms on the lines of evolution, the process of innovation is demanding in the system. The third assumption is, innovations are always associated with new entrepreneur. The idea is basically that if a new man takes hold of an old industry, with his introduction and his new innovative ideas then there might be a strong chance industry grows up rapidly and with this growth industry innovations embodied. It is the fundamental truth of the socially build industrial society. All these observations and assumptions are interpreted into two key facts as described below;

"First that innovation do not remain isolated events, and are not evenly distributed in time, but that on the contrary they tend to cluster, to come about in bunches, simply because first some, and then most, firms follow in the making of successful innovation; second that innovations are not at any time distributed over the whole economic system at random, but tend to concentrate in certain sectors and surrounding . Industrial change is never harmonious advance with all elements of the system tending to move in step. At any given time some industries move on, others stay behind; and discrepancies arising from this are an essential element in the situations that develop. Progress in the industrial as well as in any other sector of social or cultural life not only proceeds by jerks and rushes but also by one sided rushes productive of consequences other than those which would ensure in the case of coordinated rushes" (Schumpeter, [1939] 1964, p.75-76).

Åkerman and Dahmén think that established firms and industries might be the engine of an upswing. The business revival is led by firms that use modern technologies, are cost effective and financially well equipped (Åkerman 1960, p 142, 154, 189). Further Schumpeter says that we have to distinguish between innovation possibilities and the practical realization of these possibilities. Development and prosperity do not depend upon inventions or discoveries but fully depend upon the actual development of the innovations. These are the driving power to continue and enhance the period of prosperity. Schumpeter linked innovation to cycles including long waves. The microchips technology long wave is an example of innovation linked with cycles. Innovations in the shape of microchip introduced which further developed and improved and turn out to be long wave of technology based on microchip.

Contribution Kondratiev 's

It is not easy to understand the dynamic of economic life by only considering the short period or seven to eleven years business cycles. In 1922, Professor N. Kondratiev presented his theory of long cycles. He stated that "we consider the long cycles in the capitalist economy as probable (Kondratiev 1922, p.255) in his publication, first time he gave stress on his idea of cyclical character of long cycles. He investigated this phenomenon of long cycles or waves for French, English, and American whole sale price level till the end of eighteenth century.
He used the method of deviations from secular trend presented by Dr. Warren M. persons in 1920. By nine years moving, the process of smoothed series was adopted to eliminate short cycles or 7 to 11 years business cycle. Kondratiev found that by examining different series

starting from the end of 18th century to present time show long cycles. Even mathematical explanation is rather complicated but these cycles cannot be considered as a result of some kind of accident. He also stated that without secular trend e.g. prices, these cycles are formed in like a wave movement (Kondratiev and Stolper, 1935, p. 105-15). The confirmation of the hypothesis of long waves was made by examining the historical data related to price level, interest rate, consumption and production of coal, iron, and lead, moreover wages and foreign trade. Kondratiev and Stolper arrived at a position to make certain propositions which are as under;

1) The dynamic process of upswing and depression of long waves also holds complexity and the same pattern as that of intermediate cycles.

2) In recession of long waves, agriculture sector showed longer depression. This was specially observed in the years after wars.

3) In recession of long waves, plenty of important inventions and discoveries were made but these usually became applicable in the starting of next long upswing.

4) At the start of long upswing, gold production emerged as a leading factor in the worlds markets.

5) During the expansion of long upswings, sudden wars and revolutions came from nowhere to influence the path of economic development.

This literature is helpful and relevant in initial level of understanding of a short period cycles or waves that is in my case of study. Things always never happen in any long cycles as a probable some motives and functions starts even before its actual beginning. These propositions are attributed to as empirical characteristics only not the complete explanation of long waves. This was the reason, Kondratiev 's writing had to face criticism latterly, by Gubernan (1927), Oparin (1930), Eventov (1929), and Bogdanov (1928). Firstly Kondratiev 's methodology of eliminating trend was question marked. The concept of trend was so vague and not understandable in Kondratiev theory of long waves. Oparin (George Garvy 1943, p 210) stated that "the formal mathematical criterion (methods of least squares) applied by Professor Kondratieff is of little use in finding long cycles in the analyzed series.

Bogdanov (1928) also raised the similar question on Kondratieff's relation of long waves and secular trend. The decomposition of trend was artificial in the sense that both long waves and trend are similar reflection of economic system. Trend reflects the average rate of growth whereas long waves show the acceleration of the process of growth. Granovsky (1929) and

Guberman (1927) also suggested that this theory and study only describe price movements in longer period, but no evidence of long waves. Guberman (1927) concluded as "All that remains…. to be explained as an independent phenomenon is the movement of prices in the 19th century and 20th centuries".

On Kondratiev statistical grounds, he was not so successful to show long cycles in economic life and no empirical explanation about cyclical recurrence of long cycles. But in addition to cyclical character he arises to his investment theory. According to him, high investment is required to introduce any or all important inventions at a certain point of time. Capital goods so produced have a set life time and their successive replacement is possible by the big investment in one original period. I would like to mention two important points from Kondratiev 's contribution the one is, new inventions require intense investment in a particular point of time. Second new inventions are assumed to be applicable when new investment emerges to replace the original investment. So it's all about the synchronization of new and replacement investment of sufficient magnitudes which causes the long waves.

The problem which I am going to study is related to the above literature in another sense that time series of telecommunication investment formed cyclical movement. It can also be understand that long business cycle of such investment emerge on the scene as revolution. Long wave of telecom investment did not come as a result of accident. It based on empirical characteristics of historical data as well which followed a development path. On the basis of Kondratieff's study, telecommunications investment in the shape of long wave establishes a well developed telecommunications infrastructure which laid the path of growth other economic sectors of the country. This study actually tells that it is accepted a sector is developed and groomed others as well but what if investment involved in it has its direct influence on overall growth level i.e. GDP growth rate.

Long waves and Technological Innovations

The concept of long cycles is further advanced by Schumpeter in 1939. He explained that growth and occurrence of these cyclical patterns is mainly due to technical innovation. Schumpeter strongly believed that the ability and initiative of entrepreneurs to make new discoveries and inventions result in new opportunities of large investments. Due to such

investment opportunities, higher level of employment, profits and growth can become achievable.

Only a few innovations can become the reason of large profits. But sometimes imitators not necessarily follow the same growth path because large number of people adopts the newly formed technological process at the same time which of course results in fall of profits until the recession sets in. This recession may be continued until the new wave of technology and innovation appear on the economic scene. Schumpeter argued on the grounds of technological innovations that the spread of technical inventions and innovations primarily visible over the whole economy but latterly shows a concentrated trend in one or two sectors of the economy due to disharmonious nature. Moreover he argued "diffusion process is also inherently an uneven one because, first a few and then many firms follow in the wake of successful pioneers" (Freeman, 1982)

Schumpeter's Theory of business cycle

Schumpeter (1939) explained in his theory of business cycles that business cycles are appeared because of inventions and innovation on the part of entrepreneurs. These inventions and innovation comprise of discovery of new markets, new methods and techniques, changes in the component of raw material and finding of new resources. The purpose of entrepreneurs is to make inventions and innovation in order to raise their share in the market.

When a new invention is adopted by an inventor in the market, the inventor will get monopoly and starts earning abnormal profits. Soon the other entrepreneurs in the market start producing the same product with same new methods. This will take the market in a flooded position with such new products. During all this process income and employment level boosted. Each economic activity flourishes and the economy experiences prosperity and development. But with the huge amount of supply of products, the prices come down. The profits of producers also get down because of low prices. Hence the resources get unemployed and income of people decrease. Thus economy enters into the phase of depression. But at the same time the process of new inventions and innovations continues so that the economy will recover which ultimately converts economy into boom position. In other words, Schumpeter concluded that the behavior of entrepreneurs in the context of innovation and invention is major factor of business fluctuations.

The Åkerman-Dahménian theory of the Business cycle

According to Åkerman and Dahmén, the recovery phase of the business cycle is formed, as a rule, by new inventions and by firm's introduction of new products (Åkerman, 1944, p.43, 238-239; 1960, p 150, 189) Schumpeter's theory was in the view of innovations are the driving forces in prosperity phase. Åkerman and Dahmén also agreed that the initial innovations actually lead towards new ones. They also made "common references to a multiplier-accelerator mechanism reinforcing a recovery and also a recession(Schumpeter 1939, p 151-155, 181).But Åkerman and Dahmén's theory deviated from Schumpeter's theory of business cycle because they opposed Schumpeter's distinction between a revival shaped by adjustment forces in the preceding depression, and a prosperity phase started by innovative entrepreneurs in a 'neighborhood of equilibrium'(Schumpeter,1939,p.70-71) Actually entrepreneurial activities based only on innovation held together all recovery phase driving forces.

They saw the upswing as a continuous cumulative process where innovations might also characterize the early recovery phase, thus not only a specific prosperity phase as in Schumpeter's theory. They also rejected the idea that the business cycle is driven by exogenous innovation cycles, for example by recurring entrepreneurial reincarnations (Dahmén [1942]1991b, p 28, 29). Schumpeter also referred to the possibility that old firms could react faulty to innovations and "cyclical clusters of errors" in business cycles (Schumpeter 1939; p 140,146,148). In the creation of primary wave errors can appear because of the innovation and adoption process.

Åkerman and Dahmén then clearly used the concept of faulty investments in business cycles. New innovations could not easily be the entire driving force of recovery so faulty investments are main reason of profit declines. In recovery, firms expand and progress quite rapidly. As a result owners and managers become more optimistic and governed by overconfidence so concept of faulty investment falls into that. So the expansion of progressive firms and industries create imbalances (structural tensions) in the economy and they expect to have lower profits at last. In my case of telecommunication investment might behaved as faulty to certain extent because a financial bubble was created during long wave of technology in Sweden. It happened due to general credit restrictions and financial market condition in the country. The factors of this scenario does not have much relevancy to discuss here.

Structural tensions and Development Blocks

Dahmén (1994, p.2-3) says that transformation dynamic can be more easily understandable by the changing contents within and between micro entities; the center point is entrepreneurial activities, their interrelations and interaction with technology. Dahmén in his transformation analysis develops the theory of transformation process where he looks into different relationships which laid the foundations of a process. Dahmén illustrated two analytical concepts "structural tensions" and "Development blocks" both refer to complementarities in technological technical economic and other factors.(Dahmén 1994, p. 5)

"A **structural tension** is fundamental if nobody in a position to act knows how to solve the problems involved, i.e. those related to technology, applied techniques, production organization, marketing, and customer service and, not least, financing." Dahmén referred **development blocks** as *a sequence of complementarities which by way of a series of structural tension, i.e. disequilibria, may result in a balanced situation or in new structural tensions.* (Dahmén 1950, p 139).

Further, Dahmén used a metaphor of a growing plant to illustrate this concept more clearly. "After a primary underground stage, creating a growth potential, a plant starts growing above the ground whereas for the time being nothing happens below the soil. After a time this has led to an unbalanced situation which stops the growth but makes the roots system enter a secondary stage of development. This in its turn results in a new lack of balance between growth potentials and actual growth. This sets off a renewed growth of the plant above the ground. Such a biological "development block" ends up in a stable balance when the plant is capable of shedding seeds…If one stage of the process is decisively hampered, the other stages are doomed to wither away." (Dahmén, Bo carlsson 1991,p.139)

Dahmén (1994,p.9) explained the dynamics of these development blocks explained as to make products and services more marketable by taking initiative to enhance technical capabilities and to bring more technological solutions. Sometimes these blocks comes in the form of investments even form other enterprises in different other sectors of the economy. These development blocks usually act as investment blocks in complementary areas to resolve structural tensions. So investments need to be made in complementary areas which can

support innovations and entrepreneurs. They help in creating markets where entrepreneur's activities are linked together. These development blocks establish an interrelation between different entrepreneurs to facilitate comprehensive technological and other changes in related economic sectors.

Dahmén (1950) also presented an example of railroad electrification to give a clearer picture of the relationship between structural tension and development blocks. Investors will not gain profit from investing in trunk lines electrification until electrification has not been done with feeder lines of network. Along with that the whole electric rail road system will not be in earning position without other related surrounding industries to this system. Only the innovation is not sufficient to complete development blocks it must be the necessary investment arrangements in the particular sector as well as in other inter related industries. Investment has a key position in the perspective of technology and innovations are also not achievable without capital any sector of economy. Although in some cases the size and share such investment starts influencing the overall growth rate of a country. This causation is core base of this causality study.

Dahmén's concept of development blocks in long waves or cycles can be related to telecommunication sector in a way that technological changes in a certain area cannot be profitable and well utilized until other certain areas experience the same kind of technical advances. Development blocks are based on complementarities. Dahmén (1950) was also in view that banks and financial institutions formed the combination of development blocks. Investment comes in blocks of development and works in mutual network to coordinate and enhance entrepreneurial activities. Telecommunication investment in Sweden came in the combination of development blocks and also increasing the productivity growth in several sectors at the same time. It was the investment cum development blocks which not only covers the structural tensions but also raise the overall economic growth in Sweden.

"At least part of a block may be completed by a single entrepreneur or group of entrepreneurs, possibly supported and /or coordinated by financiers"(Dahmén 1950, p.140)

Dahmén's approach implies on telecommunication structure that entrepreneurial activities in promoting development blocks also more highlighted. If we relate telecommunication structure through the concept of development blocks explained by Åkerman and Dahmén then to complete such development block strong impulses come in the form of technical progress

and investment. Telecommunication structure and developments also went through different structural tensions and the main challenge is filling the gap of and after those new tensions overshoot. This process of gap filling implies two way dynamic progress economic and along with that technological progress.

Dahmén's mechanism of development block and structural tension is very easy to understand with the help of transformation process. He may be called that term of "structural tension" as malinvestment cum development block mechanism. Actually transformation process is divided into two elements that is positive side and negative side. Before explaining these two interactive elements, Dahmén distinguished between original and strategic malinvestment. The original malinvestment belongs to the negative side of the transformation process while strategic belongs to positive side.

When the demand of a firm's product increases whether the reason is exogenous or endogenous to the firm, a situation of market pull is created. This is called positive side of transformation process with strategic malinvestment. Contrary to that the negative side of process occurs when firm tries and make such own actions to increase firm's market share. It is original malinvestment by which firm puts effort to introduce new products or high quality product with lower prices. To introduce new product, firm invest in new combinations and techniques of production which costs too much and result in expensive product. It ultimately shrinks demand of the firm's product or fall in prices. The firm has to face loss. It is called market push situation or we may call it negative side of transformation process which appears due to firm's own mistake.

Transformation pressure creates in two ways, supply side and demand side. This whole phenomenon explained above can be expressed in a diagram. In the following diagram, I construct the Dahmén concept of Development Block through the construction of transformation process;
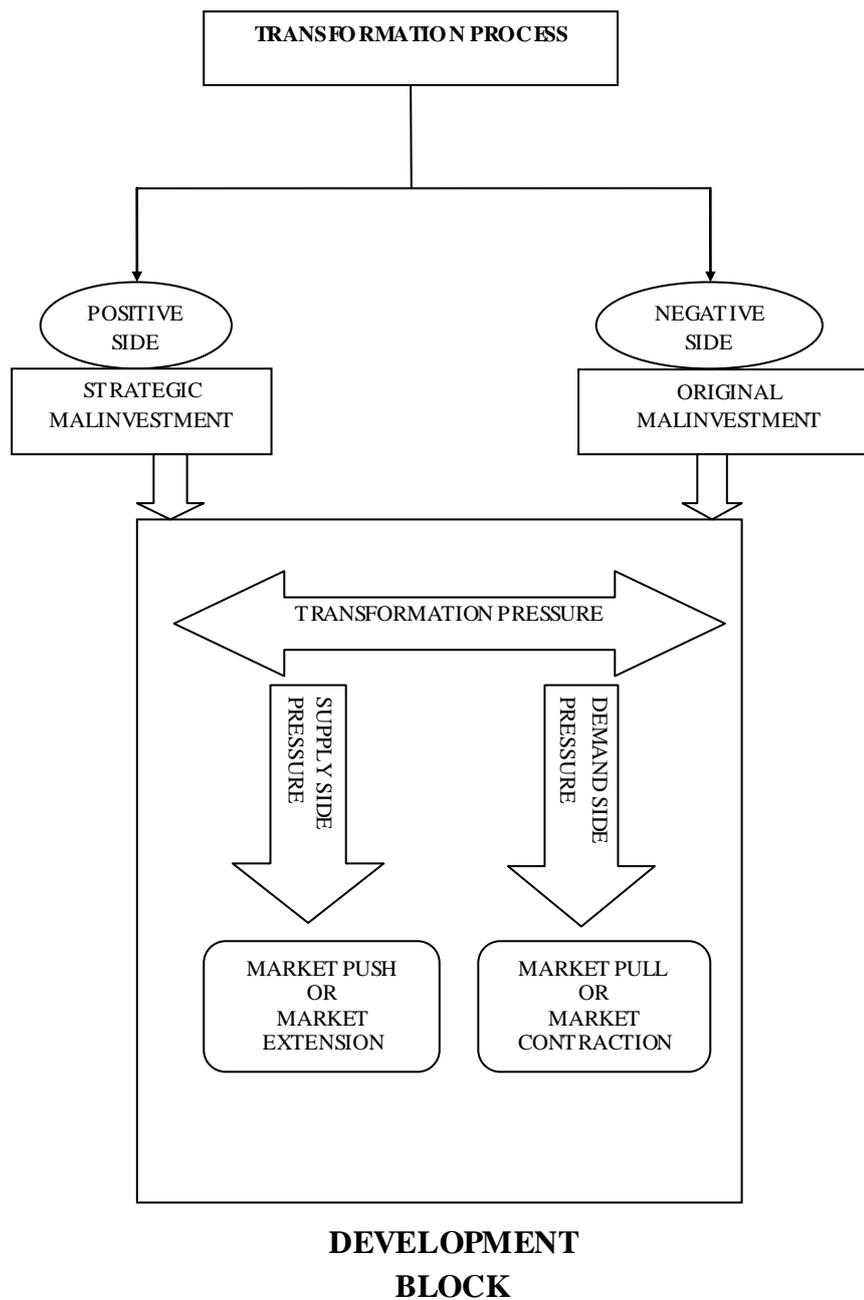
Figure 1: Diagrammatic explanation of Dahmén's Development block mechanism

Dahmén explained the problems related to Swedish telecom sector that the faulty investment is a source of expansion and progress of this sector in phase of recovery. Swedish ICT boom was actually connected with an expansion of progressive firms in computer software and consulting enterprise. These telecommunication progressive firms and industries behave quite optimistically because they earn large profits and have lower subjective discount rate than other firms and industries. As a result, structural tensions emerge in the economy due to rapid

expansion which is not possible to deal with same corresponding investment. Thus progressive firms of telecom sector face actual profit decline and their subjective discount rate raise. Along that expectation regarding banks automatically adjusted downward. Although investment is considered faulty in short run but it can be strongly affective and profitable in long run.

Sweden faced a boom period in 80s along with overinvestment or faulty investment in innovations and progressive industries i.e. telecommunications etc. while in early 1990s the Sweden along with other Nordic countries faced a bit serious economic recession due to extensive faulty investments by overconfident progressive industries. In the second half of 1990s economy entered the phase of recovery which was shaped by progress in ICT (information communication technology). Development blocks in the shape investments formed the basis of innovation driven cycles or telecommunication revolution in Sweden i.e. through the shape of Ericsson and other suppliers. This revolution expanded the relation between other industries and progressive firms which were demanding and expecting advance technology (Erixon, 2009).

I add to Erixon by saying that Åkerman and Dahmén theory actually downplayed the independent role of financial institutions or banks regarding faulty investment. This theory seems to be more accurate in explaining innovation driven cycles such as that of ICT. I analyze that no doubt financial market conditions are not everything in phase of recovery or boom but definitely put stronger weight in the expansion of progressive industries. I think that in early 90s the slight depression of ICT sector possibly emerge due to lack of radical deregulation of credit market and financial institution.

Long wave perspective

Two typologies of Long waves

"Schumpeter's view can be summarized as each and every long wave occur due to the introduction of new technologies, the diffusion of which imparts a deep material change in the reproduction process" (Aleinknecht, 1986) Thus the study of Kondratieff and Schumpeter summed up the explanation of long waves in terms of technological innovations. This typology is alternative to Šmihula modern framework of long waves where he also presented

the fifth wave based on technological innovations. The table below showing initial frame work of long waves based on of Schumpeter and kondratiev 's work.

Table 1. Scheme of Long waves (Schumpeter and kondratiev)

Period	Prosperity years	Innovations and Technologies
First Industrial Revolution (Mechanical Age)	1787–1843	Textile industry specially cotton technologies Mechanical machinery tools, iron replaces wood
Railroad and Steam Engine Era	1842–1897	Railways track and steam engines. Shipping machinery ,petroleum and chemical industry
Age of steel and electricity	1897–1939	Steel and aluminum, internal combustion engines, electrification of household and factories, electric motors.
War and Post-war Boom	1939–1982	Green revolution, greatest increase in agriculture productivity, plastics, synthetic fibers, fertilizers, air industry, electronics and military weapons.
Post Industrial Era: Information Technology	1982 – ….	Mobile and wireless technology, telecommunication infrastructure, internet, fiber optical technology, personal computers and robotic technologies.

Web source: http://en.wikipedia.org/wiki/Kondratiev_wave#cite_note-23

Šmihula presented that innovations can really speed up economic growth but to some certain extent. Without innovations in technology an economy cannot reach at maximal potential of growth and development. He pointed the Kondratieff's long cycles is most appropriate model explaining waves of the technological innovations of modern age. He is in view that in long wave of technology, there is a chain of innovations occurring at the same time but they depend on each other. Each wave of innovations lasts until it reaches its limit that is rate of return on new innovation falls to older ones and the need of new technology fully arises. Big investment is vital in a process of a transfer of a progress in technologies into economy.

Šmihula (2009) contributed that fifth long wave of technological innovation was started with introduction of computers, TV satellite and internet in 1980s.These technical changes paved the path of international financial markets and Globalization. Informational and telecommunications technological revolution was more adequately described from the perspective of one of the Kondratieff's waves (Freeman, 2001). Observable is that phase of technology innovation in the shape of a long wave almost slower down but it does not mean that information technology and telecommunication going to end but more broadly speaking

the next wave of revolution is not possible to attain without long wave of technology and telecommunication. Moreover it is noticeable that each upcoming new wave is shorter than the previous on because of rapid technological progress (Šmihula 2009,p.32-47).

Šmihula developed a modern framework of long economic waves by using the "theory of Kondratieff's cycles." He defined six economic waves based on some certain technological revolution. During the modern age, Šmihula (2009) elaborated six long waves in his conception of each new "wave" due to acceleration of scientific and technological progress) is shorter than a previous one which are shown in the following table;

Table 2. Modern Framework of six long waves

	Technological Revolution	Period of Revolution	Length	Leading sector
1	Financial-Agriculture Revolution	1600-1740	180 Years	finance agriculture, trade
2	Industrial revolution	1780-1840	100 Years	textile, iron, coal, railways, channels
3	Technical Revolution	1880-1920	60 years	chemistry electro technical industry, machinery
4	Scientific-Technical Revolution	1940-1970	45 years	air-industry, nuclear industry astronautics synthetic materials, oil industry cybernetics
5	Information and Telecommunication Revolution	1985-2000	30 years	telecommunications cybernetics informatics internet
6	Post-Information and Technological Revolution	2015-2020	20 or more years	Biotechnical and biomedical Sciences, development of nanotechnology, biogas fuel, biomedical-hydrogen revolution, and industrial robotics.

*** Approximate Years are used for guidance and understanding purpose only
References used from Source: "The waves of the technological innovations of the modern age and the present crisis" by Daniel Šmihula(2009) Studia Politica Slovaca (Studia Politica Slovaca), issue: 1 / 2009, pages: 32-47, on www.ceeol.com

Mensch (1979) and Šmihula (2009) presented two different thoughts and classification of long waves. I studied and analyzed them comparatively, according to Mensch in the period of depressions basic innovations occur in clusters constitute of time span about 50 to 60 years. He called them basic because they create wholly new industries and occur at about the same

time. The reason (why these basic innovations occur in depression period) is investors usually tend towards conventional investment rather than that of basic innovations. They assume high risk associated with basic innovations. It is totally hypothetical idea of Mensch without any empirical evidence. He also tried to claim that waves of innovations do not systematically follow waves of inventions.

Šmihula suggests the telecommunication-based long wave is approaching its end along with that the telecommunication infrastructure is integrated in the economy, so it is no longer a source of long-run growth. However it does not mean that development in the area of telecommunication and information technology also going to end. Telecommunication infrastructure is integrated part of modern human life and economy but even still in Central and South – East European part, nations are trying to catch up in this sector and do something. The telecommunication infrastructure contributed to productivity growth through high level of business opportunities in industry, employment increase, trade push and foreign investment in the economy. The massive use of telecommunication infrastructure in the form of computers, internet and mobile phones acted as an excitant in business, economic and political structure. The telecommunication revolution is almost over but still attracts attention on certain features to think and focus for future longer term possibilities.

It also does not mean that my study of telecommunications infrastructure investment totally as a historical case of a long wave. It is indeed a very closely connected and the most recent time existing phenomenon. The other justification for that can be clearly hypothesized that telecom infrastructure provides the basis of future technological progress and revolution. For example, computers and internet will remain there in technology advancement regarding communication and interaction. It is a useful study to predict about post information technology wave that is, telecommunication sector investment will show or not dynamic causation to growth. This study actually can put lights on the phenomenon that upcoming long waves are associated with this present age of telecommunication. The demand of new innovations and inventions keep pressuring the further advancements in telecommunication technology. These require more research and development as a result investments and finances get involve in that. The role of banks and financial institutions in terms of investment keep pushing development in telecommunication sector as it was before in the beginning of telecommunication revolution especially in the case of Sweden. This paper can answer the

question that only investment push have one to one direct influence on economic growth rate of Sweden or the situation has some different understanding.

Schumpeter's Theory of Economic Development and evolutionary economics

Nelson and winter (1982), in their famous book, *An Evolutionary Theory of Economic Change,* developed the concept about evolutionary behavior of firms and operating units in the economy. Evolutionary theory explained that firms or operating units in the market are based on the motivation of profit maximization but their decisions and functions are not to be assumed as profit maximizing. Satisficing is a routine and is used instead of optimization. In distinguish manner, industry equilibrium associated with the situation, all profitable firms keep their positions in contact whereas none or less profitable firms thrown out from business. The hypothetical state "industry equilibrium" is actually characterizing behavior and capabilities of the firm.

This explanation is basically presented in contrast with the orthodox theory of firm. The firms following orthodox position actually rely on the usual, calculus, and conventional techniques of profit maximization. The orthodox theory focuses on the hypothetical state of industry equilibrium whereas evolutionary theory views firm behavior consists of their capabilities, different sets and rules of decision making which may also result in profit maximization. In evolutionary theory, firm always remains in search for better and advanced operational techniques and methods. Thus we can say that evolutionary means in a term of "bunch of processes of progressive and developmental changes. Moreover all business firms have different key elements in the determination of decisions and of decision outcomes. Simply in the words of Nelson and winter;

 "The core concern of evolutionary theory is with the dynamic process by which firm behaviors pattern and market outcomes are jointly determined over time. The typical logic of these evolutionary processes is as follow. At each point of time, the current operating characteristics of firms, and the magnitudes of their capital stocks and other state variable, determine input and output levels. Together with market supply and demand conditions that are exogenous to the firms in question, these firm decisions determine market prices of inputs and outputs. The profitability of each firm thus determined"

I analyze the process of technical innovation which gives new product or service resides strongly on R&D functions and departments of the organization. It is the R&D professionals and engineers who collect and share with each other technical information regarding patents, scientific articles, business data, and news information. They speed up the process of innovation and become capable of providing new solutions to the organizational problems. It can be said that it also enhances the capability of generating new innovations. In addition Nelson and Winter neo-Schumpeterian synthesis argue "in their internal interactions, firm organizations are therefore bound to use rules of thumb and develop organizational routines. Production, calculations, price setting, the allocation of R&D funds, etc. are all represented as a rule-bound behavior and organizational routines" (Nelson and Winter, 1982, Ch. 5). In my case of study the component of a dominant firm and role of R&D in innovation and technology has brought the Sweden telecom sector at such growing position in recent times. Both telecommunications growth and overall economic growth in Sweden are linked in the same perspective. The key sectors of economy somehow depend upon growth of communications and global interactions.

The comparison between theory of economic developments (1911) and Nelson and Winter's evolutionary theory of economics (1982) confirmed that there exist strong linkages and connections between evolution and technology. Evolution literally means unfolding as captured by the development of a particular entity over time. The developments in any particular entity emerge due to technological changes. These technical changes heavily rely on innovativeness and advance technology. The economic development of any sector like telecommunication can be described as an evolutionary process in which technological knowledge and learning strongly highlighted. The new evolutionary growth and economic development is ensured by the co-evolution of technologies, industrial plus organizational structures and regulating institutions.

I believed that in evolutionary context empirical example of telecommunication infrastructure fits because this sector with introduction of technology opened the possibility to large business firms to market their products and services on a large scale. On the other hand economic and social changes evolved on the basis of technical changes. Development blocks are essential to enhance entrepreneurial activities and technological changes.

In telecommunication revolution I put a distinguishable thought where one factor is investment and other is three issues i.e., technology, institutional changes and sector development. These three linked together and can closely explain the causality of telecommunication sector. Suppose for a while I neglect investment, then technology brings changes at firms and institutions level. While on return these changes start focusing more technology and ultimately through the evolutionary economics my specific sector flourish and develop. Of course without investment any sector cannot build technology nor institutional changes. The thing is that Sweden 's telecommunication sector developed with investment technology and evolutionary changes. I am not discussing and analyzing share of investment influence within particular infrastructure development, I am interested in that size and share of investment involved in world 's best developed infrastructure has its influence on growth rate of the country. Investment is there without degrading the value of capital abundance I am looking one step further. That is investment can be enough for this sector development and that sector to aggregate growth level. But it might be not all the time right this part of investment does cause or has an influence to country 's real growth rate (GDP).

Sweden's telecommunication tradition in an evolutionary context

In this part the history of Sweden's telecommunication sector and its evolution briefly presented. The foundation of telecom sector was laid down by Abraham Niclas Edelcrantz in 1794 when he invented the optical telegraph. This telegraph was used as a network linking of different stations. This network gradually expanded and used around Stockholm till the end of war against Russia 1809. After that Sweden start developing this optical telegraph and replaced by electric telegraph line in 1853. It was initially opened between Stockholm and Uppsala but at the end of 1860 Sweden developed and establishes communication links to Denmark, Norway and Finland. Stockholm's telegraph continue focusing on the improvement of telegraph instruments through research. Öller & Co. was the leading company at that moment who was supplying telegraph instruments. In 1866, Lars Magnus Ericsson also joined development and improvement of telegraphs instruments. The rapid growth of telegraph facilities in Sweden was evident when Atlantic cable connection was made between Sweden and America in 1866. Lars Magnus Ericsson and Carl Johan Anderson started Ericsson & Co in 1876 which did really good business in production of telegraph instruments. (Telemuseum.)

Graham Bell's telephone entered the Swedish market with the name of International Bell Telephone Company in 1880 which establish telephony local systems in Stockholm, Göteborg and Malmo. Ericsson refrained company setup and converted its telegraphy instruments to own telephones manufacturing. On the other side many domestic companies also entered to compete with Bell Company. Stockholms Allmänna Telefonaktiebolag – SAT was the leading one which provided large number of subscribers and local connections. L. M. Ericsson & Cos Mekaniska Verkstad in 1889 developed one of the first portable telephones in the world. This phone was initially addressed to the needs of Ericsson's major customers and for rail road services. Ericsson was supplying telephone equipment capturing the market on basis of price and service quality so Bell Company gave up. Telkegrafverket constructed long distance lines and also build private networks in Sweden throughout the 1890s. With technical performance, Telkegrafverket was holding the major private networks and dominating long distance calls in Sweden. It also took control of SAT in 1918 and Telkegrafverket was finally renamed Televerket in 1923. Televerket remained the sole telecom operator in Sweden for many upcoming years.

Karlsson (1998) pointed out that Televerket occupied the Swedish telecommunications industry with monopoly from 1910 to 1960. During that era technical development, expansion of networks and automation of networks made possible. Complete automation of national networks and coaxial cable was also the key role played by Televerket. According to Karlsson (1998) up to 1993 Televerket remained responsible for the overall Swedish telecommunications due to several reasons. Firstly there always exist strong relation between Televerket and Ministry and secondly no linkage between Televerket and postal service which means no worry about telephony substituting for postal services. Third reason, the Televerket was independent public enterprise under the supervision of Ministry of transport and communications. In the end it could also manufacture telephony equipment and develop R & D expertise. In the 1980s Televerket dominated telecommunications in the sense that it was in the forefront by employing different new ranges of technology.

Evolution of Swedish Telecommunication Sector and Developments

The strength of Telecommunication sector in Sweden was not emerged and built over night. It also passed through phases and seen different stages of evolution. Televerket being the most responsible and characteristic feature of Sweden telecommunications also represent building block of revolution. Even in early period, it had offered answering machines since 1950s especially for usage in terminal equipment. It also provided modems of data com since 1960s. in the era of 1970-1993, lots of new models and technologies were introduced and developed by Televerket with Ericsson itself. In 1968, Ericsson developed switches AKE 12 which further developed by Televerket in the shape of AXE in 1980. Digital radio links in 1977 and INTELSAT satellite station was also launched in 1971. Televerket was becoming more market oriented so that in mid 1970s, Televerket established two new market departments one for telephony and one for data which among other things were allowed to advertise (based on economic considerations) (Karlsson 1998,p.96-97)

In Sweden deregulation has also been a pervasive trend during 1970s. Karlsson(1998) stated major forces behind that case in Sweden was economic interest driven by technological development and policy diffusion. Deregulation actually paved the path of large telecommunications technology developments by promoting competition in industry. When microelectronics and telephony technology was developed on large scale in 1960s and 1970s so large groups manufacturing and trading also emerged in the sense of taking advantage such intense competition. Then process of liberalization was very first time in telecommunication initiated and promoted quite similar to the US and its policy was advocated by WTO.

In this way role of Televerket was protected through a legal framework i.e. liberalization. Before that Televerket was all in all and also forcing constraints for new entrants in the sector. Televerket virtually remained monopolist in telecom sector but in 1981 government made a decision to permit Comvik AB to operate as a second mobile operator company in Sweden.

Lately this decision gave rise to lots of confrontations between the two. Although the deterioration of monopoly is Sweden telecom began but even then Sweden stayed at top among world's leading telecom sectors. This monopoly remained positive and rationale in Sweden to the evolution of telecommunications due to several aspects and features. The basic

consideration was that in telecom sector financial and societal optimum can be achieved through monopolistic firm. The reason for that is economies of scale and large network effects. So it can be said that it was a natural monopoly in Sweden which ensured the compatibility and connectivity. This monopoly eliminated the risk of private poor firms and networks and maintained the technical integrity in telecommunication sector. It was centralized in the country so its long term planning and policy was comprehensive and excellent.

Televerket also played a role in constructing long term telecommunication R & D policy. For example, it was funded and commissioned by the Government for both research and development of telecommunication equipments. Televerket 's performance and improvement in technologies was above international standards. The following table gives us an idea of Sweden's telecommunication performance during the 1990-2010 period

Table.3 Sweden's telecommunications performance some key ICT indicators : an overview

	1990	1999	2000	2009
Fixed telephone subscription per 100 inhabitants	68.34	68.83	68.35	55.2
Mobile Subscription per 100 inhabitants	5.7	57.9	71.8	125
Fixed (wired) Internet subscription per 100 inhabitants	--	21.24	25.37	35.24
Telecommunication Revenue USD (M)	5330	4623	4413	6601
Mobile Telecommunication Revenue USD (Millions)		1532	1505	2531
Total communication access paths per 100 inhabitants	68.3	126.8	141.1	209
Total Broadband (percentage) subscription per 100 inhabitants	0.00	0.12	2.16	31.49
% of households with access to home computers	--	--	59.9	87.58
Percentage of individuals using internet	0.58	41.43	45.69	91

Sources: International Telecommunication Union ICT data explorer and OECD communication Outlook, 2011

Liberalization in Swedish telecommunications sector was formally established in 1993. The liberalization structured into three phases 1) monopoly phase 2) phase with a mix of monopoly and competition 3) Extensive competition phase. On July 1 1993, new telecommunication act entered in Swedish telecom sector. According to which Swedish

telecommunications became a modern marketplace, and several added amendments ensure this "The political objective of the Telecommunications Act was to grant access for everybody, regardless of localization, to efficient telecommunications services at the lowest possible cost, and to ensure that telecommunications would be sustainable and accessible during crises and wartime. The means for achieving this objective was to create scope for and maintain efficient competition within all parts of telecommunications through legislation and implementation of the laws. The law was quite gentle, imposing very few restrictions on the market. Virtually unlimited access to the Swedish market was established without provisions for reciprocity. The purpose of the law was to ensure that operators met certain basic requirements in order to ensure good service quality and durability.

The basic requirements were that sufficient financing resources and technical competency was available, and that some public duties, such as defense and services to the handicapped, were fulfilled".(Telecommunications Act SFS 1993:597 section 2, 3 & 17 a). The share of telecom sector to economic growth has increased largely and almost become 50% of the contribution of industry in 2001. Telecom sector and Ericsson grew altogether specifically 1990 to 1999. It is also evident from the fact that the total production volume of telecom manufacturing industry rose up by 258 percent between 1990-1995.(The Swedish Engineering industry report 1996) similarly share of telecom sector to Sweden 's total exports increased by 16 percent in 2001. Although Ericsson 's share to telecom growth fell in the start of 21st century because of its slow response to deregulation privatization and mobile revolution through which many new operators entered the market.

But after that Ericsson held together the telecom sector and growth of the industry so in 2011 its revenue raised up to 226.9 billion which represents a big share of overall growth of the economy. "It may be hypothesized that, for telecom R&D, Ericsson's growth, in particular in mobile communications, has played an imperative role. If so, the Swedish R&D system overly depends opon the success and failure of one product area of one firm. This has been strength for Sweden, but may equally turn out to be a threat and weakness". (Vinnova Analysis 2004 page 379). The R&D expenditure in public and private sectors has its own important role. It is an absolute necessary part of ICT investment in Sweden as well as all other countries. The most recent figure shows that Sweden spent more R & D expenditures in ICT industries and so it generated more benefits. These benefits are shown in the shape of increase in Sweden 's ICT exports, firms performance and generation of highly qualified ICT

professionals and scientists. The rate of R&D expenditure in the ICT industries is the 2nd highest in Nordic region after Finland in year 2008. The below figure shows R&D expenditure in both ICT services and manufacturing industries of Nordic region up till year 2008.

Figure (2) :ICT Business R&D expenditures by selected ICT industries, 2008 or latest available year. As a percentage of GDP
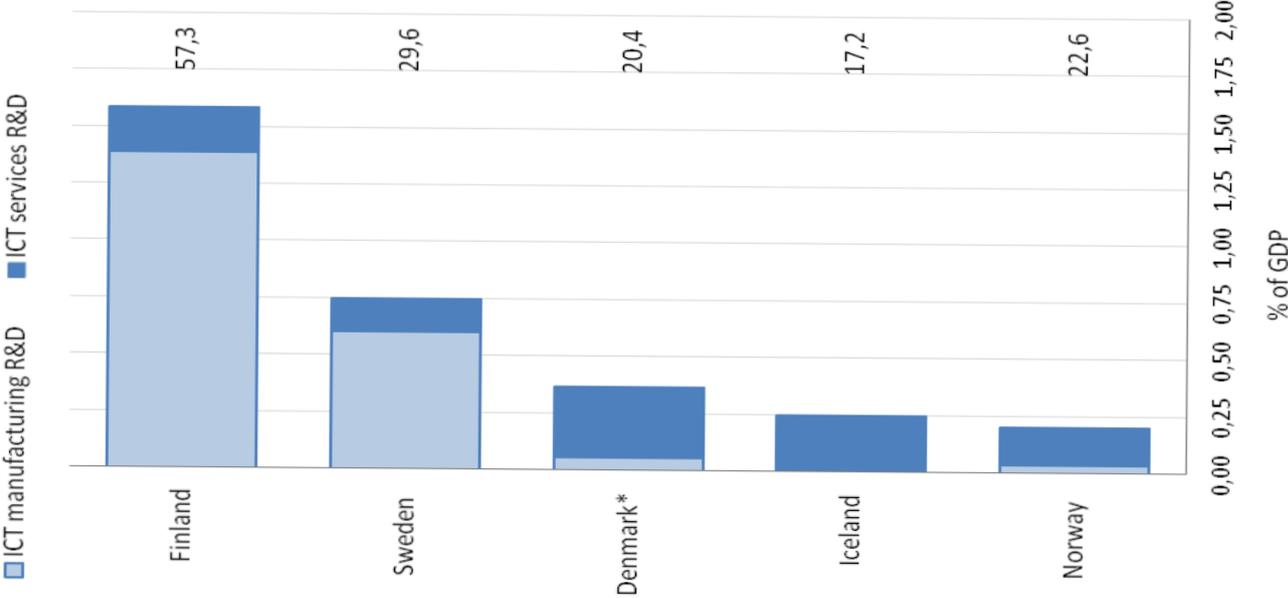
In this part I studied and presented an overview of telecommunication sector in Sweden. I studied this in the scenario of international developments of Swedish telecommunications. Telecommunication sectors in all over the world contributing significantly to economic growth more especially in developed countries. Telecommunications is also equally important to Swedish economy. Edquist and Henrekson (2001a) strongly argued that in major countries the productivity growth in ICT was much higher than any other sector of the economy. In Sweden this growth was even much higher than other sector in the late 1990s. Landmark (2002a) analyzed that in Sweden the contribution of ICT sector to total productivity in manufacturing industry raised to an average 48% in 1997-2000. He concluded that in Sweden

almost 50% of economic growth in the manufacturing industry based on productivity and developments in the telecom sector till late 1990s. Although still there are people who are in argue and believe that overall productivity growth is not aggregately influenced by ICT. The figure below shows that telecommunications export and total trade was in booming position in the late 1990s but communication equipment exports exhibit a drastic decline which consequently drop the total Swedish communication equipment trade in 2001. But after that total trade and equipment exports exhibit a consistent pattern shown in the following graph

Figure(3) Communication equipment in total trade and exports (USD Million) comparison year 1996-2009

■ Communication equipment total trade, USD millions, 1996-2009
■ Communication equipment exports, USD millions, 1996-2009
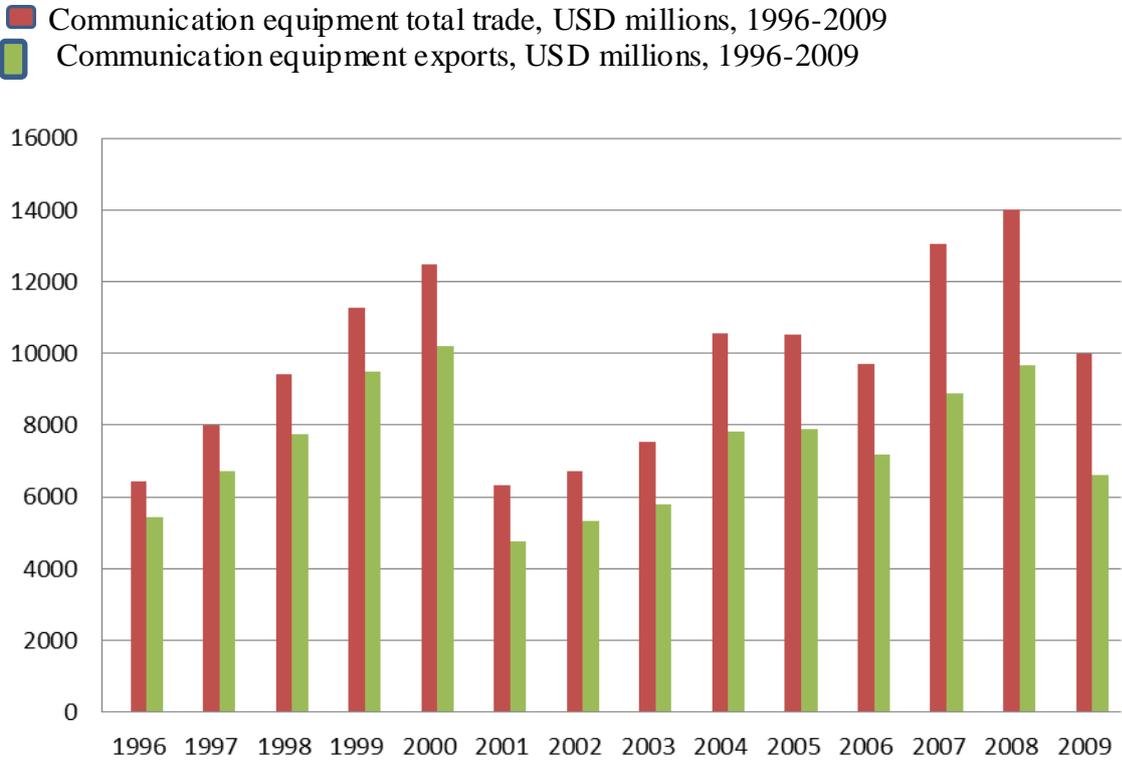
Source: OECD - Telecommunications database 2011

After 2003 total trade of communication equipment showed a continuous and equal pattern of growth without any further drastic fall. This export figure consists of telephone sets, transmission equipment and other broadcasting/wireless equipment. This also explains the Swedish telecom industry's strength in equipment especially. Furthermore till 2009 Communication equipment exports as a percentage of GDP in Sweden 1.63% which is high value in the Nordic region countries after Finland 2.39 %. It is similar to the

telecommunications revenue as a percentage of GDP in Sweden 2009. But it is also quite noticeable that revenue generation capacity as a percentage of GDP has decreased since the year 1995. Although it is quite small percentage as compared to whole Nordic region.

Table 4 Telecommunication revenue as a percentage of GDP in Nordic region

Year	1990	1995	2000	2005	2009
Denmark	1.77	2.07	2.61	2.55	2.47
Finland	1.62	1.95	3.30	2.70	2.36
Sweden	2.24	2.91	1.79	1.79	1.62
Iceland	1.35	1.92	2.91	2.85	2.87
Norway	2.02	2.14	1.56	1.57	1.36

Source: OECD - Telecommunications database 2011

Whereas in recent years the share of information and communication technology (ICT) investment is dynamic component of Sweden's investment in the expansion of capital stocks and sustainable economic growth. ICT shares in total non-residential investment in 2009 were particularly high more than 20% in the United States, Sweden, Denmark and New Zealand. The following figure below gives us an idea that Sweden also leading in the share of ICT investment in the Nordic region. Sweden also has the highest ICT investment in software acquisition even more than United States in 2009. The table below is percentages of each country's gross fixed capital formation, excluding residential construction.

Figure (4) As a percentage of total non-residential gross fixed capital formation, total economy, 2009
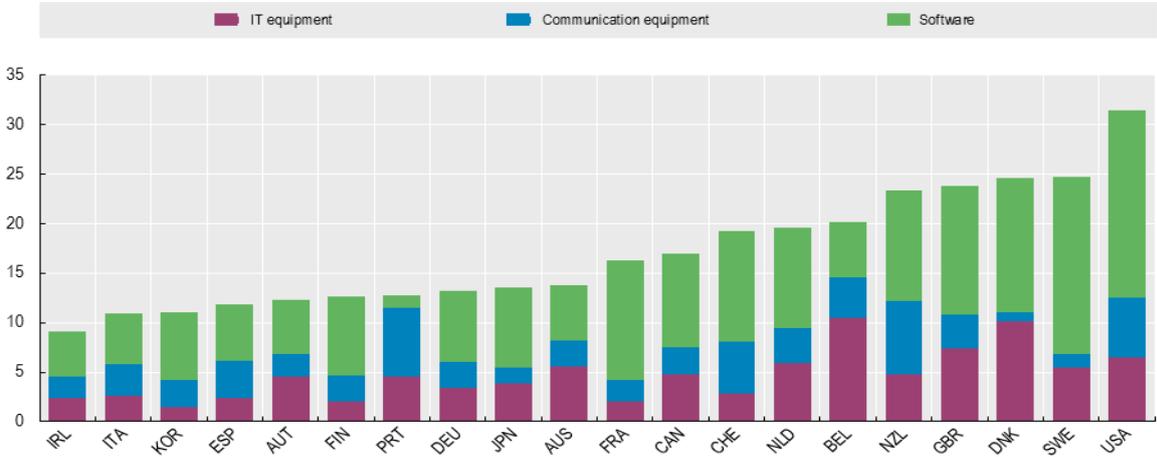
Source: OECD Fact book 2011: Economic, Environmental and social statistics.

Review of literature:

Hardy (1980) investigated the impact of telecommunication investment on GDP. He used the data of 15 developed and 45 developing countries from 1960 to 1973 and he investigated the potential impact by regression model of GDP per capita on fixed telephone lines per capita and radios per capita. He found the largest potential effect of telecommunication development in developing countries while the smallest effect in developed countries.

Cronin (1991) conducted an analysis of causality between telecommunications infrastructure and economic growth. In this study, 31 years US time series data for the period 1958-88 used to test the two causal hypotheses. First, the level of US economic activity at any point in time is a reliable predictor ('cause') of the amount of US telecommunications investment at a later point in time. Second, the amount of US telecommunications investment at any point in time is a reliable predictor ('cause') of the level of US economic activity at a later point in time. The results obtained by using Granger and modified Sims tests suggest that both null hypothesis can be rejected at two years lag interval. With the inclusion of (lagged first difference) result suggest that "the telecommunications investment enhances economic activity and growth while economic activity and growth stimulate demands for telecommunications infrastructure investment".

Norton (1992) studied the link between transaction costs, telecommunication and economic growth. He used the framework of Kormendi and Meguire (1985) and examined the cross national growth of 47 countries from 1957 to 1977.His analysis of telecommunication development and transaction costs were carried out with macroeconomic variables and two telecommunication variables. He found the telecommunication variables are positive and significant and the stock of telecommunication lowers the transaction costs because output increases. He concluded that less developed telecommunication infrastructure is also one reason why some countries are least developed.

Zhu (1996) attempted to study the casual relationship between communication and economic development and also done comparison of mass media and telecommunication share in economic development. By using 17 years pooled time series data of 23 countries. He found that telecommunication not only have higher contribution as well as more rapidly affect the economic development than mass media. Further this study also detected the fact that many countries give priority to telecommunication investment in their policies formulation as well.

Madden and Savage (1998) examined the relationship between gross fixed investments, Telecommunications infrastructure investment and economic growth for a sample of 27 transitional economies in Central and Eastern Europe (CEE). In sectorial economic growth equation, by using OLS for annual data of eight countries (1991 to 1994), estimated co-efficient of growth rate of main telephone lines per 100 inhabitants was both positive and highly significant 0.918 at 5% level of significant. It also plays a vital role in explaining the economic growth. "The finding of a strong and positive relationship between telecommunications investment and economic growth suggests that the allocation of investment funds to productive infrastructures, such as telecommunications is important"

Roller and Waverman (2001) used the evidence from 21 OECD countries over 20 years (1970-1990) to examine the impact of telecommunication infrastructure investment on aggregate growth. They estimate a model in which telecommunication investment specified into micro model of supply and demand for telecommunication investments. With country specific fixed effects they found a positive and causal relationship between telecommunication investment and aggregate output.

Seung-Hoon Yoo and Kun-Oh Jung (2001) examined the causality between telecommunications investment and economic growth for South Korea. They obtained results from Hsiao's version of the Granger causality tests that there exists bidirectional causality between telecommunications investment and economic growth.

Datta and Agrwal (2002) studied the long run relationship between telecommunication infrastructure and economic growth by using the data from 22 OECD countries. Their estimation is based on a dynamic panel model which corrects for omitted variables bias of single equation cross section regression and they found a significant positive correlation between telecommunications infrastructure and growth after controlling for a number of other factors.

Shiu and Lam (2006) used a dynamic panel model to investigate the casual relationship between telecommunications development and economic growth for 22 provinces of china from 1978 to 2004. They divided the total 22 provinces of china into three regions (eastern, central and western region) and applied the panel data to overall model as well as to each region. It was found that causality is running from real GDP to teledensity for whole data and for the western region but eastern region showed the opposite result i.e. no causality was found from teledensity to real GDP in eastern part of china. It actually indicating that

stimulated economic growth in that particular region due to increase in teledensity (penetration rate).

Cieślik and Kaniewska (2004) adopted the theoretical framework of De La Fuente and Vives (1995) to investigate the relationship between telecommunications infrastructure and the regional level of income using panel data for Polish regions from 1989 to 1998. Their study supports the positive and statistically significant causal relationship between telecommunications infrastructure and the level of income for Polish regions. "With causality running from telecommunications to income, this clearly suggests the necessity of taking into account the role telecommunications infrastructure in developing a policy aimed at promoting regional development."

Beil, Ford and Jackson (2005) used 50years time series data for United States to analyze the relationship between telecommunication investment by firms and GDP. This study conducted on Granger-Sims causality tests and found that "the investment by telecommunications firms is caused by, but does not cause, economic activity, and the findings are robust across lag lengths" so that policies aimed at stimulating the economy by accelerating investment in the telecommunications sector may not be successful.

Rufael (2007) further re-examined this empirical evidence, by using the approach in his study of "Another look the relationship between telecommunications investment and economic activity in United states" actually proposed by Toda and Yamamoto (1995) i.e. modified wald tests. He used the same data set used by Beil, Ford, and Jackson (2005) for the period 1947-1996 but contrary to their result Yamane found that by accelerating the telecommunications investment basically stimulated the US economy. There exist a bi-directional causality between telecommunication investment and economic growth.

Tella, Amaghionyeodiwe, and Adyesoye (2007) investigated the simultaneous relationship between telecommunications and the economic growth in Nigeria, using econometric method (3SLS equations) of analysis for the period 1970 to 2004. Even though the data limitation problem, they estimated that economic growth faces the significance effects from fixed and mobile phones penetration. In the case of Nigeria, as penetration affects economic growth, they observed that telecom investment can also affect the penetration.

Sridhar and Sridhar (2009) investigated empirically the relationship between telephone penetration and economic growth. He used panel data for 63 economies of developing

countries for 1990-2001. Using 3SLS they estimated demand for and supply of telecom infrastructure, and endogenize telecom investment and the change in telephone penetration. They estimated that with one percent increase in teledensity (total telephones per 100 population) increases national output by 0.15 percent without fixed effects and by 0.10 percent with fixed effects moreover the income elasticity of demand for telecom services is positive and greater than 1. It has also been observed that with almost 10 percent increase in telecom investment increases the telecom penetration by 0.2 percent. They concluded "the estimates of the effect of landlines, mobile phones and all telephone lines are consistent.10 percent increase in all phones increases GDP by 1 percent; a similar increase in landlines increases GDP by1.4 percent, and a 10 percent increase in mobile phone penetration increases GDP by 0.01 percent. Thus the combined effect of all telephones is higher than that of mobile phones, but less than that of landlines alone"

The above studied literature strongly assumed that telecommunication is a factor which affect the growth of an economy and on the reverse growing economy also raise the demand and growth of telecommunication infrastructure and its services. This sector is based on technology and innovations which evolves an economy into a new scenario of information and communication development. Technology based evolution constructed the path of a long wave in the case of telecommunication. It can be said that the telecom sector experienced a technological wave in which organizational and evolutionary economics strengthen the significant relationship between telecom infrastructure development and economic growth. By reviewing the above mentioned literature, I can synthesize that the relationship between telecommunications development and economic growth is very significant and highly correlated. But the question in my case study arises that to what extent telecommunication development through size of investment contributed to the economic growth of Sweden. The situation can also be opposite as well because I have to consider two causalities which both can be true or either false at the same time. It means in case of Sweden investment at times might behaved faulty in particular long wave The result of this study can also oppose some of reviewed previous literature because circumstances and situations vary from one country to another. The causality study tells us about how the sensitivity of investment played his part in the technological long wave of telecommunication in Sweden. This is the core issue of my study to analyze the causation between telecommunication investments and economic growth.

Variables and Data Source

In this research paper, two time series variable data covering the period 1980-2009 is used. The choice of this time period is constrained by the availability of latest year data on investment in information and communication technology. The first variable is real GDP growth rate of Sweden , unit of measure annual growth in percentage. The reason of selecting real GDP growth instead of gross national product may be more suitable for my casual analysis case because Sweden's investment in ICT as aggregative may depends upon the acquisition and production of ICT goods and services within the country. The other variable is investment in ICT that is shares of ICT investment in non-residential gross fixed capital formation (GFCF).It is a measure of gross net investment in fixed capital assets by government , enterprises and households domestically during a year. Gross fixed capital formation is basically a component of the expenditure on gross domestic product, which shows how much of the new value added in the economy is invested rather than consumed. The data characteristic is, it is a percentage of total non-residential gross fixed capital formation calculated typically every year. The source of data is OECD.StatExtracts (online 2012)which is complete databases available via OECD's library. It is an official data source of countries members with Organization for Economic Cooperation and development (OECD) which is updated regularly on quarterly and annually basis.

GDP growth rate and ICT Investment trend in Sweden

GDP Growth trends

The GDP growth rate shown over all a positive average increase in the case of Sweden. It also followed a some sort of cyclical characters during the period 1980-2009. In year 1980 the GDP growth rate was 1.699% and it raised to 2.799 before the start of year 1990. It experienced a sudden downfall of 1.769% in one year from 1989 to 1990. It was the early 90 's recession period which lasts for a couple of year then a slight recovery begins from year 1993 to 1995 can be observed in the figure. But the effects of early recession keep it down to 1.612% in 1996. After that a big boom of increase lasts till the start of next century. Then another fall of GDP growth was in early years of 2000. Except that till the most recent years (2009) it was a positive increasing trend. The following figure showing the percentage annual GDP growth rate trend of Sweden in the period of 1980-2009.

Figure (5) GDP growth rate trend in Sweden
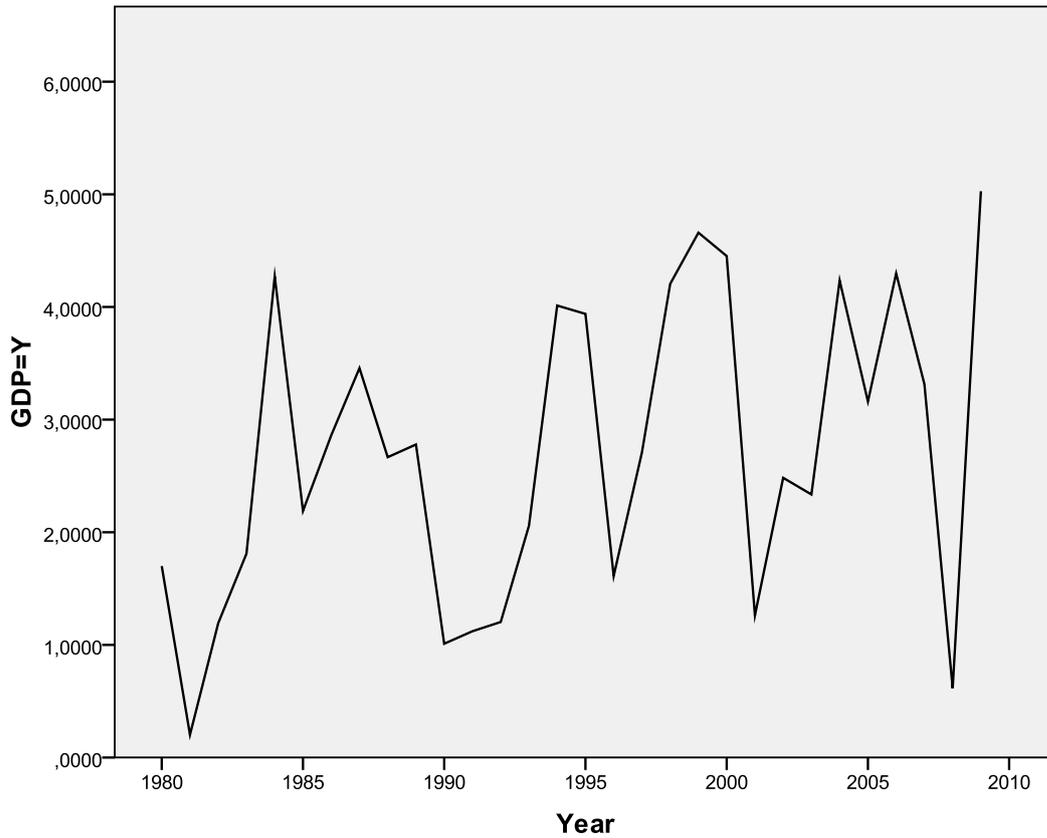
ICT Investment trend

The direction of share of ICT Investment in case of Sweden was very much positive and increasing as well. In the start, year 1980 ICT investment share was 9.342 %. It has a very smooth increase till the start of year 1990. But with the start of 1990 a very steeper increase was seen and share of investment raised up to 25.709 in year 1993 it was the period when GDP growth rate was declining a bit due to some sort of symptoms of recession. The same sort of Peak was in the years early 2000. The share of ICT investment was 31.324 % in year 2000 which is the highest level of investment in the whole period of 1980-2009. After these couple of highest values the share of investment starts lowering but it always maintained an average increasing trend till the year 2009 so the following figure showing the whole scenario.

Figure (6) The ICT Investment trend in Sweden.
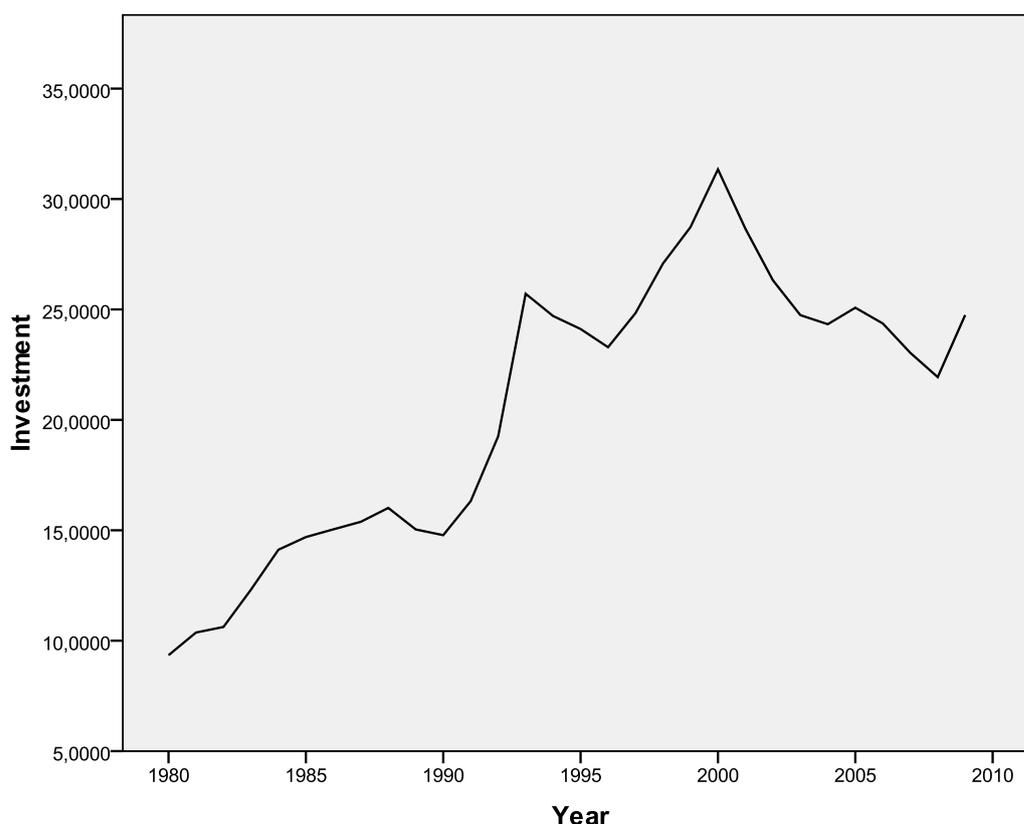
Methodology

Regression analysis explains the dependence of one variable on other but the existence of a relationship or dependence between variables does not prove causality or the direction of influence. To prove and analyze such situation, regression involving time series data sometimes gives different ideas and results. Because time is something which always move forward never backward so one variable in previous time can cause the happening of other variable in the present state of time. This is a rough ideology behind the so-called **Granger causality test.** C. W. J Granger(1969) made the first attempt for testing the direction of causality between two variables. So I am also dealing with two variables causality which also known as bi-variable causality. The Granger causality test is considered as a standard statistical method for testing causal relationship and direction of causality between two variables. (Gujarati and Porter, 2009)

The most convenient and simple approach to detect causality is the Granger test. The reason of choosing the Granger test for this study is based on Guilky and Salemi 's (1982) applied work. They reported that Granger test provide more accurate estimates and results in detecting causal relationship for the small sample size as that is in my case of research study. The similar sort of test of causality but mathematically different proposed by C. A Sims (1972). But here I prefer and focus on Granger test for my research analysis due to its standard applications, accuracy and standard estimation for small sample size. Granger defines causality " X causes Y if and only if Y is better predicted by using the past history of X than by not doing so, with the part of Y being used in either case" More simply in my case study, the time series of GDP (X) is said to granger- cause the time series (Y) telecommunication investment if the prediction error of current Y declines by using past values of X in addition to past values of Y.

In macroeconomic perspective, it is a study of answering the question is GDP that causes the telecommunication investment (GDP→ T-investment) or is it the telecommunication investment that causes GDP (T-investment →GDP) sign of arrow defines the direction of causality. Converse to that there can also be no causal relationship what so ever between the variables. The Granger causality test assumes that the information relevant to the prediction of the respective variables GDP and T- investment is contained in time series data. (Gujarati and Porter, 2009).

The Granger Test

The Granger causality test assumes that the information relevant to the prediction of variables GDP growth rate (Y) and ICT investment (TINV) solely in time series data on these variables. The test involves estimating the following pair of regressions model,

$$GDP_t = \sum_{i=1}^{n} \alpha_i \, TINV_{t-i} + \sum_{j=1}^{n} \beta_j \, GDP_{t-j} + \mu_{1t}$$

$$TINV_t = \sum_{i=1}^{n} \lambda_i \, TINV_{t-i} + \sum_{j=1}^{n} \delta_j \, GDP_{t-j} + \mu_{2t}$$

I am dealing with two variables so it is a case of bilateral causality where it is also assumed that the disturbances $\mu 1t$ and $\mu 2t$ are uncorrelated. The following steps are involved in implementing the Granger causality test

(1) Regress GDP on all lagged terms of GDP and other variables if any but do not include lagged values TINV variables in this regression. It is a restricted regression from which I obtain restricted residual sum of squares RSS R

(2) Now run the regression including lagged TINV terms so it is the unrestricted regression from which I obtain unrestricted residual sum of squares RSS UR

(3) The null hypothesis Ho : $\Sigma \alpha i = 0$ that is TINV causes GDP or lagged TINV terms do not belong in the regression.

(4) To test hypothesis F test apply

$$F = \frac{(RSSR - RSSUR)/m}{RSS\ UR/(n-k)}$$

which follow F distribution with m and (n-k) df

Where m = The number of lagged TINV terms , k = The number of parameters estimated in the unrestricted regression , RSSR= Residual sum of squares from restricted regression and RSSUR= Residual sum of squares from unrestricted regression

(5) If the computed F value exceeds the critical F value at the chosen level of significance we reject the null hypothesis that is it shows TINV causes GDP.

Hypothesis Testing Criteria for Granger causality test in three cases as follow;

Unidirectional TINV→GDP   Ho : $\Sigma \alpha i \neq 0$ and $\Sigma \delta j = 0$

Unidirectional GDP→ TINV   Ho : $\Sigma \alpha i = 0$ and $\Sigma \delta j \neq 0$

Bidirectional GDP↔TINV   Ho: $\Sigma \alpha i \neq 0$ Ho : $\Sigma \delta j \neq 0$

No Causality GDP ↮ TINV   Ho : $\Sigma \alpha i = 0$ Ho : $\Sigma \delta j = 0$

Pre estimation tests

We cannot directly apply the granger test before going into the detail of steps and procedure of Granger test certain things need to be noted and some pre estimation tests performed which discuss as follows.

Test of Stationary

"A stochastic process is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance or gap or lag between the two time periods and not the actual time at which the covariance is computed. A non-stationary time series has a time-varying mean or a time varying variance or both. In short, if a time series is stationary, its mean , variance and auto covariance remain the same no matter at what point of time we measure them; that is they are time invariant. while non stationary time series is will have time varying mean , variance or both" (Gujarati 2009, p 797-98)

It is important for causality analysis that time series should be stationary because if we take a non stationary time series then results show only for certain time period and cannot be generalized on other time periods along with that propose of forecasting will not be in valid. The another reason why time series should be stationary because to avoid the phenomenon of spurious regression. Because R^2 value is very low or tends to zero in such regressions showing that there should not be any relationship between the two variables. The results of spurious regression are meaningless and impractical in use. It is assumed that both the variables GDP and telecommunication investment are stationary or even sometimes taking the first differences of the variable convert them into stationary form. To check that I would apply two stationary tests on both times series variables.

The Unit Root Test

Firstly I would like to give brief idea behind Unit root test procedure that is the begin with the following equation,

$$Y_t = \rho\, Y_{t-1} + \mu_t \qquad\qquad -1 \leq \rho \geq 1$$

where μ_t is a white noise error term and we know when $\rho = 1$ then it becomes a random walk model without drift which we also know as a non stationary stochastic process.
 By doing so we can find that ρ is statistically equal to one or not . If it is equal to 1 then Y_t is non stationary. It is the most basic idea of unit root test of stationary (Dickey- Fuller Test.) I

am going to estimate stationary of two variables GDP (Y) and ICT investment share (TINV) so DF test estimates three different forms of possibilities for each variable under three different null hypothesis that are as follows;

GDP growth rate

Yt is a random walk: $\qquad \Delta Y_t = \delta Y_{t-1} + \mu_t \quad ... (1)$

Yt is a random walk with drift: $\qquad \Delta Y_t = \beta_1 + \delta Y_{t-1} + \mu_t \quad ....(2)$

Yt is a random walk with drift $\qquad \Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \mu_t \quad ...(3)$

around a stochastic trend:

where $\quad$ Yt = growth rate at period t $\qquad t =$ is the time or trend variable in eq (3)

$\qquad$ Yt-1 = growth rate at period t-1 $\quad \Delta =$ first difference operator and $\delta = \rho\text{-}1$

In each three cases the null and alternative hypotheses are as follows
Null hypothesis, $\qquad$ Ho: $\delta = 0$ (GDP growth is non stationary) there exist Unit root
Alternative hypothesis, $\quad$ H1: δ less than 0 (GDP growth is stationary) there is No Unit root.

If the null hypothesis is rejected thus it means we have stationary time series with zero mean. Dickey and Fuller computed critical values of *tau statistics* for statistical inference but MacKinnon prepared more extensive table which usually used in DF tests.(Gujarati 2009, p 814-815). Similarly for Investment variable three forms can be estimated and in the same way null hypotheses carried out in the Unit root DF test.

ICT Investment

TINVt is a random walk: $\qquad \Delta TINV_t = \delta TINV_{t-1} + \mu_t \quad ... (1)$

TINVt is a random walk with drift: $\qquad \Delta TINV_t = \beta_1 + \delta TINV_{t-1} + \mu_t \quad ....(2)$

TINVt is a random walk with drift $\qquad \Delta TINV_t = \beta_1 + \beta_2 t + \delta TINV_{t-1} + \mu_t \quad ...(3)$

around a stochastic trend:

where $\quad$ TINVt = Investment in ICT at period t $\qquad t =$ is the time or trend variable in eq (3)

$\qquad$ TINVt-1 =Investment in ICT at period t-1 $\quad \Delta =$ first difference operator and $\delta = \rho\text{-}1$

In each three cases the null and alternative hypotheses are as follows

Null hypothesis Ho: $\delta = 0$ (ICT investment is non stationary) there exist Unit root

Alternative hypothesis, $\quad$ H1: δ less than 0 (ICT investment is stationary) there is No Unit root.

The Augmented Dickey Fuller (ADF) Test

In simple DF test it was assumed that error term μ_t was uncorrelated but if it is not so that error terms μ_t are correlated then Dickey and Fuller purposed ADF test by augmenting the three equations of DF test by adding the lagged values of the dependent variables. Suppose if I use eq (3) of Yt then ADF test consist of estimating the following regression equation ;

$$\Delta Y_t = \beta_1 + \beta_2\, t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t$$

Where ε_t is pure white noise error term and $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$. The number of lagged difference terms to include is often determined empirically, the idea being to include enough term so that the error term in the above regression equation is serially uncorrelated, so that we can obtain an unbiased estimate of δ, the coefficient of lagged *Yt-1*. In ADF test we still test whether $\delta = 0$ and the ADF test follows the same asymptotic distribution as the DF statistics, so the same critical values can be used. (Gujarati 2009, p 817)

Transforming Non Stationary time series

After getting the results from stationary tests if it is found that both variables GDP growth rate and ICT investment are non stationary time series then next step is to transform them into a stationary time series. In causality analysis it is an important assumption should use stationary time series to avoid unpractical results. So sometimes taking the first differences of the variables make them stationary. Simply If a time series has a unit root, the first differences of such time series are stationary. If a time series differenced twice to make it stationary, then it is called time series of integrated order 2 denoted by I(2). In general, if it is differenced more than twice than a non-stationary time series is said to be integrated of order "d" and that time series is represented as *Yt ~ I(d)*. Returning to my case suppose if GDP time series have unit root then I require to take the first differences of the GDP time series that is

Δ GDPt = (GDPt - GDPt-1) , Let Yt= Δ GDPt and consider the following regression;

$\Delta \hat{Y}_t = \beta_1 + \delta Y_{t-1}$ thus it is *I(0)*. Similarly the other variable TINV can also be transformed into a stationary time series.

Co integration

According to Granger (1986) "A test for co integration can be thought of as a pre test to avoid spurious regression situations". As earlier mentioned spurious means no relationship what so ever due to lowest R^2 value which has no economic meaningfulness. Therefore we should focus on that the regression of a non stationary time series on another non stationary time series may produce a spurious regression. The basic idea of Co integration is to show a systematic co movement among two or more economic variables over the long run. Two variables will be co integrated because they have a long term, or equilibrium relationship between them. According to Engel and Granger (1987), if X and Y both variables are non stationary, it would be expected that their linear combination cancels out the stochastic trend and linear combination would be a random walk. Although any particular combination such as Z= X-bY of both the variables show stationary property. By holding this property it can be said that Y and X are co-integrated.

Engle & Granger (1987) also suggested that if both variables are non stationary and co integrated then, any standard Granger causal inferences will be invalid and non applicable. In such situation an error model correction procedure should be adopted to test causality. However Toda and Philips (1993) purposed if two variables are non stationary and their linear combination of the series also non stationary , then standard Granger causality test should be adopted. That is the reason in my case of study, I would like to test the co integration property for both the series of GDP growth and ICT investment before applying standard causality test.

Testing for Cointegration

There are several ways for testing cointegration but two comparatively concise methods are:

(1) Engle-Granger (EG) or Augmented Engle-Granger (AEG) test and

(2) Johansen co-integration test

Engle-Granger (EG) or Augmented Engle-Granger (AEG) test

Engle and Granger (1987) calculated this test and to illustrate this test first the following regression should be obtained: $GDP_t = \beta_1 + \beta_2 TINV_t + \mu_t$

where GDP_t = GDP growth rate at period t ,

$TINV_t$ = Investment in ICT at period t

μ_t = Residuals in time period t

since (assumed)GDP and TINV are individually non stationary so this regression may be spurious as well. But we save the residuals and perform usual unit root test along with that Davidson and Mackinnon (1993) correct critical values for EG approach are used for statistical inference. In the present context DF and ADF tests are known as Engle Granger (EG) and augmented Engle Granger (AEG). Thus we obtain the following result

$$\Delta \hat{u}_t \ = \ \delta' \mu_{t-1}$$

Null hypothesis, $\qquad$ Ho: $\delta' = 0$ (residuals are non stationary or has unit root)

Alternative hypothesis, $\qquad$ H1: δ' less than 0 (residuals are stationary or has no unit root)

Long Run Johansen co-integration test

EG test is more commonly applied only if there is one integrating relation. Due to restrictive nature of EG test, and due to certain limitations Johansen Co integration test is applied to investigate long run relationship between two variables. Johansen (1988) developed an autoregressive model which require the same order of integrating for finding the long run relationship among the variables. This test determines the number of co integrating equations for any normalization used. Although we have only two variables so the Null hypothesis is that there is no co integrating equation between the variables. It provides two different likelihood ratio (LR) tests; one is based on the trace statistic and the other on the maximum eigenvalue.

Appropriate Lag structure

It is an essential autoregressive process which is the specification requirement of the structure of the causality test. The number of lagged terms to be included in causality test is an important practical question. Firstly we need to find out the appropriate lag structure or order of the process. It should also be added that the direction of causality may depend on the number of lagged terms included. To make that choice I use Akaike or Schwarz information criterion (AIC and SIC), which embody a term for residual sum of square and a penalty term for adding extra parameters, are taken into consideration to specify the appropriate lag level. AIC and SIC can be formulized as follow ;

AIC = $e^{2k/n}$ (RSS/n)   **SIC** = $n^{\frac{k}{n}}$ (RSS/n)

Where; k is the number of repressors (including the intercept).

n is the number of observations   RSS is the residual sum of square..
(Gujarati 2009, p 537)

Empirical results

Unit root ADF test results

The following tables are the result of all the three possibilities of Unit root ADF test. First I showed the analysis for GDP(Y) variable with three different null hypothesis and consider at 5 % as level of significance.

(1) GDP(Yt) is a random walk : $\Delta Yt = \delta Yt{-}1 + \mu t$

   Null Hypothesis :   GDP(Y) has a unit root

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP_Y(-1)	-0.210699	0.129320	-1.629280	0.1145

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.629280	0.0964
Test critical values:	1% level		-2.647120	
	5% level		-1.952910	

Table 5.(a)

(b)Yt is a random walk with drift: $\Delta Yt = \beta 1 + \delta Yt{-}1 + \mu t$

   Null Hypothesis: GDP (Y) has a unit root

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP_Y(-1)	-0.373483	0.204664	-1.824859	0.0791
C	0.610482	0.595270	1.025555	0.3142

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.824859	0.3615
Test critical values:	1% level		-3.679322	
	5% level		-2.967767	

Table 5.(b)

(c) GDP with drift and trend : $\Delta Yt = \beta 1 + \beta 2\ \mathbf{t} + \delta Yt{-}1 + \mu t$

Null Hypothesis: GDP (Y) has a unit root

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP_Y(-1)	-0.333870	0.211896	-1.575632	0.1272
C	1.079561	0.838107	1.288094	0.2091
TREND	-0.037229	0.046502	-0.800586	0.4306
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.575632	0.7779
Test critical values:	1% level		-4.309824	
	5% level		-3.574244	

Table 5.(c)

The three tables above (a) (b) and (c) represent a detailed stationary analysis of the variable GDP(Y).In table (a) we just run the model without intercept and got the p value 0.096 which is more than 5% meaning that we cannot reject null hypothesis. It means that GDP (Y) has a unit root so (GDP)Y is a non stationary variable. It is the one way to check but the another way is to take a decision GDP has a unit root or not is that if the ADF test statistic absolute value is more than the absolute critical value at a chosen level of percentage we can reject null hypothesis which is the standard procedure. But if the test statistic value is less than the critical value then we cannot reject null hypothesis which mean we accept it. In this method one important thing is we chose only absolute values of test statistic and critical values. In all these tables the absolute values of test statistic 1.629, 1.824 and 1.575 are smaller than absolute critical values 1.952, 2.967 and 3.574 respectively at 5% level of significance. It means that we accept null hypothesis GDP has a unit root and all three ADF models represent that GDP is a non stationary variable.

In a similar way I perform the unit root Augmented Dickey fuller test for the variable Investment in ICT (TINV) and following three tables showing the results;

(1)

TINVt is a random walk: $\Delta TINVt = \delta TINVt-1 + \mu t$

Null Hypothesis :   Investment has a unit root

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INVESTMENT(-1)	0.015816	0.016858	0.938166	0.3562
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			0.938166	0.9029
Test critical values:	1% level		-2.647120	
	5% level		-1.952910	

Table 6.(a)

(2)

TINVt is a random walk with drift: $\Delta TINVt = \beta 1 + \delta TINVt-1 + \mu t$

Null Hypothesis :   Investment has a unit root

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INVESTMENT(-1)	-0.094935	0.054692	-1.735804	0.0940
C	2.467628	1.165959	2.116393	0.0437
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.735804	0.4034
Test critical values:	1% level		-3.679322	
	5% level		-2.967767	

Table 6.(b)

(3) TINVt with drift and trend: $\Delta TINV_t = \beta_1 + \beta_2\, t + \delta TINV_{t-1} + \mu_t$

Null Hypothesis :   Investment has a unit root

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INVESTMENT(-1)	-0.219170	0.109689	-1.998100	0.0572
C	3.155484	1.364988	2.311731	0.0297
TREND	0.111149	0.085382	1.301794	0.2053

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.998100	0.5771
Test critical values:	1% level		-4.323979	
	5% level		-3.580623	

Table 6.(c)

The investment variable (TINV) also showed the similar kind of result as that of GDP because in all the possible model of Unit root tests p values are 0.3562, 0.4034 and 0.5771 respectively more than 5 % so we can not reject null hypothesis that is investment also has unit root. TINVt variable is also non stationary. The other guide line is all the three absolute augmented Dickey-Fuller test statistics values (0.938, 1.735 and 1.998) are less than absolute critical values (1.952 , 2.967 and 3.580) respectively at the 5 % level of significance which confirms that all results holding true (Null hypothesis is accepted) that is the Investment variable is also non stationary. It is necessary to transform them into stationary variables because then it can be possible to use them in time series model such as VAR, VECM and Granger Causality etc.

Transforming Non stationary time series
Results: Difference Stationary Processes

As I got the result that both variables are non-stationary or has unit root. So it is important to make the time series stationary. Therefore I used the 1st difference of both the variables GDP(Y) and Investment (TINV) and again applied the Unit root test this time it gives reliable results for all the possibilities of ADF test. So I found that the GDP and investment at first difference *I(1)* is stationary. It means that 1st difference of variables do not have unit root

issues. After taking first difference the Unit root has been completely eliminated. The table below showing the results of stationary time series of GDP and Investment (TINV) ;

Table.7 ADF Unit root test for stationary on the difference variables i.e. *I(1)*

Variable	Without drift & trend	With drift	With drift & trend
Δ **GDPt**	-0.9604	-0.9642	-0.9986
Critical value at 5 %	-1.9533	-2.9718	-3.5806
ADF test statistic	-4.6585	-4.5999	-4.8412
ΔTINVt	-0.6528	-0.7003	-0.7509
Critical value at 5 %	-1.9533	-2.9718	-3.5806
ADF test statistic	-3.4843	-3.6364	-3.6460

In both variables the absolute test statistics values are greater than the absolute critical values at the 5 % level of significance so null hypothesis having unit root is now rejected in all cases. Therefore unit root effect has been completely eliminated in both time series variables. In simple words first difference of variables GDP(Y) and Investment in ICT (TINV) has no unit root and become stationary. Therefore both variables of integrated order 1 that is *I(1)* is best to use for my Time series econometric analysis. Now I can use first difference of both variables in different kind of econometric modeling.

Cointegration Tests:

Result of Engle-Granger (EG) test

$$GDP_t = \beta_1 + \beta_2 TINV_t + \mu_t$$

GDPt=   0.6905+ 0.0643 TINVt
   t   (0.9539)   (0.4772)
       R² = 0.031   d= 0.8816

$$\Delta \hat{u}_t \ = \ \delta' \mu_{t-1}$$

$$\Delta \hat{u}_t \ = \ -0.3934 \ \mu_{t-1}$$
       t (-1.827) Prob (0.0786)
       R² = 0.1101   d= 1.4349

From the above result I got the t statistic value which is -1.827 and now I can compare it against set of correct critical values for Cointegration test using Engel-Granger approach provided by Davidson and Mackinnon (1993). With two variable model(m=2) and constant term Davidson and Mackinnon critical values at 1% and 5% level of significance are -3.90 and -3.34 respectively. But as computed value of t-statistic is -1.827 which is smaller than the critical values at 1% and 5 % level. So we can not reject null hypothesis residuals series has a unit root issue. That is residual series is non stationary. EG test resulted in favors of that both variables are not Co-integrated so moreover both variables have no long run equilibrium and relation. Due to some drawbacks in EG test this no long run association ship needs to be tested further.

Results of Johansen co-integration test

Here I apply Johansen Cointegration test on both the variables GDP(Y) and Investment (TINV) to check Long-run association between them. Before applying the test I make sure that variables are at level form that is they are at initial data position. I showed the result of Johansen test at lag interval 1. The Trace test and the Max-Eigen statistic are the two statistic to test the Null Hypothesis which is

Null Hypothesis : There is no Cointegration among variables or there is no co integrating equation among variables.

The outcomes of this test are showed below

Series: GDP and INVESTMENT

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.311646	11.57088	15.49471	0.1787
At most 1	0.039013	1.114238	3.841466	0.2912

Trace test indicates no cointegration at the 0.05 level

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.311646	10.45664	14.26460	0.1836
At most 1	0.039013	1.114238	3.841466	0.2912

Max-eigenvalue test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

For the Trace statistic the null hypothesis of no co integrating equation the p value is 0.1787 which is more than 5% so we can not reject null hypothesis. It means we accept null hypothesis that there is no co integrating equation. Trance test statistic is indicating no cointegration at the 0.05 level.. In the same way in Max-Eigen statistic we cannot reject null hypothesis that there is no co integrating equation because p value (0.1836) is more than 5% so we accept no cointegration equation between the variables. So Max-eigen statistic values also guiding in the same direction. So the result of Co integration test confirms the EG results that there is no Long run association among variables which means they are not co integrated and do not have co movement. These result highlight one fact that ICT was a progressive industry which was driven on the basis of technology and innovation. The telecommunication development block and structural tensions can only be fulfilled and explained through extraordinary share of investment involved during Swedish telecommunication revolution. It does not prove that investment was faulty in ICT growing industry because actually different interruptions and subsequent crash (bankruptcies) would not allow to establish a continuous long run relationship with GDP growth.

Appropriate Lag structure (Lag Selection)

Now the important question is how many lags should I chose for granger causality model. There are two ways AIC and SIC to chose optimal lag or appropriate lag for any model. I already checked that both variables GDP (Y) and Investment (TINV) have no long run association that is both variables are not co integrated. Therefore I apply Unrestricted VAR model in selecting the lag length. The rule of thumb is to chose the lowest AIC or SIC value and that model will be better to explain the results. So the results of AIC and SIC criterion are given in the following table;

Table.8 Result of the AIC and SIC values

Lag Length	AIC value	SIC value
1	8.3839	8.6668
2	8.3938	8.8696
3	8.6857	9.3576
4	8.9020	9.7730
5	9.1239	10.1965
6	9.2061	10.4823
7	9.1145	10.5955
8	7.2406	8.9267
9	2.7462**	4.6363**

As the rule of thumb for choosing the lag length is that the lag with the lowest AIC or SIC value should be chosen. In the above table, the lowest AIC and SIC value is for the lag 9 that is it has the AIC value of 2.7462 and SIC value of 4.6363. Therefore I can use till 9 lag lengths in the test of the granger causality to better understand the results of causation.

Result of Granger Test:

The following table is showing the result of pair wise Granger causality test between GDP growth rate and Investment in ICT (TINV) at different lag lengths and found that all result values are indicating a unique and interesting explanation ;

Table 9. Pairwise Granger Causality Tests

Null Hypothesis	No of lags	F value	Prob	Decision
ICT Investment (TINV) does not Granger cause GDP(Y)	1	5.2339	0.0309	Reject
GDP(Y) does not Granger cause ICT Investment (TINV)	1	0.1739	0.6801	Accept
ICT Investment (TINV) does not Granger cause GDP(Y)	2	2.3994	0.1141	Accept
GDP(Y) does not Granger cause ICT Investment (TINV)	2	1.0038	0.3827	Accept
ICT Investment (TINV) does not Granger cause GDP(Y)	3	1.3492	0.2883	Accept
GDP(Y) does not Granger cause ICT Investment (TINV)	3	0.2124	0.8865	Accept
ICT Investment (TINV) does not Granger cause GDP(Y)	9	45.7323	0.1143	Accept
GDP(Y) does not Granger cause ICT Investment (TINV)	9	373.003	0.0402	Reject

The above results clearly indicates that granger causality test is very sensitive and critically depends upon the number of lags introduced in the model. The probability value 0.309 at lag one is less than 5% so I can reject the null hypothesis that ICT does not cause GDP growth rate. It means that there exist unidirectional causality between ICT investment and GDP growth rate running from ICT to GDP which ultimately confirms that investment was not completely faulty in telecommunication development block. The share of ICT investment has

influence on GDP growth rate with a very short term benefits that only one year lagged values. After this result till the 9th lagged values introduction there was no causation was found so ever. It is consequently due to the reason that long run co movement of the variables was not witnessed before. There is no bi directional or unidirectional causality is running between both the variable and all p values are greater than five percent and computed F statistics values are smaller than F critical values. I accept all the null hypothesis that no causation exist from lags 2 to 8 so finally independence is suggested here as the sets of GDP and TINV coefficients are not statistically significant in both the regression. It means that Ho : $\Sigma \alpha i = 0$ and Ho : $\Sigma \delta j = 0$. Simply both variables have no influence on each other. In the end interesting and noticeable result is at lag 9 when p value 0.0402 is less than 5 % and reject the null hypothesis that GDP(Y) does not cause ICT investment. The unidirectional causality running from GDP growth rate to ICT investment but very sensitive and critically depending upon nine years lagged values. This very sensitive result of causation is attributed due to the overall economic and infrastructure development in the country.

Concluding remarks

The conclusion of one way causality in any direction means increasing or reducing telecommunications (ICT) investment may have any positive or negative effect on economic growth rate. In my findings ICT investment does causes GDP growth rate when only one year lagged values involved in the model otherwise no causal relationship. It is because information and communication technology played two important role in telecommunication infrastructure development and revolution of Sweden. Firstly of course it contributed through the increase in investment or capital deepening and other contribution is multi factor productivity growth. But the strength of ICT investment in Sweden truly attributed to technical and innovational progress along that strong competitive pressure was put in the production of ICT goods and services. The empirical results of this study also give understanding that capital or investment deepening was crucial enough for telecommunication infrastructure development but it is not all the time right that economic growth rate (GDP) also have an impact significantly. It is explaining some thinking and understanding for researchers, economists and some policy makers.

I studied that the share of ICT investments are worthwhile in economic growth because most of the previous studies and researchers highlighted this assumption. This is not simply true at all the time and at all the places because of course country to country situation and

circumstances varies. There exist disparity in payoffs from ICT investment for developing and developed countries. It requires more close and proper investigation of causal relationship between the two variables. In my case study it also gives a different idea of causal relationship. Despite the reality that Sweden has worlds most developed telecommunication infrastructure with high-tech investment, technological products and trade, there found absence of cointegration and feedback relationship between ICT investment and GDP growth rate. There was no long run association and co movement was found. Same sort of results observed for Sweden by Sang-yong Tom lee (2004) in his study of panel data including all Nordic countries.

It means technological development of telecommunication infrastructure failed to reap long term benefits and contribution from the ICT investment to GDP growth rate. One may assume that this information and technology investment promotion contributed for a very short time period. The absence of cointegration raises attention that some areas of inadequacy are still present in Sweden's ICT strategies and policy structure to ensure a longer and sustained period of overall growth rate.

The implications of this study is in promotion and establishing such policies that long term relationship will also be establish between share of ICT investment and GDP growth rate in Sweden. The reason of this investment disparity payoff is due to more intensive care should require on other key ICT's other complementary factors such as human resources, research and development (R&D), telecommunication liberalization, remove restrictions on imports, give more business opportunities, providing excellent business environments, well-developed transportation for ICT sectors, educational training and grooming of manpower, flow of ICT knowledge and structural adjustments to enhance efficiency. These fundamental factors must, to a large extent, be established by government policies and development strategies. Some real efforts must be made to encourage government and ICT sector to overcome the constraints as a strategy toward advanced development in the long haul. When significant long run relationship is built through policy promotions and strategic actions then the level of Sweden 's economic activity at any point in time can be reliably predict the amount of ICT investment at a later point in time. In other words, hypothesis of bidirectional causal relationship between GDP growth rate and ICT investment would be valid and worthwhile. It can also provide more accurate estimation and forecasting about level of ICT investment for future prospects.

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