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A Bundled Approach to Explaining Technological Change: The Case of E-estonia

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Abstract
Explaining change is an abstract endeavor. Many management scholars have adopted metaphors to explain change. In this paper, we discuss technological change. We use a historical and theoretical approach to review and elaborate on concepts and context about a specific case. We discuss the limitations of each approach proffered and the implications thusly on technological change. We present plurality and multiplicity of perspectives through socio-technical lens to explain technological change contextually on an organizational level. We show by using our model how technology absorption and diffusion can be accelerated through artefactual institutions to engineer social change. The multiplicity of perspectives and plurality of our arguments creates a fine explanation of the e-Estonia case as an example.
Keywords: artefactual institutions, e-Estonia, social change, technological trajectories

1. Introduction

Explaining any form of change remains a daunting task. Explaining technological change is more herculean. A framework explaining development and change is described by Van De Ven and Poole (1998) even though they assert that explaining how and why organizations change has been a central and enduring quest of scholars in management and many other disciplines. In this paper, change is an empirical observation of difference in form, quality, or state over time in an organizational entity - organizational entity is broadened to country-level analysis. Process refers to progression (i.e., order and sequence) of events in an organizational entity's existence over time. Development is a change process (i.e., a progression of change events that unfold during the duration of an entity's existence – from the initiation or onset of the entity to its end or termination). Technological trajectories describe the rate and direction of technological change within each technological paradigm (Abernathy and Utterback, 1978). Technological change is consequently regarded as an empirical observation of difference in form, quality, or state of specific technical mechanisms, over time.

This research seeks to answer the following questions:

- what constitutes technological change over two decades in Estonia, and how can it be explained?
- what factors triggered accelerated technology absorption and diffusion in Estonia?

Van De Ven et al., op. cit. contended that integration of perspectives is possible if different perspectives are viewed as providing alternative picture of the same organizational processes without nullifying each other. According to Van De Ven et al., the interplay between different perspectives help to gain a more comprehensive understanding of organizational life, as any one theoretical perspective invariably offers only a partial account of a complex phenomenon. Working out the relationships between such seemingly divergent views provides opportunities to develop new theory that has stronger and broader explanatory power than the initial perspectives.

Byoung Soo Kim (2012) has shown that measuring a technological state is not easy but is instead a complicated activity. Even though Soo Kim discussed several measuring methods such as scoring models, data analysis, surveys, growth models and indicators, he noted cautiously that as the concept of technology is abstract, a specific technology is sometimes regarded as an end product or the process of realizing the product as well. We, against this backdrop define meticulously the scope of this study and technologies as objects for our argument. The study is focused within socio-technical theory, acknowledging fully the overlaps between this facet and others, such as evolutionary and quasi-evolutionary approaches to explaining technological change.

Measuring change on a national level has been regarded as simplistic for a long time. Mechanisms such as census surveys is commonly employed to arrive at some concrete conclusions. Porter (1995: 49-50) argues that quantification is a social technology and a crucial agency for managing people and nature. There has been a lot of literature analyzing national technological states. For example, Merton (1978) analyzed the state of science and technology in the seventeenth century England using available data. Different scholars define national 'innovation systems' differently. The 'system' generally includes 'all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations' (Ediquist, 2005: 183, as cited in Ediquist, 1997)

Estonia, as at 2015, had ranked consecutively and consistently for nearly two decades, between 2nd and 34th places without fail on many global indicators. One such is the Global Information Technology Networked Readiness Index. Another is the World Economic Forum Global Competitiveness Index (see Notes). Regarding the latter, Estonia remains the best performer in terms of country competitiveness and macroeconomic stability in Eastern Europe. For the former, which provides a ranking of countries and how they have leveraged on technological advancements for development, Estonia has shown a strong performance as well. Issues of real country economic pointers and what accounts for such are not exclusively considered in this study, but for technology and its effects consequently.

While current figures show a sterling performance and budding prospects in country technological capabilities, the Soviet era (see Note 2), which reached terminal point in 1991 after several years, left Estonia with nothing to look forward to. Ruth Alas (2004) describes the state of Estonia after this period, as one of transience and utter confusion. But Estonia was not alone. Other countries within the region succumbed to similar fate. To understand how this small Baltic country transmogrified from a low-technology country to an advanced-technology country remains prodigiously intriguing.

In this paper, we deal with the drivers of technological change - technology absorption and diffusion - and social change, concomitantly. The research method used is case study set in a post-positivistic paradigm. A historical and theoretical approach is used to review and elaborate on concepts and context about a specific case. The limitations of each approach proffered and the implications hence on technological change in Estonia are discussed.

2. Literature Review

In the ensuing section, literature on several dimensions to technological change and social configuring are reviewed to create an anchor for the study.

2.1 Exogenous Economic Theory Views of Technological Change

While Kuhn (1962) defines the concept of paradigm as 'the framework upon which scientific knowledge relies on and develops over time', Dosi and Grazzi (2006) describe technological paradigm as 'specific form of knowledge, procedures and the basic system on which a particular activity is based and which results from a complex selection of process whose variables have a scientific, institutional and economic nature'. Cantwell (1999) has asserted that 'an incremental and gradual process of technological change is enforced by a continuous process of learning and is characterized by cumulativeness and irreversibility'. Robbins (1932, p.16) noted that 'economic theory had historically dealt with technological change because of its intimate causality link with economic growth', being the 'science which studies human behavior as a relationship between ends and scarce means which have alternative uses'. The first half of the 20th century witnessed the building of a general theoretical framework for the analysis of technological change. This was due to the contributions of Hicks (1932) and, in particular, Joseph A. Schumpeter (1883-1950). The former introduced the 'induced innovation' hypothesis, which states that changes in factor process determine a substitution in favor of the relatively cheaper factor through a factor-biased technological change (Hicks, 1932, p. 125). In the context of production function, such substitution is represented by both a movement of the isoquant toward the origin (Technological Change) and a movement along the isoquant (factor substitution). Kaldor (1932) and Blaug (1963) both provided alternative views by narrowing the concept of technological change only to occurrence of autonomous improvements. Schumpeter in his 'The Theory of Economic Development' (1934; 1st edn. 1912) set the general taxonomies and definitions which are still widely-used nowadays for both theoretical and empirical research on technological change. An example is given by OECD (2005) definitions and methodologies related to collection of innovative data. Schumpeter, op. cit., defined technological change as the 'carrying out of new combinations of the means of production and provided the famous trilogy by distinguishing the process of technological change in invention, innovation and diffusion.

Mainstream economics has tended to treat technological change as an exogenous variable, which does not have to be studied itself. If economic growth cannot be explained by other economic variables, it is then ascribed as being the result of technological change. Whatever is left to explain economic growth in a regression equation, after the effects of labor and capital have been accounted for, treating technological change as a shorthand for any kind of shift in the production function. Robert Solow (1957) developed the aggregate production function as an attempt to differentiate variation of output per head due to technical change from those due to changes in availability of capital per head. Salter (1960) also looked at productivity and technical change extensively. Charles Cobb and Paul Douglas examined 1899-1922 manufacturing data from the USA and derived the Cobb-Douglas Growth model on technological progress and growth, further entrenching the position of mainstream economic theory.

2.2 Diffusion of Technological Change

According to the taxonomy provided by Schumpeter, op. cit., process of technological change can be distinguished by a trilogy: (1) invention, (2) innovation process, and (3) diffusion phase. To Schumpeter, the last component of the trilogy allows the measurement of the impact of new technologies on the economy. Different lines of research have addressed the determinants and patterns of technology diffusion. Economic historians such as Scoville, (1951) and Landes, (1969) have stressed the impact of geographic movement of skilled workers on the diffusion of technologies. Graham, (1956); North, (1958 and 1968); Walton, (1970); and Saxonhouse, (1974) have attributed diffusion of technological change to other institutional factors, such as the presence of business trade associations or the use of a common capital-good supplier, as a contributor to the diffusion process as well by lowering the cost of acquiring information. Diffusion cannot be discussed without noting the useful insights it has provided into the analysis of technology diffusion, by borrowing terminology from analyses of diseases. Epidemic theories of diffusion have emphasized the positive externality obtained by the transfer of information. The process of technology diffusion is represented by an equation which is characterized by a sigmoid-shaped curve, obtained by the given equation (Bain, 1962; Bass, 1969). The epidemic models have been characterized by several shortcomings, mostly related to firm level. (Dixon & Griliches ,1980; Gold, 1981; Jaffee and Stavins, 1994).

2.3 Alternative Views of Technological Change

There have been several attempts to endogenize technological change in mainstream economics. Some of the theories include induced innovation (Kamien & Schwatz , 1968: Binswanger, 1974) as well as new growth theories such as endogenous growth models, where technological change derives from research (leading to designs, blueprints and general knowledge) and human capital accumulation, and modelled as a stock variable, with spill-overs to other factors of production (and in some models, also to research) (Romer, 1986, Lucas, 1988; for surveys, Verspagen 1992, Scheider & Ziesemer, 1995). However, these models only explain incentives for organizations to do research under different conditions. By the 1970s, scholars turned to discuss the importance of technological change per se when interest in growth theory declined as a result of the marked diffusion of technological change and as Petit (1995) reported 'a worldwide decrease in the rate of productivity growth'. Rosenburg (1982) imputed the 'productivity' or 'Solow' paradox to a slow technological change diffusion while Griliches (1994) pointed at measurement problems in the services sectors, that is where most of the productivity increase occurred. Mansfield (1983a) provided a critical view of the link between long waves and technological change. Evolutionary economics put a strong emphasis on micro-foundations by building a heterodox behavioral theory firms while at the macro level, it applied Schumpeterian concepts of equilibrium and dynamics to the representation of the economic system. This same period saw a growing critique of mono-causal explanations of the evolution and direction of technological change.

Nelson & Winter (1982) and other evolutionary economists have struck out in a different direction to endogenize technological change. They developed a dynamic picture of firms and an evolutionary theory of economic change in which an evolutionary theory of technological change was embedded. Thus, they combined the focus on firms with a perspective on technology. Their theories are an alternative to neoclassical economics. (Dosi et al. 1988) [36]

From a sociological point of view, explanations of technological change have included: (1) quasi-evolutionary theories (Van den Bet & Rip 1987, Rip 1992, Schot 1992) and (2) socio-technical theories focused on configurations that work. In the case of the former approach, heuristic search practices leading to technological options, artefacts, or transferable skills or embodied knowledge relate to shared repertoires embodied in an organization, in a community of technical practitioners, or in an inter-organizational network. The latter, focused on configurations that work, are mutually compatible and appear to complement, rather than contradict, evolutionary economic theories. In socio-technical theories, the building, maintaining and expanding of configurations that work is the starting point of the analysis, with due recognition of the necessary complementary configuring of the environment. Hughes (1983, 1987), especially in his study of electric power networks (networks here in the sense of linked artefacts) has shown how network builders bring together social as well as technical elements to make the environment part of the system. The socio-technical approach has been used to address contemporary issues of large technical systems (Maytntz & Hughes 1988) and to understand telecommunication networks (e.g. Schmid & Werle 1992). Case studies on actor-network theories (focusing on interactions between actors and evolving techno-economic networks have been carried out extensively and made further visible socio-technical dynamics of heterogenous actors. (see Callon 1986a,b, Law 1987, Law & Callon 1988, Mangematin & Callon 1995, Latour 1996)

2.4 Conceptualization of Social Change

Since the study posits that technological change results in social configuring, it is prudent to contextualize social change. The conceptualization of social change can be approached from many directions. Hans Gerth and Wright Mills (1953) define social change as 'whatever may happen in the cause of time to the roles of the institutions or the orders comprising social structure, their emergence, growth and decline' Morris Ginsberg (1958) views it as a change in the social structure, for example, the size of a society, the composition or balance of its parts or the type of its organizations. Social changes comprise modifications in social systems or subsystems in structure, functioning, or process over some period of time (Allen, 1971; Davis, 1959:622; Johnson, 1960: 626). Some authors consider social change principally in terms of a specific change in social relationships such as MacIver and Page (1949) and Ronald Edari (1976:2) who combines elements, social structure and social relationships in his definition. Nisbet (1969) takes a somewhat broader and more inclusive view. Robert Laver (1977) considers social change as an inclusive concept that refers to alterations in social phenomena at various levels of human life from the individual to the global. Vago (1992) attempted to harmonize the numerous and conflicting viewpoints by proposing a somewhat different approach towards a workable definition that social change must be conceptualized as the process of planned or unplanned qualitative or quantitative alterations in social phenomena which was depicted on a six-part continuum, composed of interrelated analytic components.

3. Methodology

3.1 Conceptual Framework

3.1.1 Artefacts, Artefactual Institutions and the Information Society

On the back of the literature reviewed above, the model adopted in this paper asserts that social configuring can be induced in a desired direction, and begins with artefacts, which eventually, as the complexity level increases, from micro (artefacts) to meso (technological systems and regimes) to macro (socio-technical landscapes), leads to an Information Society. The level of inclusion or embeddedness of technology into social set-ups, defines the seamlessness of the web they form, creating an ever broader irreversible and immutable dependence path in social and economic life, sectoral structures, strategic games, consumption patterns, and lifestyles. (Rip, op. cit.)

To visualize this concept, at the different levels with linkages to explain technological change in Estonia, Figure 1 depicts the framework.

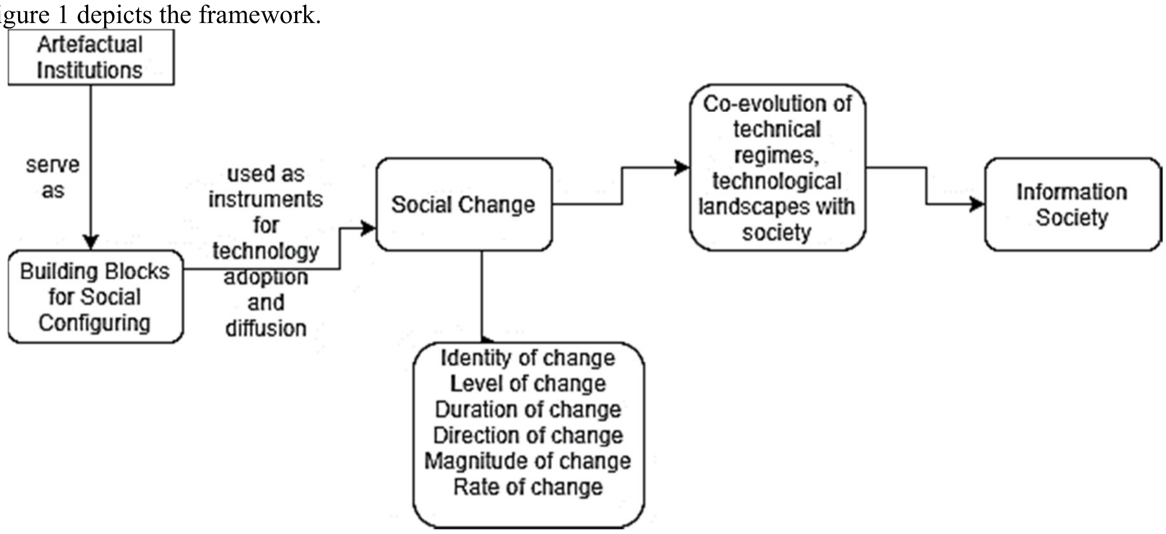

Figure 1. Conceptual Framework for Explaining Technological Change

Technology, at the level of artefacts, from the socio-technical point of view, is viewed as configurations that work (Hughes, 1983, 1987). These are tangible arrangements, machines, etc., that are technical in nature. These are considered irreversible by their immutability. For example, the placement of a string of street lights meant to illuminate an area is considered an established and set configuration that works. Artefactual institutions, which comprise artefacts and other institutions, serve as building blocks for social configuring. These artefactual institution, when set up properly, aid in the establishment of technical systems, which are just tangible components configured and interconnected as a workable system. Workable systems lead to technical regimes, where institutionalized practices evolve in their own terms and are hard to change. Technological regimes are the coherent complex of scientific knowledges, engineering practices, production process technologies, product characteristics, skills and procedures, and institutions and infrastructure that are labelled in terms of a certain technology (e.g., a computer) or mode of work organization (for example, the factory-based system of mass production). Technological regimes are a broader, socially embedded version of technological paradigms. Technological regimes are the intermediary between specific innovations as they are conceived, developed, and introduced, and the overall socio-technical landscape.

When a path is created and societal dependence on this path is attained, it is the level of socio-technical landscapes, where physical infrastructures, artefacts, institutions, values, and other patterns, considered the material culture of society, which are the backdrop against which specific technological change play out, are fully embedded and become cultural conscripts, ingrained in the entire workings of society. We assert that technological change, at the level of artefact cannot lead of an Information Society without social evolution and that they co-evolve. The ultimate is an Information Society, an e-state or e-country.

3.2 Research Design

The purpose of this study was to identify those factors which drive techno-social change in Estonia. The required data was collected through secondary sources from government policy documents, national and international published reports, journal articles, and web sources. Quantitative data were analyzed to draw qualitative conclusions.

4. Findings

4.1 Profile of Estonia - A Small Baltic Country

Estonia is a relatively small country in the Baltic region of Northern Europe, bordered to the north by the Gulf of Finland, to the west by the sea, to the south by Latvia and to the east by Lake Peipus and Russia. With a population of 1.3 million, it is reported to be the least populous member of the European Union (EU), Eurozone, North Atlantic Treaty Organization (NATO), Organization for Economic Co-operation and Development (OECD) and Schengen Area (See Note 3).

Estonia is a developed country with an advanced, high income economy. Estonia has a high human development ranking and ranks equally well in economic freedom, civil liberties and press freedom, ease of doing business, country competitiveness, prosperity, democracy, press freedom and networked readiness, among others. Citizens of Estonia are provided with universal healthcare, free education and the longest paid maternity leave in the OECD. The country since its independence has developed its Information Technology sector rapidly. Estonia pioneered the first elections over the internet in 2005, and in 2014, and was the first nation to provide e-residency to non-citizens with about 20,000 e-residents as at 2017. Estonia broke Canada's world record of 54% e-census participation in 2011 with an estimated 67% e-census participation.

Key indicators which go to show the strong position of Estonia include a very transparent government and policies that sustain a high level of freedom, rule of law, a simplified tax system with flat rates and low indirect taxation, as well as openness to foreign investment and a liberal trade regime, but to mention a few. Estonia ranked 12th globally on the World Bank Ease of Doing Business Index, ahead of many European countries. Notwithstanding, the fact that Estonia is in general resource-poor, industries and the wide-ranging environment are very conducive for growth, supported by the very good economic indicators mentioned earlier. The country's strong focus on the IT sector, through the integration of services and online platforms has led to much faster, simpler and efficient public services. For example, the filing of tax returns takes barely five minutes to complete online and by 2015, a reported over 96.3% on income tax returns were submitted electronically. This has sped up inter-agency procedures and increased opportunities for communication between the citizens and the state. As at end of 2015, Estonia ranked between 2nd and 34th on various indices (see Table 1. Estonia's International Rankings 2014 - 2015), a remarkable feat indeed, showing very strong performance on most global growth and development indicators.

4.2 Findings from Data Analysis

Table 2. provides a summary of country data, discussed below (see Table 2. Socio-Economic Indicators of Estonia (Five-years Interval) 2000 – 2015). Graphical representations of data analysis, are depicted by Figures 3., 4., 5. and 6.

4.2.1 Population, Land Size and Administrative Demarcation

The population of Estonia has remained same with an average of about 1.3 million people over the period under review. The total area is 45,336 km² (17,504 square miles) with a population density of about 30 inhabitants per km² (75 inhabitants per square mile). Administratively, the country is divided into 15 counties, 213 administrative units, including 30 cities and 183 rural municipalities. The official language is Estonian. However, English, Russian, Finnish and German are widely spoken as well. This has not changed significantly since the year 2000. Tallinn is the capital city. Other principal cities in Estonia are becoming more and more urbanized. The Estonian society is undergoing considerable change with increasing levels of stratification and distribution of family income.

4.2.2 Key ICT Milestones and Country Networked Readiness

4.2.2.1 Internet Usage

Prior to the period under review, data available clearly showed the state of internet usage per 100 people in Estonia (between 0% in 1990 and 14.5% as at 1999 per 100 inhabitants). After re-independence in 1991, internet usage picked up again steadily rising from 28.6% in 2000 to 61.5% in 2005 (percentage change of 32.9). By 2010, 74.1% of internet users had been recorded (thus, a percentage change of 13.21 since the 2010 figure), jumping to 84.2% by 2014 (a percentage change of 10.1). Conversely, the number of individuals who had never used a computer before dropped from over 32% as at 2006 to a little over 20% in 2010 and significantly, to less than 10% by 2015.

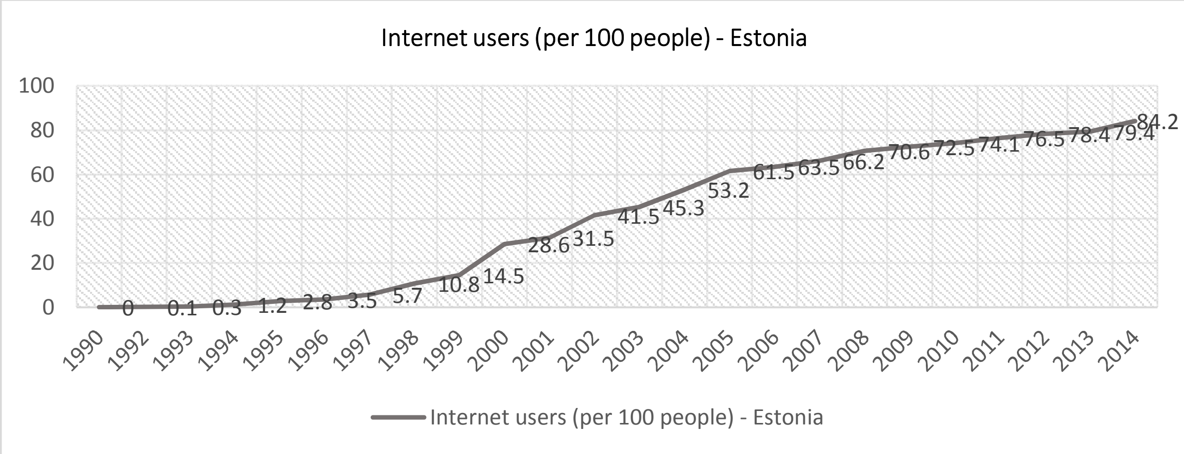

Figure 2. Internet Users per 100 inhabitants, (1990 – 2015) Estonia (Source: Authors)

By 2015, 64% of Estonian internet users ordered some product or service from the internet and slightly more than a third (37%) made a financial transaction of some kind on the internet. 87% of 16–74-year-old internet users in Estonia used public sector services and information, sharing second place with Finland among the EU member states. By 2016, 87% of 16–74-year-old Estonian residents used the internet in the 1st quarter of 2016, surpassing the EU average by 5 percentage points. 85% of 16–74-year-olds used the internet daily (the EU average stood at 79%). In the 16–34 age group, almost everyone uses the internet. Of the 16–24-year-old internet users, 91% used the internet on the mobile phone while on the move.

4.2.2.2 Penetration of Main Telephone Lines

By 2000, per every 100 inhabitants, penetration of main telephone lines was 38%. This dropped to 33.5% by 2005 and thence up again to 37.4% by 2010. By 2013, it was hovering around 33%. In terms of number of fixed telephone lines, by 2015, it had dropped down from 407,289 in 2014 to 387,607 in 2015, the ensuing year, which is a change of 4.83%.

By 2004, the percentage of households with broadband internet connection was about 20%. By 2015, this had risen to almost 90% of households with broadband internet connection. Between 2005 and 2011, some household still had modems or ISDN connections which were non-existent by 2012 to 2015.

4.2.2.3 Enterprise-wide Usage of Online Resources

Broadband access in enterprises in Estonia rose marginally from over 60% in 2004, to about 90% as at 2010 and almost 100% coverage by 2015. By 2016, more than a fifth (22%) of Estonian enterprises used paid cloud services especially e-mail and file storage services on the internet, and financial and accounting software applications. Data reveals, as at end of 2015 that 29% of Estonian enterprises have vast experience in big data analysis of information and communication, 28% in water supply and waste management and 21% in financial and insurance data analysis. Further, more than three quarters (78%) of Estonian enterprises have their own website and 37% of enterprises use social networking services such as Facebook and LinkedIn. 77% of Estonian enterprises give their employees remote access to the enterprise's mailing system, documents or applications.

4.2.2.4 Global Position on Networked Readiness Index

In terms of Networked Readiness, by year 2000, Estonia ranked 23rd place before its accession to the EU in 2004. In 2001 for example, Estonia, in terms of ICTs being overall priority of Government, scored 5.8 on a scale of 7.0, ranking 3rd in that category. Overall, for the year 2001-2002, Estonia ranked 25th place. In the 2003-2004 edition of the Global Information Technology Report (GITR) series, which measures annually and ranks countries based on how well they leveraged on ICT for development using the Networked Readiness Index, Estonia is quoted as 'the leader amongst the Eastern European countries with a rank of 25' (The Networked Readiness Index 2003-2004, Chapter 1, pg. 4). Estonia's place in the category of world rankings peaked in 2009 when Estonia made 18th position. By 2010, it was down to 25th place, dropping 7 places down the prior year. Its position hovered between 26th in 2011 to 22nd by 2015.

4.2.3 Economic Growth and Global Competitiveness

The Estonian economy saw an average growth of about 7% per year between the years 2000 and 2008 (Statistics Estonia, 2015). This placed Estonia among the three countries in the EU with the fastest growing real Gross Domestic Product (GDP) with then improved living standards and a GDP per capita inching up from 45% of the European Union (EU) average to 67% in 2008. This business-friendly situation saw a steep downward descent during the economic crisis in 2008. GDP growth rate decreased 14.7% for 2009. Interestingly, by the second half of 2010, the annual GDP recorded had grown by 2.5% as compared to the prior year. According to Statistics Estonia, the annual GDP increased by 1.5% in 2015, compared to the previous year 2014. In 2016, the annual GDP increased by 1.7% also compared to the prior year, 2014. For the 2017/2018, economic growth should stabilize at around 3%. The registered unemployment rate, in January 2012 was 7.7%. By 2015, employment rate in the 20-64 age group had increased to 72% and it is expected to rise to 76% by 2020. (see Notes on National Reform Programme, 'Estonia 2020')

The Global Competitiveness Index did not feature Estonia in its 2000 report. By 2004, Estonia had taken 20th place and by 2010, 35th place. It moved up a few notches to 30th place by 2015.

4.2.4 Human Development

Estonia recorded a strong performance on Human Development Index (HDI) in 2000 of 0.781. Between 2000 and 2010, the average annual HDI growth in percentage terms was 0.70. This remained stable between 2010 and 2015 at 0.65 percent. It must be noted that Estonia, prior to the period under review in 1990 recorded a value of 0.726 percentage points, a slightly marginal increase in 2000. Estonia's human development capabilities continues to hit above EU average levels. Consistently over the period, has ranged between 0.781 in 2000, 0.838 in 2010 and 0.865 by 2015. (Table 3. Average Annual Human Development Growth (%) summarizes)

5. Discussion and Recommendations

Joan Robinson claimed in 1952 that 'technical progress is difficult to discuss in precise language'. As a matter of fact, over the years the term technical progress has been given a wide range of meanings and interpretations (Kennedy and Thirlwall, 1972: 12). One is technological change, itself is defined with a wide range of meanings and interpretations: inventions, production techniques, shifts in production function, among others. The uses of the concept oscillate between the large and the restricted, from social (including economic) change due to technology, to change in technology. Technological change is also a concept that is much valued, with terms such as progress and advance or growth used in place of change.

The study sought to tackle the following problems:

- What constitutes technological change in Estonia over two decades, and how can it be explained?
- What factors triggered accelerated technology absorption and diffusion in Estonia?

To answer these questions, it is imperative to provide what constitutes technological change in Estonia.

5.1 Question 1: What socio-technical mechanisms have changed and how can it be explained?

To manifest technological change within context, an attempt is made to not equate conceptual abstractions of reality with the actual piece of reality, since the difficulty with understanding what is changing aggravates the effort. All the same, the key elements which include change in social structure, functioning of society, social relationships, forms of social processes and time, which can be isolated, are considered carefully in this paper. To stratify the manifestation of change, identity of change, level of change, duration of change, direction of change, magnitude of change and rate of change are used as parameters to provide scope.

5.1.1 Identity of Change

Change or progress or advancement has been established above, along several lines in the study. Social change is conceptualized as processes, either planned or unplanned, qualitative or quantitative, alterations of social phenomena. 'e-Estonia' as a path has triggered transformations such as practices, behavior, attitudes, interaction patterns, authority structures, productivity rates, voting patterns, prestige and stratification systems in Estonia by providing an identity to the digital transformation. The concept of e-Estonia as a country brand strategy remains more than just a brand, but also an ideology. Myriad electronic facilities have contributed in re-configuring the social set-up. There is faster more enhanced communication across the spectrum on all levels, from individual to enterprise to state levels. This has greatly improved productivity as lead and lag times are reduced drastically, giving meaning to growth.

5.1.2 Level of Change

Identity elaborates on level by providing span. On level of change, which is defined as location of change delineation in a social system, it is posited that e-Estonia has transformed all levels of society on the individual, group, organizational, institutional and societal levels. The comprehensive set of data available as well as other sources, some cited in this paper confirm this position (see relevant data sources in Notes, and Analysis sections)

5.1.3 Duration of Change

Duration is defined here as the time span over which a change form remains in initially institutionalized state. The study focused on a 15-year time span. We argue that artefactual implantations introduced during this period have been deeply institutionalized and channeled a path for future growth and development. The study showed that the change rhythm in the first half of the period was quick and became fully embedded, forming conscripts and patterns for further social evolution. It is asserted that techno-social change has remained linear over the period following this, especially after the initial phase of technology absorption and diffusion.

5.1.4 Direction of Change

Direction of change indicates development, progress or decline. The pattern may be linear or evolutionary, occur in cycles or stages or correspond to some other pattern. It may be a simple fluctuation or variation on a particular theme. Based on earlier analysis, e-Estonia as artefactual institutions have indicated development and or progress, creating a pattern of immutability and irreversibility deeply entrenched in the social structure. The change pattern has been again, linear following a steady pattern. At every point in the cycle of change, technological advancement has been steady without fluctuation or variation. Arguably, the inevitability of social change is not under contest in this study. We posit that in the simplest sense, technology can be equated with tools for social change to influence the way people think and how they relate to one another, in agreement with Stromquist (2005). However, the sociological importance of technology is that its importance goes far beyond the tool itself and how it is used is far more salient in magnanimity.

5.1.5 Magnitude of Change

Magnitude has been denoted in a three-part schema: (1) incremental or marginal change, (2) comprehensive change and (3) revolutionary change. The first part denotes change that occurs in piecemeal fashion, gradual and slow. The second, comprehensive, shows full scale of change and the third, rapid and sudden change.

The e-Estonia in terms of magnitude showed revolutionary tendencies post-the re-independence era after 1991. On attaining some level of Information, Communications Technology (ICT) status, begun a steady gradual ascent along every phase, over the three 5-year periods, as indicated earlier in the analysis from 2000 to 2015. A conclusion against this milieu, in favor of revolutionary change is impetuous, nonetheless, close to call. Jaffe and Stavins (1994) in their studies on technological change found that diffusion of new superior technologies is a gradual rather than instantaneous process. New technology adoption and its diffusion is slow and gradual and therefore economists over time have characterized the adoption of new technology and its consequent diffusion process with a sigmoid-shaped curve, which indicates increasing adoption through growing popularity, however slowly. The e-Estonia is a departure from this very established stance and on an unprecedentedly extensive scale over a relatively short period of time.

5.1.6 Rate of Change

The rate of Technological Change (TC) may be based on an arbitrary scale or method, such as fast or slow, continuous or spasmodic, orderly or erratic. Drawing from epidemic theories of diffusion (Bain, 1962; Bass, 1969), we show the rate of technology absorption and diffusion in Estonia for the period under review, which is represented by the rehashed differential equation (typically, the resultant logistic equation derived from this equation produces an s-shaped curve):

$$\text{e-Estonia Rate of TC } (\partial s / \partial t) = \beta\, s\, (1-s)$$

Where s represents the share of users which have already adopted the new technology as at our reference point, year 2000 in the study. New technology here denotes e-Estonia as artefactual institutions. Using assumptively *Internet* as new technology and data from *Internet Users* in Estonia for our analysis, s therefore is as shown below in Table 4.

Table 4. Internet Adoption in Estonia 2000 – 2015

Year	Population (Value) '000	Share of Users Already Adopted Technology (%)	Share of Users Already Adopted Technology (Value) (S)
2000	1.379	28.6%	394,394
2005	1.355	61.5%	833,325
2010	1.331	74.1%	986,271
2015	1.316	84.2%	1,108,072

Now, β describes contagiousness of the spread (speed of diffusion process). Based on the above (at same reference point, *ceteris paribus*, we indicate rate of technological change as follows in Table 5., below, in tandem with the notion of arbitrariness and abstraction. Percentage change below is percentage difference in share of users already adopted new technology after each five-years interval. Rapid and continuous diffusion is percentage change by more than 30 percentage points and incremental and continuous diffusion is a steady, almost equal change such as below by about 3.1 percentage points between 2005 and 2015.

Table 5. Rate of Technology Diffusion 2000 - 2015

Period	Percentage Change (Diffusion)	Rate of Technological Change
2000 – 2005	32.9%	Rapid, Continuous
2005 – 2010	13.21%	Continuous, Incremental
2010 – 2015	10.1%	Continuous, Incremental

5.2 Question 2: Factors that triggered accelerated technology absorption and diffusion in Estonia

After re-establishing independence in 1991, Estonia made significant progress in reforming economic and social conditions in the country. Several factors account for this reform process, and consequently its inclusion in the EU, the first country in the Baltic region to be included in EU accession negotiations. At the time, one of the country's major challenges was to make the transition from its industrial dependence to a networked economy. Several facets of the country's economy saw upgrading. The Estonian telecommunications infrastructure was upgraded. There was state financed Internet access in Estonia for government, education, and medical sectors and affordable dial-up Internet at the very onset. It was reported barely two decades ago that Internet penetration had been relatively high by European standards. There were challenges to the efforts. The country suffered IT Brain Drain due to non-competitive salaries and qualified ICT specialists had an increased tendency to work abroad. By the year 2000, Estonia had become a leader among central and eastern European countries in liberalizing its fixed lines telecommunications market. It was also the leader in Networked Readiness, ranking 23rd place globally.

Estonia has proved an ICT success story through an early decision to transform the economy from state-planned economy to a market-oriented economy. Estonia entered the top twenty-five economies in digital opportunity with a DOI (see Notes) score of 0.65, the only Central and Eastern European transition economy to make it to the top twenty-five (see section 3.3.1 of World Information Society Report 2007). Estonia was privatized in 1993, mobile competition was introduced in 1994 and full-service competition in 2002. More than half the population, as at 2007 used the Internet and had the highest Internet and broadband penetration in Central and Eastern Europe, with levels of ICT development exceeding EU averages at the time, although it only joined the EU in 2004. Some key factors are discussed below:

5.2.1 ICT in Estonia Post-Re-Independence in 1991 - Government ICT Education Policy and Initiative, Civic Participation and Legislation:

Nelson and Phelps asserted in 1966 that 'education played a positive effect on the speed of technology diffusion'. Cantwell (1999) also noted that 'technological change evolution is enforced by a continuous process of learning and is characterized by cumulativeness and irreversibility'. A major overarching factor in the speed of technology adoption and diffusion in Estonia was the 'Tiger Leap program'. The Estonian Educational and Research Network (EENet) was created in 1993 as a nationwide scientific and educational computer network to further the ICT cause in Estonia. In February 1996, the Government launched the 'Tiger Leap' program to modernize education. Tiger Leap had the slogan 'one computer for every 20 pupils' and helped to provide IT facilities to schools. National programs were launched massively on network usage and e-government with a goal to attain internet penetration of more than 70 percent. Internet services were heavily supported from all fronts. By the year 2000, all schools had computers and by 2003, 98 percent had been connected to the Internet. ICTs were integrated into the curriculum, as a subject and a tool for teaching other subjects.

The fact that Estonia's government became more connected and ICT-literate and integrated e-government practices into existing frameworks, was remarkable. The Prime Minister's office begun by opening a platform for public participation in the legislative process online. The most notable of the initiatives that garnered the most attention was the Electronic Cabinet, which allows government ministers to review legislation, make comments and suggestions, and vote online.

The Estonian Parliament adopted the 'Principles of the Estonian Information Policy' as early as May 1998 as a roadmap for the country's development in ICTs and different programs were created, focusing on specific areas. The case of Estonia depicts a unique example of civic participatory culture developed in parallel with and strongly influenced by ICT development. For example, Reinsalu and Winsvold (2008) have looked at ICTs as tools for civic involvement in political affairs in Estonia. ICTs have strongly influenced democracy and e-participation and much more integrated into Estonia's concept of democracy and political participation. Pruulmann-Vengerfeldt (2007) have also extensively covered social development and civic participation in the political agenda. To buttress these positions, the Principles of Estonian Information Policy churned out in 1998 sought to use ICTs to (1) increase competitiveness of Estonia; (2) reduce division within society; and (3) foster state–individual relationships, as part of efforts towards social configuring, which has been argued is not a mutually exclusive component of technological change.

5.2.2 Homogeneity of Estonian Society, Population Size and Proximity:

Smallness is both an advantage and a disadvantage. There is some evidence in the economic literature that smallness retards economic growth. Small countries have less scope for utilizing scale economies in production and marketing. Smallness and homogeneity of the Estonian society was beneficial for the rapid technology adoption and diffusion process. However, it appears to be a kind of small country paradox since most of the economic literature (including new growth theories) suggests that larger countries grow faster than smaller ones and thus, should achieve higher levels of income (Lundvall, 1999). Even though there is some validity in the argument that small countries with greater homogeneity and closer interaction (or networking) among economic agents, may well be an advantage in adjusting to new economic growth, there is no such evidence to support the same for Latvia and Lithuania, all former Soviet republics and neighbors with Estonia, yet Estonia has remained the vanguard and continues to be the 'Eastern European Tiger' (Global Information Technology Report 2015, pg. 13)

The location of Estonia, especially its proximity to Finland, which had already gained grounds in terms of ICT continues to be a major playing factor in the rapid technology absorption and diffusion process. Advancements in technology had reached Finland from northern and central Europe and was quickly spreading. (GITR 2001-2002, Country Profiles, pg. 200-201)

5.2.3 Dialectical Tensions, Technological Inertia and Induced Socio-technical Change

Merton (1976) had argued that 'when there is a sizeable discrepancy between what is and what people think ought to be, strain appears'. Many scholars consider a gap between society's ideal or basic values and real patterns as an ever-present condition for social change, therefore, a new way of doing things is the best wager. Estonia is a resource-poor country generally. After re-independence and several years of incursions by many European powers over centuries, a state of dissatisfaction and uncertainty emerged. This pluralistic period of uncertainty led to a quest to evolve, re-configure the environment taking advantage of technological inertia. Technology adoption was no more another option but a sole one.

6. Conclusion: Configuring Artefactual Institutions for a e-Society

To bridge the gap between technology and society towards positive growth, the set of artefacts depicted in Figure 7. Building Blocks for configuring e-Estonia, were used in Estonia. All the artefacts must move simultaneously together with education and learning to ensure irreversibility of the outcomes of technological change. To induce an 'e-society' or 'e-state', the technological or technical which include (1) establishment of computer infrastructure (2) array of innovations (3) new technologies (4) merge of IT and communications (5) use of internet and (6) spread of information exchange between all entities must be set up to drive economic forces such as (1) proportion of GDP accounted for by information business to lead to an information economy, (2) increase in information industries and (3) to chart the growth in economic worth of informational activities. This leads to spatial advancements which include (1) expansion of networks exponentially (2) access to satellites, databases, computer systems, etc., and (3) effect on information networks connecting locations on time and space. In terms of occupational advancements, when done right, the following are evident: (1) rise of an elite techno-structure, (2) preponderance of occupations in information work and (3) decline in manufacturing work and rise of service sector employment. These impinge on cultural advancements such as (1) extraordinary increase in information in social circulation (2) a contemporary culture (3) extensive use of digital environments (movies, podcasts, e-business), (3) a new media society or a media-saturated environment.

Estonia set up artefacts right by establishing an X-Road Data Exchange layer together with requisite state infrastructure to bridge the gap between the physical set up and the state online services portal. The components of this digital transformation were made possible by infrastructure, an open decentralized system that links together various services and databases, with each part serving as a building block to energize integrated e-services. These orgware and socioware were crucial in mapping the complex technological trajectory in Estonia. The components are elaborated on and depicted in Table 6. Explanation of e-Estonia Framework Components and Figure 7. Building Blocks for configuring e-Estonia (See Tables and Figures), respectively.

To conclude, adoption of diffusion of technology led to social change on various levels in Estonia. Social change led to co-evolution of technical regimes and socio-technical landscapes which cut through every fabric of social structure and relationships, creating a e-society, a e-Estonia, a socio-technologically embedded and immutable framework.

6.1 Lessons from the Case of e-Estonia

- Education should be intensified at the initial phase of new technology adoption with a focus on increasing the number of early adopters to accelerate the diffusion process.
- It is imperative to quickly unfreeze the status quo, set up artefactual institutions for social re-configuration to continue in an induced direction and refreeze, when socio-technical landscapes are established.
- Diffusion of new technology requires a composite approach to succeed. Education alone may not thrive. In the case of Estonia, the drive was tackled on all fronts – including policy initiatives, Government effort, infrastructure upgrades and new installation, parallel environmental and social architecture, among others. Technology policy must increasingly integrate long-term knowledge acquisition and environmental monitoring, and increasingly feature both mission-oriented objectives (with a focus on long-term development objectives rather than short term technology selection) and diffusion-oriented objectives (with a focus on contextual factors and incentives that steer technology diffusion).

7. Research Limitation and Future Research

The main research limitation was giving scope to technological change. Technological change is a loose concept that has multiple meanings. This study merged a restricted meaning of technological change and a larger one: change in methods or techniques of industrial production and change in society (social, cultural, economic) due to technology. These meanings are explained according to the study' interests, namely the Estonian case studied from a socio-technical perspective, where the study of technological change is concerned with the effects of technology on people's lives, through configurations that work. This culminated in a challenging depiction of a broader perspective of the relationship between technological change and growth by capturing insights gained from related streams of literature and a narrowed view of technological change and trajectories such as adoption and diffusion paths. Secondly, some scholars argue that change in society proceeds according to blind forces over which people have no control. Such arguments center around the determining force of culture and social structure such as technology, the stratification system of the economic system and acknowledge that it is a difficult and complex process to measure the effect of one on the other. Thirdly, to arrive at a theory of technological change is methodologically complex because of the retrospective bias in using history to explain the present. In the new history and sociology of technology, conceptual and methodological issues rather than explanations have taken precedence. In discussing rate of technological change using the differential equation, applied epidemic studies have shown that β depends on economic forces and that the change curve is s-shaped. Fourthly, paucity of data available continues to render conclusions based on data analysis, not full-proof. *Internet usage* alone as basis for arriving at rate of change and diffusion may be insufficient to say the least, yet time and resource constraints account for this. This may be explored fully in future research. The study concentrated on path dependence created using artefactual institutions. Other determinants of technology diffusion such as Keynesian approach, mono-causal explanations, vintage models, learning processes and evolutionary and quasi-evolutionary approaches were either not mentioned or fully dealt with.

Future research should focus on the conceptualization of social change and the relationship between economic growth and technological change as well as correlation or causality of one on the other. Transactional and other costs to society of implementing technological change may also be investigated.

References

Abernathy, W. J., & Utterback, J. M. (1978). Patterns of Industrial Innovation. *Technology Review*, Vol. 80, pp. 40-47.

Abernathy, W. J., & Clark, K. B. (1985). Innovation: Mapping the winds of creative destruction. *Research Policy*, 14(1), 3–22. https://doi.org/10.1016/0048-7333(85)90021-6

Alas R., (2004) Organizational Changes During the Transition in Estonia, University of Tartu Press, Tartu, Estonia [Online] Available: www.tyk.ut.ee, Tellimus nr. 591

Allen F (1971). Socio-Cultural Dynamics: *An Introduction to Social change*. New York: Macmillan.

Angulo, J. J., Pederneiras, C. A. A., Ebner, W., Kimura, E. M., & Megale, P. (1980). Concepts of diffusion theory and a graphic approach to the description of the epidemic flow of contagious disease. *Public Health Reports*, 95(5), 478–485.

Bain, A. D. (1962). The Growth of Television Ownership in the United Kingdom. *International Economic Review*, Vol. 3(No. 2), pp. 145{167.

Bass, Frank M. (1969). A New Product Growth for Model Consumer Durables. *Management Science*, Vol. 15(No. 5), pp. 215{227.

Binswanger, Hans P. (1974). A Microeconomic Approach to Induced Innovation. *The Economic Journal*, Vol. 84(No. 336), pp. 940{958.

Bijker, W. (1995). Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change. *Inside Technology*. https://doi.org/10.2307/2077312

Blaug, M. (1963). A Survey of the Theory of Process-Innovations. *Economica, New Series*, Vol. 30(No. 117), pp. 13{32.

Callon, M. (1986a). The sociology of an actor-network: the case of the electric vehicle. In *Evaluation des politiques publiques de la recherche et de la technologie: analyse des programmes nationaux de la recherche*, janvier 1986: mission scientifique et technique, R. Arvanities, M. Callon, B. Latour (eds). Paris: Documentation française.

Callon, M. (1986b). Some elements of a sociology of translations: domestications of the scallops and fisherman of St Brieuc Bay. *In Power, action and belief: a new sociology of knowledge?* J. Law (ed.). London: Routledge & Kegan Paul.

Callon, M. 1993. Variety and irreversibility in networks of technique conception and adoption. *See Foray & Freeman* (1993).

Callon, M., P. Larédo, V. Rabeharisoa, T. Gonard, T. Leray 1992. The management and evaluation of technological programs and the dynamics of techno-economic networks: the case of the AFME. *Research Policy* 21, 215–36.

Cantwell, John A. 1999. Innovation as the Principal Source of Growth in the Global Economy. In D. Archibugi, J. Howells and J. Michie (eds.), *Innovation Policy in a Global Economy*, Cambridge: Cambridge University Press.

Conte, A. (2006). The Evolution of the Literature on Technological Change over time: A Survey. *Papers on Entrepreneurship, Growth and Public Policy*.

Cutler, D. M., & McClellan, M. B. (1998). What Is Technological Change? *Inquiries in the economics of aging* (Vol. I).

Davis K (1959). *Human Society*. New York: Macmillan
Dosi, G., Freeman, C., Nelson, R., Silverberg, G., & Soete, L. (1988). Technical Change and Economic Theory. *LEM Book Series*. https://doi.org/10.2307/2234048
Edari R (1976). *Social Change*. Dubuque: Lowe.
Edquist, C. (2005). Systems of Innovation: Perspectives and Challenges, In: *The Oxford Handbook of Innovation*, Jan Fagerberg et al. (Eds.), 181-208, ISBN 0-19-926455-4, Oxford University Press, New York, the United States
Ginsberg M (1958). Social Change, Bri. J. Sociol. 2 (1): 205- 229. Hans G, Mills CW (1953). *Character and Social Structure*. New York: Harcourt.
Godin, B. (2015). Technological Change: What do Technology and Change stand for? *Project on the Intellectual History of Innovation*, (24), 1–51. Retrieved from http://www.csiic.ca/wp-content/uploads/2015/12/Paper24_TC.pdf
Gold, Bela. (1981). Technological Diffusion in Industry: Research Needs and Shortcomings. *The Journal of Industrial Economics*, Vol. 29(No. 3), pp. 247{269.
Graham, Gerald S. (1956). The Ascendancy of the Sailing Ship 1850-85. *The Economic History Review*, New Series, Vol. 9(No. 1), pp. 74{88.
Greene, I., & Greene, I. (2007). The Innovation Journal: *The Public Sector Innovation Journal*, 12(3), 1–16.
Griliches, Zvi. (1994). Productivity, R&D, and the Data Constraint. *The American Economic Review*, Vol. 84(No. 1), pp. 1{23.
Hughes, T. P. (1983). Networks of power. *electrification in Western society*, 1880–1930. Baltimore: Johns Hopkins University Press.
Hughes, T. P. (1987). The evolution of large technological systems. See Bijker et al. (1987). Hughes, T. P. 1989. *American genesis: a century of invention and technological enthusiasm*, 1870– 1970. New York: Viking Press.
Hernes, T. (2009). Understanding organization as process: Theory for a tangled world. *Organization Studies* (01708406) (Vol. 30). https://doi.org/10.1177/0170840608101793
Hicks, John R. (1932). *The Theory of Wages*. London: MacMillan & Co.
Hirsch, Jaffe, A. B., Newell, R. G., & Stavins, R. N. (2003). Technological Change and the Environment. *Handbook of Environmental Economics*, 1, 461–516. https://doi.org/10.1016/S1574-0099(03)01016-7
Jaffe, A. B., Newell, R. G., & Stavins, R. N. (2001). Technological Change and the Environment, (November). *Handbook of Environmental Economics,* 2003 Elsevier Science B.V
Kaldor, Nicholas. (1932). A Case against Technical Progress? *Economica*, Vol. 36(May), pp. 180{196.
Kamien, M. I. & N. L. Schwartz (1968). Optimal "induced" technical change. *Econometrica* 36(1), 1–17.
Kim, B. S. (2012). Measuring Technological Change – Concept, Methods, and Implications, Korea Institute of S&T Evaluation and Planning, *Research Paper Series*, Seoul, South Korea
Kuhn, Thomas. (1962). *The Structure of Scientifc Revolutions*. Chicago: University of Chicago Press.
Landes, David S. (1969). *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present.* Cambridge: Cambridge University Press.
Law, J. (1987). *Technology and heterogeneous engineering: the case of Portuguese expansion*. See Bijker et al. (1987).
Law, J. & M. Callon (1988). Engineering and sociology in a military aircraft project: a network analysis of technological change. *Social Problems* 35(3), 284–97.
Lucas, Robert E. Jr. (1988). On The Mechanics Of Economic Development. *Journal of Monetary Economics*, Vol. 22(No. 1), pp. 3{42.
Lunenburg, F. C. (2010). Approaches to Managing Organizational Change Lewin's Three-Step Change Model. *International Journal of Scholarly Academic Intellectual Diversity*, 12(1), 1–10.
MacIver R, Page C (1949). *Society: An Introductory Analysis*. New York: Holt, Rinehart.
Mansell, R. (2010). Information Societies: History and Perspectives. *The Information Society. Critical Concepts in Sociology*, 1, 1–21.
Mansfeld, Edwin. (1983a). Long Waves and Technological Innovation. *The American Economic Review*, Vol. 73(No. 2), pp. 141{145.
Mayntz, R. & T. P. Hughes (eds) (1988). *The development of large technical systems*. Frankfurt: Campus.
Merton, R. K. (1978). Science, Technology and Society in Seventeenth Century England, *Humanities Press*, ISBN 0-85527-357-7, New Jersey, the United States
Nelson, Richard R., & Winter, Sidney. (1982). *An Evolutionary Theory of Economic Change*. Cambridge (Mass.): Harvard University Press.
Nisbet R., (1969). *Social Change and History*. New York: Oxford.
North, Douglass C. (1958). Ocean Freight Rates and Economic Development 1750-1913. *The Journal of Economic History*, Vol. 18(No. 4), pp. 537{555.

North, Douglass C. (1968). Sources of Productivity Change in Ocean Shipping, 1600-1850. *The Journal of Political Economy*, Vol. 76(No. 5), pp. 953{970.

OECD. (2001). Overview of productivity measures. Measuring Productivity - *OECD Manual*, 2, 11–21. https://doi.org/10.1787/9789264194519-en

OECD Organization for Economic Co-operation and Development. (2003). *Technology innovation, development and diffusion*. OECD Environment Directorate and International Energy Agency, 4, 2–48.

OECD. (2005). *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*. 3rd edn.

OECD (2017), *Population (indicator)*. doi: 10.1787/d434f82b-en (Accessed on 09 August 2017)

Petit, Pascal. (1995). Employment and Technological Change. In Stoneman P. (ed.), *Handbook of the Economics of Innovation and Technological Change*, Blackwell Publishers Ltd., pp. 366-408.

Petri Rouvinen and Pekka Ylä-Anttila (2003) Chapter 5 of Case Study: Little Finland's Transformation to a Wireless Giant (p. 88-108), *The Global Information Technology Report: Toward an Equitable Information Society*, Oxford University Press with World Economic Forum

Porter, T. M. (1995). *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*, Princeton University Press, ISBN 0-691-03776-0, Princeton, New Jersey, the United States

Rip, A., & Kemp, R. (1998). *Technological change. Human Choice and Climate Change*, 2(Vol. 2: Resources and Technology), 327–399. https://doi.org/10.1007/BF02887432

Robbins, Lionel. (1932). *Essay on the Nature and Significance of Economic Science*. Palgrave Macmillan. 1984.

Romer, P. M. (1990). Endogenous Technological Change. *Journal of Political Economy*, 98(5), S71–S102. https://doi.org/10.1086/261725

Rosenberg, Nathan. (1982). Inside the Black Box: *Technology and Econo*mics. Cambridge: Cambridge University Press.

Runnel, P., Pruulmann-Vengerfeld, P., & Reinsalu, K. (2009). The Estonian Tiger Leap from Post-Communism to the Information Society: From Policy to Practice, *Journal of Baltic Studies*, 40:1, 29-51, DOI: 10.1080/01629770902722245

Salter,W. E. G. (1960). *Productivity and Technical Change*. Cambridge: Cambridge University Press.

Sarkar, J. (1998). Technological Diffusion: Alternative Theories and Historical Evidence. *Journal of Economic Surveys*, 12(2), 131–176. https://doi.org/http://dx.doi.org/10.1111/1467-6419.00051

Scoville, Warren C. (1951). Spread of Techniques: Minority Migrations and the Di?usion of Technology. *The Journal of Economic History*, Vol. 11(No. 4), pp. 347{360.

Saxonhouse, Gary. (1974). A Tale of Japanese Technological Diffusion in the Meiji Period. *The Journal of Economic Histor*y, Vol. 34(No. 1), pp. 149{165.

Schmid, S. K. & R. Werle (1992). The development of compatibility standards in telecommunications: conceptual framework and theoretical perspectives. In *New technology at the outset: social forces in the shaping of technological innovations*, M. Dierkes & U. Hoffmann (eds). Frankfurt: Campus.

Schot, J. (1992). *The policy relevance of the quasi-evolutionary model: the case of stimulating clean technologies*. See Coombs et al. (1992).

Schumpeter, Joseph. (1934). *The Theory of Economic Development. Cambridge* (Mass.): Harvard University Press, 1st edn. 1912.

Solow, R. M. (1957). Technical change and the aggregate production function. *Review of Economics and Statistics*, 39(3), 312–320. https://doi.org/10.2307/1926047

Schneider, J. & T. Ziesemer (1995). What's new and what's old in new growth theory: endogenous technology, microfoundation and growth rate predictions: a critical overview. *Zeitschrift für Wirtschafts- und Sozialwissenschaften* 115, 429–72.

Vago S (1992). *Social Change.* London: Halt Rinehart and Winston

Van den Belt, H. & A. Rip 1987. The Nelson–Winter–Dosi Model and synthetic dye chemistry. See Bijker et al. (1987).

Van De Ven, A. H., & Poole, M. S. (1995). Explaining Development and Change in Organizations. *Academy of Management Review*, 20(3), 510–540. https://doi.org/10.2307/258786

Verspagen, Bart. (1992). Endogenous Innovation in Neo-Classical Growth Models: A Survey. *Journal of Macroeconomics*, Vol. 14(No. 4), pp. 631-662.

Walton, Gary M. (1970). Productivity Change in Ocean Shipping after 1870: A Comment. *The Journal of Economic History*, Vol. 30(No. 2), pp. 435{441.

Estonia World Ranking (2015) [Online] Available: http://www.vm.ee/en/estonias-position-international-rankings-2014-2015

'Estonia 2020' reform programme. (2015) [Online] Available: https://riigikantselei.ee/en/supporting-government/national-reform-programme-estonia-2020

Estonia's broadband strategy. (2009) [Online] Available: http://elasa.ee/public/files/ESTWIN_network%20track_20090420.pdf

Notes

Note 1

The Global Information Technology Report (GITR) series is the result of a long-standing partnership between the World Economic Forum and INSEAD. The GITR has a record coverage of 144 economies, remains one of the most comprehensive and authoritative assessments of the impact of ICT on the competitiveness of nations and the well-being of its citizens. The Global Competitiveness Report series is also from the World Economic Forum and partners.

Note 2

Soviet era – refer http://en.wikipedia.org/wiki/Soviet_Union for more on Soviet Union and regimes

Note 3

The European Union (EU) is a political and economic union of 28 member states that are located primarily in Europe. Officially called the euro area, is a monetary union of 19 of the 28 European Union (EU) member states which have adopted the euro (€) as their common currency and sole legal tender

The North Atlantic Treaty Organization (NATO) is an intergovernmental military alliance between several North American and European states based on the North Atlantic Treaty that was signed on 4 April 1949

The Organization for Economic Co-operation and Development (OECD) is an intergovernmental economic organization with 35 member countries, founded in 1960 to stimulate economic progress and world trade.

The Schengen Area is an area comprising 26 European states that have officially abolished passport and all other types of border control at their mutual borders. The area mostly functions as a single country for international travel purposes, with a common visa policy. The area is named after the Schengen Agreement.

Note (additional)

Relevant data were sourced from EU, International Telecommunications Union (ITU), OECD, Global Information Technology Report series, Global Competitiveness Reports, World Bank Reports, United Nations Databases Statistics Estonia and other Country Strategy documents.

See ITU World Telecommunications/ICT Indicators Database. http://www.itu.int

United Nations Statistics Division collects, compiles and disseminates official demographic and social statistics on a wide range of topics each year. Data collected since 1948 have been published in The Demographic Yearbook. See http://data.un.org/

The Human Development Index (HDI) is a composite index measuring average achievement in the three basic dimensions of human development – a long and healthy life, knowledge and a descent standard of living. See http://hdr.undp.org/sites/default/files/hdr2016_technical_notes.pdf for details on how the HDI os calculated

Digital Opportunity Index (DOI). The definitions of the core indicators used to compile the DOI are available from the Partnership for Measuring ICT for Development. See ITU/UNCTAD/KADO Digital Opportunity Platform

Tables

Table 1. Estonia's International Rankings 2014 - 2015

Estonia's Rankings 2014 - 2015		
	Ranking	**Total No of Countries**
Freedom on the Net (Freedom House)	2nd	65
Index of Economic Freedom (Heritage Foundation and the WSI)	8th	177
Press Freedom (Freedom House)	15th	197
Doing Business Economy rankings (World Bank)	17th	189
Networked Readiness Index (World Economic Forum)	21st	148
Corruption Perception Index (Transparency International)	26th	175
Global Competitiveness Index (World Economic Forum)	29th	144
Prosperity Index (Legatum Institute)	32nd	142
Human Development Index (UN Development Programme)	33rd	187
Democracy Index (Economist Intelligence Unit)	34th	167

Table 2. Socio-Economic Indicators, Estonia (Five-year intervals)

Year	**2000**	**2005**	**2010**	**2015**
Population (in million)	1,379 (2002)	1,355	1,331	1,316
Internet user per 100 inhabitants	28.6	61.5	74.1	84.2
Mobile cellular telephone subscriptions per 100 inhabitants	40.78	109.07	127.28	160.68 (2014)
Main telephone lines per 100 inhabitants	38.27	33.35	37.14	31.72
GDP per capita (at current process)	US$ 4,067	10,330	14,641	17,112
Networked Readiness Index (GITR)	23	25	25	22
Global Competitiveness Index	29 (2002)	20(2004)	35	30
Human Development Index	.78	.82	.83	.86
Freedom Index (Score: 100 reps. Max)	69.90	75.20	74.70	76.70
CO2 emissions from fuel combustion (Mln tonnes)	15	16	19	-

Source: Authors (United Nations Database (2017), ITU, OECD, Statistic Estonia, EU)

Table 3. Average Annual Human Development Growth (%)

HDI (Value)				Change in Rank (Value)	Average Annual HDI growth (%)		
Year	**2000**	2010	2015	2010 - 2015	2000-2010	2010-2015	1990-2015
Value	**0.781**	0.838	0.865	2	0.70	0.65	0.69

Source: Authors

Table 6. Explanation of e-Estonia Framework components

Component	Brief Explanation
DigiDoc	is a system that is widely used in Estonia for storing, sharing and digitally signing documents.
Digital Signature	enables secure, legally-binding, electronic document signing.
e-Business Register	enables entrepreneurs to register their new business online in minutes.
e-Cabinet	a powerful tool used by the Estonian government to streamline its decision-making process.
e-Law	allows public access to every piece of draft law that has been submitted since February 2003.
e-Tax	has drastically reduced the time spent by individuals and entrepreneurs on filing taxes.
Electronic ID Card	Acts as definitive proof of ID in secure electronic environments.
Mobile-ID	allows a client to use a mobile phone as a form of secure electronic ID
Mobile Payment	enables payment for goods and services using mobile phones.
m-Parking	allows drivers to pay for city parking using a mobile phone.
Electronic Land Register	a one-of-a-kind information system for storing real estate and land data.
State e-Services Portal	a one-stop-shop for the hundreds of e-services offered by government institutions.
e-Residency	Estonian e-Residency is a digital identity that allows everyone in the world to do business online with ease.
e-Police	Revolutionizes police communication and coordination for maximum effective policing
Location-based services	A positioning service that detects device location and provides information
Electronic Health Record	Integrates data from healthcare providers into national records for each patient
e-Prescription	A centralized, paperless system for issuing and handling medical prescriptions
Social Welfare e-services	Benefit system is accessible everywhere online
e-school	Allows students, teachers, parents to collaborate in the learning process
Population Register	State database for information about each person living in Estonia
i-Voting	Allows voters to cast their ballots online
Smart Grid Energy Sector	Estonian developed involving a number of cutting edge solutions in the energy sector on smart grid
X-Road Data Layer	Allows databases to interact making integrated e-services possible

Figures

Figure 3

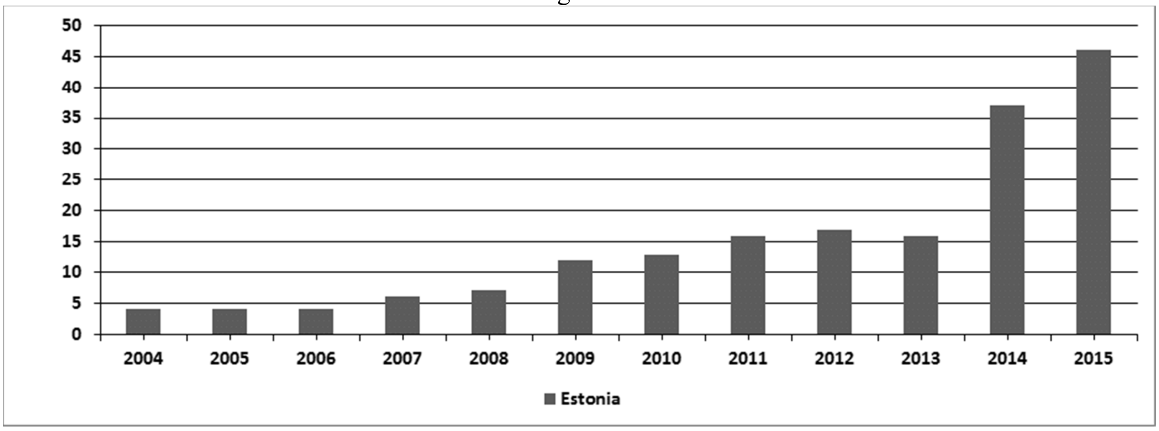

Figure 3. Last online purchase in last 3 months – percentage on individuals, (2000 – 2015) Estonia (Source: Authors)

Figure 4

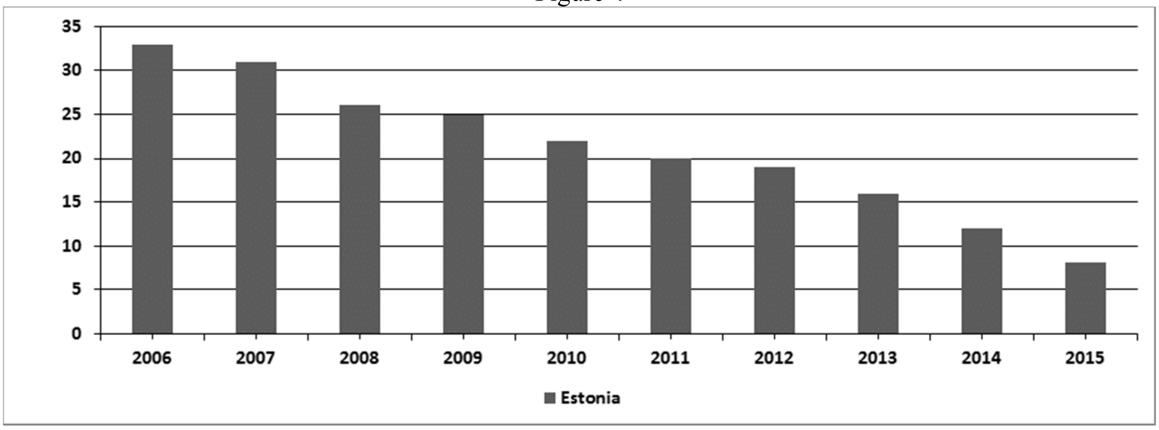

Figure 4. Computer use: Never – percentage on individuals, (2000 – 2015) Estonia (Source: Authors)

Figure 5

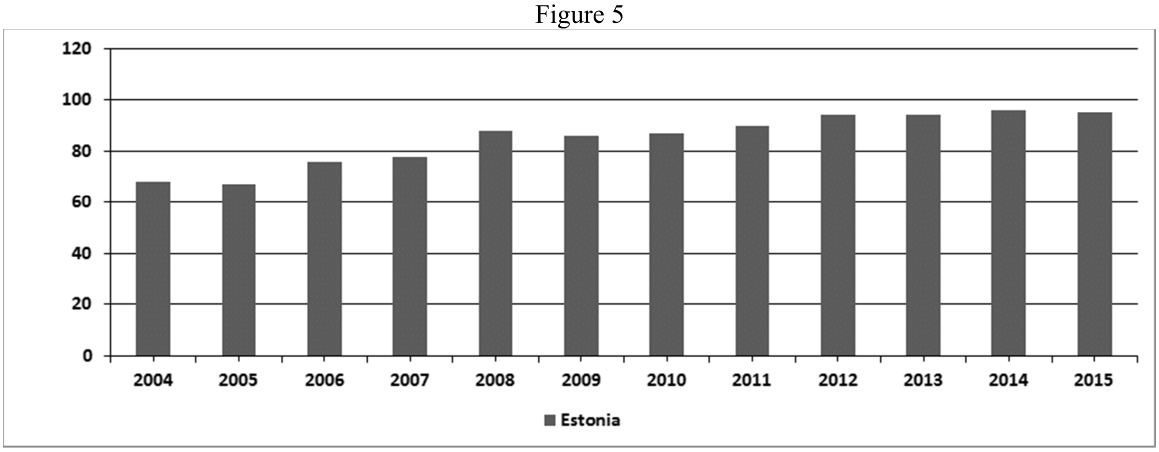

Figure 5. Broadband Access: All enterprises – 10 or more persons employed, (2000 – 2015) Estonia (Source: Authors)

Figure 6

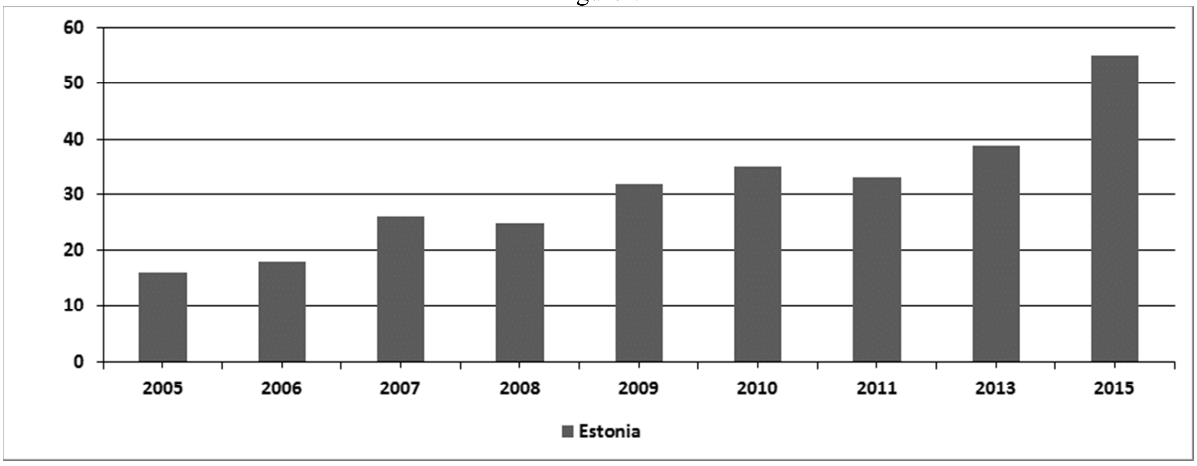

Figure 6. Internet Use: Seeking Health Information – percentage of individuals, (2000 – 2015) Estonia (Source: Authors)

Figure 7

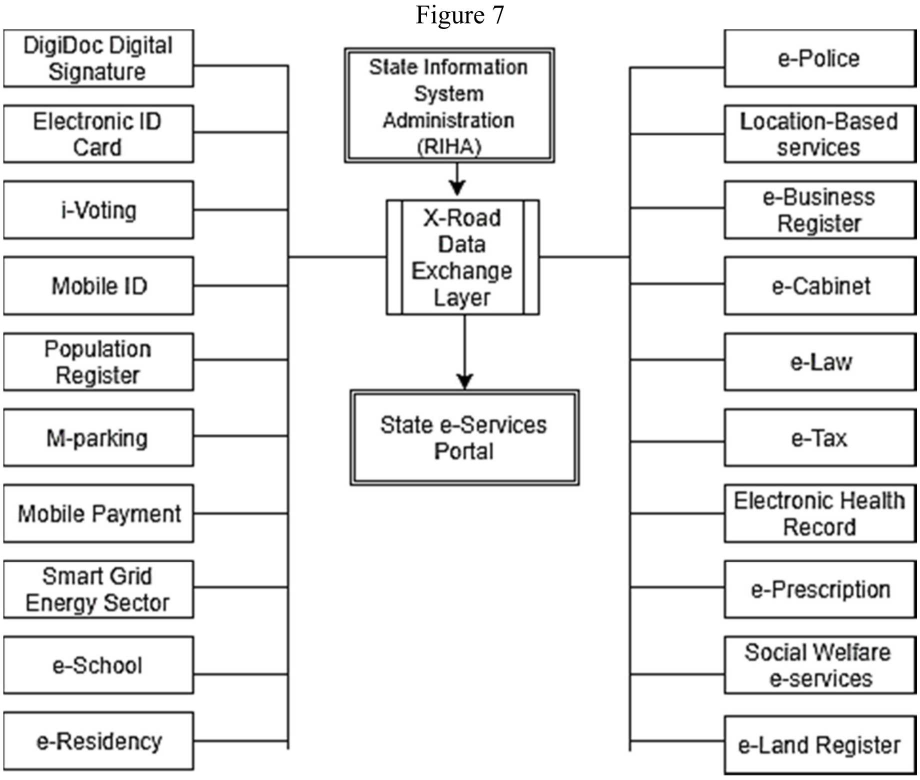

Figure 7. Building Blocks for Configuring e-Estonia (Source: Authors)