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Doctoral School of Management and Business Administration

The Learning Economy, Innovation, and ICT-generated productivity: International comparison between the European Union and North America

Ph.D. Dissertation

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Table of Contents

Abstract

There is much academic literature concerning Innovation, Forms of Work Organization, and Productivity, but apparently very little combining all three measures into one body of comparative research examining the European Union, the United States of America, and Canada. As the EU moves toward a potential post-Brexit reality and the United States is seemingly moving toward a more isolationist stance (e.g. leaving the Paris environment agreement), the need to increase productivity and innovation are now of prime importance to all governments, and especially to the EU where productivity has been perceived to have fallen behind the United States. Innovation, on the other hand and using the mainstream innovation indices, has maintained a healthy competition with some European countries routinely placing ahead of the United States in various indices. With the uncertainties around the economic future, this research could be used to not only support national innovation, but also cast outward looking to determine which countries are potential trading partners.

Chapter 1 introduces the reader to the background, research aims, objectives, and overview of the approach. In Chapter 2, the review of the literature on Organizational Learning and Forms of Work Organization establish the basis of the different forms of work organization indicators that will be utilized later in the Principal Components Analysis and the Hierarchical Cluster Analysis. The term "Knowledge Economy" is attributed to Peter Drucker (Drucker, 1969;263) and is one where organizations and people acquire, create, disseminate, and use knowledge more effectively for greater economic and social development. Knowledge and learning constitute a remarkably difficult subject to have one dominant theory encompassing the acquisition and retention of knowledge in a commercial setting, ultimately leading to innovation, that covers all the different types of organizational designs and management approaches. In all, five Forms of Work Organization will be examined: Discretionary Learning, Constrained Learning, Independent Learning, Taylorist, and Simple/Traditional learning approaches. Data from the Programme for the International Assessment of Adult Competencies (PIAAC) first cycle are used to quantify the types of learning that each of the twenty-two sample countries exhibit.

A brief history of recent productivity results are included in Chapter 3 to allow the reader to become familiar with the economic history of the sample countries, although most of the productivity review deals with the European Union as a single entity or only selected countries, the Author uses Conference Board (2018) adjusted productivity data to compare the previous research and what the differences are using the adjusted data. Additional review of the academic literature on the impact of Information and Communication Technologies (ICT) to business and then national and supra-national productivity results is explored. Although Artificial Intelligence (AI) and Automation are not a direct subject of this research, the potential impact AI may have on jobs and types of jobs cannot be ignored, and a high-level literature review addresses potentially how different jobs may be impacted.

Innovation means many things to many people, and in Chapter 4 the definitions from the Oslo Manual, 4th Edition (OECD,2018) are used to frame what innovations are to give a framework for choosing indicators that will be utilized in the analyses in this exploratory research. The author briefly discusses how Canada, the United States, and the European Union provide government support for innovation within their borders. How national innovation is also

measured through the various innovation indices is reviewed at a high level to give the reader an understanding of the various current approaches to quantifying "innovativeness".

Chapter 5 contains the first of the analyses, the Principal Components Analysis (PCA). As stated earlier, there is very little research combing the Forms of Work Organization and Innovation for Canada, the United States, and the European Union. The chapter starts with the descriptions of the indicators used for consideration in the two analyses completed by the author. The methodology followed the example of the European Digital City Index Report (Bannerjee et al.,2013). Whilst PCA does not indicate causality, for this type of exploratory research it allows an indication of which characteristics are correlated to the data set and which are not. There were two levels of unexpected findings, one on the individually highly correlated indicators, and the number of relatively equally highly correlated indicators. The "Regulatory Quality" of the individual country is the highest correlated indicator in Principal Component 1 which was not expected by the author. The other unexpected finding was that there were many highly correlated indicators in the Principal Component 1, which suggests that there is no one single "magic bullet" solution that countries could use to quickly increase their innovation status.

Chapter 6 examines whether countries that are innovative share more "like" characteristics with other innovative countries versus less innovative countries, and what those differences are. Through a Hierarchical Cluster Analysis, groupings and sub-groupings were established that found, indeed, countries considered to be highly innovative share more characteristics with each other, and the same is true for countries that have lower innovation levels. There were stark differences using the same data as the Principal Components Analysis in this chapter as the research established results with similarities to the existing innovation indices.

The Chapter 7 elucidates the results of the analyses in the preceding chapters together and discusses the findings of both analyses and establishes the working themes to understand the results. Two of the three hypotheses are proven, with thoughts about why the non-proven hypothesis occurred. Innovative countries share more characteristics with each other than they do with less innovative countries. ICT use does also positively impact innovation within nations. Productivity, as the academic literature has borne out, is often used as the proxy for innovation, yet, the countries that appear to exhibit less innovation have had the highest growth rates in the most recent past. One reason may be the use of these countries as "factor economies" to outsource various business requirements or manufacturing of goods, but the economic "headwinds" that Gordon (2018) cites in the most developed countries may also not have had as great an impact on the economies of the Central and Eastern European countries at this time. Whether the result of the "great catching up" will also result in the CEE countries also experiencing the same fate is yet to be seen.

The final chapter summarizes the research of the author, lists the key findings of the research, and suggests avenues of potential future research connected to subject. The key findings are that Forms of Work Organization do have an impact on innovation, Regulatory Quality is import to innovation, but there are many almost equally impactful characteristics that have to be considered when examining overall conditions for innovation. Future research will benefit from the completion of the Programme for the International Assessment of Adult Competencies (PIAAC) surveys that will be able to identify the Forms of Work Organization in more countries in the European Union and OECD, allowing a larger study to be conducted that will assist the academic community in reaching a better understanding of the nuances of supporting innovation. There are also governmental policy implications that the author suggests that nations could undertake to support innovation in their domestic economies that are a result of this research.

List of Tables

List of Figures

1. Introduction

In a world on the precipice of potential life-altering advances such as Artificial Intelligence, realignment of traditional trade partnerships, and the potential large-scale global action to respond to critical Climate Change emergencies through innovation, what facilitates innovation and makes it successful is imperative for governments, business, the academic community, and society at large to understand. Many of the things we hold dear may not survive the coming turbulence of potential massive change, but having innovative economies will allow the world to react in a manner that will maximize benefit to society and the future of the planet.

There is much academic literature concerning Innovation, Organizational Work Forms, and Productivity, but apparently very little combining all three measures into one body of comparative research examining the European Union, the United States of America, and Canada. As the EU moves toward a potential post-Brexit reality and the United States is seemingly moving toward a more isolationist stance (e.g. leaving the Paris environment agreement), the need to increase productivity and innovation are now of prime importance to all governments, and especially to the EU where productivity and innovation of many countries has stagnated behind the United States, despite the recent modest improvement.

Moving beyond the sample countries in this exploratory research, this research may extend to other countries to determine their level of innovation potential, and which aspects of their society or economy will foster innovation and economic development more easily than others, or identify which needs are the ones to be reinforced or upgrade to create success. In addition, as the global value chains keep expanding, identifying the underlying characteristics of potential partners through trade or direct investment opportunities may suit sectoral needs or national foreign aid priorities.

1.1 Experiences of the researcher leading to the research

I find myself continuing a very circuitous route from where I started, to where I am today, and to where I hope to be in the future. Working in the building design and construction industry for over fifteen years I managed projects of all types with various degrees of responsibility. What I enjoyed was working with others to a common goal in a collegial atmosphere. I had never equated this to high performance organizations or work teams until I was studying in the Masters of Project Management degree program at the Université du Québec en Outaouais (UQO) in the mid-2000s. There I started to understand and put labels and understanding to what I had experienced in the project teams I had been involved with during my career to that point. The aspects that I focused on in the latter part of my degree were organizational trust, organizational design, and organizational justice, as they pertain to project teams. I was humbled to receive the "Mention d'excellence du doyen" (Dean's award of Excellence) for my studies. My experiences with the literature and connecting to employment experiences to academic observations led me to submit my first conference paper in 2012 which, in hindsight I will freely acknowledge, is somewhat "cringe-worthy" compared to the efforts I have been involved with since that time. The additional research I completed for that first conference paper ignited my thirst for more knowledge, and a framework to satisfy it.

The next step in my personal journey was working with Dr. Tamas Koplyay after graduation from UQO on various conference and journal papers. I learned much more about the corporate life-cycle and especially how it connected with High-technology firms and markets. This research direction not only allowed me to research and contribute to research papers, but also allowed me to start understanding the multi-disciplinary landscape that surrounded organizations at different points in their existence. It was as if the multi-dimensional chess board was unveiled to me and I had a chance to look inside to discover why things work the way they do. One of the foundational realizations I had during this time of reading conventional academic literature focused on one small and precise subject or approach was limiting the scope and scale of investigation of business and organization phenomena did not allow a full understanding what is actually occurring in the workplace and how that affects the organization.

1.2 Background to the Research

I entered that Szent István doctoral program without a defined research objective per se, I intended to "learn as I go", and did that very thing. My first course with my advisor, Dr. Csaba Makó, focused on the forms of work organizational that formalized my understanding of the differences in organizational design, forms or work organization, and expanded my world view significantly to include the approach of the European Working Conditions Survey, for which Dr. Makó had been an author. Adding innovation was the final thread that, conceptually, I wanted to investigate; what conditions does a company, or a country need to be innovative and thus increase productivity, ergo increasing prosperity for that country.

1.3 Research Proposition

This researcher was not able to find a body of systematic research that addresses the three research questions containing the EU, Canada, and the United States in the academic literature.

1.4 Research Questions

In short, the following questions will be investigated and answered in my research:

1. What are the differences and similarities between the various countries which influence innovation?
2. What are the differences between the various countries that influence productivity?
3. And finally, how does ICT use affect all aspects?

Once these questions are answered, the interaction between can be investigated to determine the real drivers of the results.

1.5 Research Scope and Objectives

This research will be an examination of forms of work organizational, productivity, and innovation; and especially the effect of Information and Communication Technologies (ICT) adoption and use. The literature and data will be gleaned from academic papers from journals, research from various governmental and non-governmental sources including, but not limited to; the Organization for Economic Co-operation and Development (OECD), Eurostat and the various Eurostat supported projects and programs, The World Bank, The United Nations (UN), and various other non-government-funded bodies such as the Conference Board.

1.6 Hypothesis

Hypotheses:

H1: Innovative countries share more characteristics than less innovative countries.

Idea: *The hypothesis is that innovative countries share traits that make them innovative; whether it is education, government support, or social characteristics, common threads will enable countries to be innovative.*

H2: Productivity and Innovation are connected, but are not proportional.

Idea: *Although Innovation and Productivity are inter-connected, the same levels of each in different countries may not achieve the same results.*

H3: ICT use supports organizational or process innovation, but outside influences may limit the actual increases to productivity.

Idea: *Information and Communication Technologies have allowed productivity to increase, but some countries can harness the innovation better.*

1.7 Research Design

The research methodology will contain two separate approaches:

1. Review of academic literature that has investigated any aspect of the three aspects of the investigation;
2. Review of applicable governmental or quasi-governmental (i.e.: World Bank and OECD) datasets to have somewhat comparable results. Obtain and review data concerning Innovation, Employment Types, and Productivity from various data bases and reports from the governmental and non-profit bodies and research organizations. During this review, definition of the main investigation points will be determined and those results or indicators will be examined in view of the other three.
3. Complete a Principal Components Analysis to determine which of the indicators have correlation to the dataset.
4. Complete a Cluster Analysis using the same variables to determine the characteristics of the sample countries in relation to the principal Components Analysis.

1.8 Limitations

The limitations of this research are very important for the reader to understand. This is exploratory research combining elements of classic Productivity research, Innovation, and Forms of Work Organization, which is the novelty of the research proposal in that these three subjects have not been, in this author's investigation, brought together into one academic work. Indicators chosen to review have been aligned with the Oslo Manual on Innovation research, Organizational Learning and Design, and productivity growth statistics, but the sample size is very small, consisting of the twenty-two countries that are included in the analysis. This creates some difficulty in ensuring that the data is appropriate for the analyzes, but through accepted academic processes, the data is transformed to conform to academic rigour. This research is not a final answer, it is a starting point for a potential plethora of lines of future academic inquiry.

1.9 Structure of the Dissertation

The dissertation is structured in the following manner:

Chapter 1: Introduction: This Chapter provides an introduction, purpose and background to the research, the research problem, questions and objectives, as well as the research methodology, limitations, and the structure of the dissertation.

Chapter 2: Literature Review on the Resource-Based View, Knowledge-Based View, and Learning in the Firm: This Chapter provides a detailed overview of the way people and organizations learn, and the different ways that organizations can evolve to become what they eventually become. Included in the Chapter is how the academic literature has viewed the Forms of Work Organization and those changes over time.

Chapter 3: Productivity is the benchmark that classical economic theorists judge innovation, this Chapter reviews the recent past of the Productivity for the countries included in the sample for this research.

Chapter 4: Innovation is a complex subject. This Chapter delves into what it is, how national and supra-national governments support innovation, and how the academic literature has attempted to quantify it.

Chapter 5: Analysis of Indicators: This Chapter outlines the approach and selection of Indicators for the Principal Components Analysis, the methodology, and the results of the Analysis.

Chapter 6: Hierarchical Analysis: Using the variables from the Principal Components Analysis, this Chapter conducts a hierarchical Cluster Analysis to group the subject countries into logical groupings for comparison and analysis.

Chapter 7: Consolidation of Research Findings and Results: This penultimate Chapter combines the outputs of the Principal Component Analysis and the Cluster Analysis together to create the findings of this research.

Chapter 8: Conclusion: This Chapter brings together the various strands of investigation and summarizes the knowledge created through this investigation and identifies the key findings and identifies avenues of future research to extend the understanding of the academic community on this subject.

Chapter 9: Bibliography

1.10 Summary of the Chapter

This chapter has elucidated the reasons this author has chosen the research subject for this dissertation. The structure, research questions, and approach to solving this puzzle has also been outlined as the roadmap to arriving at the destination of increased knowledge and contribution to the academic community.

2 Literature Review on Resource-Based View, Knowledge-Based View, and Learning in the Firm

2.1 Introduction

The term "Knowledge Economy" is attributed to Peter Drucker (Drucker, 1969;263) in describing how the knowledge worker had displaced the "men on the assembly line" from the centre of the American economy. A knowledge economy is one where organizations and people acquire, create, disseminate, and use knowledge more effectively for greater economic and social development. Knowledge and learning, in the context of business and commerce, is a remarkably difficult subject to have one dominant theory encompassing the acquisition and retention of knowledge in a commercial setting, ultimately leading to innovation, that covers all the different types of organizational designs and management approaches. Once learned and retained, the diffusion of knowledge creates further challenges due to the differing natures of tacit versus explicit knowledge.

This section shall review a number of theories of organizational learning and their connection to forms of work organization, and examine organizational structures and which types of learning tends to be prevalent in their economies. A number of learning frameworks are integrated and examined to identify similarities and differences. A review of the dispersion of organizational forms, adult training and economic performance of selected states within the European Union, Canada, and the United States are examined to discover if there are connections between all three elements.

2.2 From Resource to Knowledge-Based View of the Firm

Edith Penrose (1959;178-179) stated that a company's success depends upon its' possession and development of unique resources. As Dosi, Faillo and Marengo (2008;1169) ventured, Penrose's view is now aligned with the "Resource-Based View" (RBV) that looks upon organizational knowledge as a corporate resource that is used to create or sustain competitive advantage within the market sector (or sectors) for a firm. This view ties directly into current business strategy theory, and especially that of Michael Porter, who examines the "Unique and Valuable Proposition" (1996;3), "Tailored Value Chain" (1996;3), and "Continuity of Time" (1996;17) all have direct connections to the continuous process of organizational learning in ensuring the survival of the firm. The construct of the resource-based view theorists is that knowledge is a key part of the firm, and the author posits that much of the reviewed literature is written in the context that such knowledge is "owned" by the firm, and little is credited to the individual employees, but more to the organizational habits and management. Different from technological or product design ownership that can be protected by patents, the organizational learning and knowledge base of a firm is generally looked upon as a set of procedures or processes that allow the production of an output that the firm then sells to customers. There is a difference between those researchers who view organizational knowledge as that which resides in the firm itself; "only a company can make a car"; versus those who consider knowledge as inherent in the individual, but shared with the firm as in the case of the J-Form organization.

The Knowledge Based View (KBV) of the firm is a recent development, being solidified in the later 1990's and early 2000's, and is greatly enhanced by the shift of the economies of developed nations from manufacturing to services-based firms (Curado,2006:5). Curado (2006:12) concludes that knowledge in the KBV is the most important resource that a firm can retain. Thus, the intangible nature of knowledge makes it more important than any other resource that a firm can muster in the face of competition.

Not withstanding the RBV and KBV dichotomies, it remains that knowledge, whether in a position of primacy or subservient in the corporate structure, is dependent upon the creation and subsequent retention of knowledge. Academic literature has examined the two foundational types of knowledge; tacit and explicit; in many different manners. From the philosophical approach of Polanyi (1958) to the organizational learning approach of Lam (2000:506), and the knowledge creation models by Nonaka et al. (1994: 20, 2000a: 23, 2000b: 10), the difference between explicit and tacit knowledge is simple, yet how knowledge is acquired and transferred is complex enough that it has created a unique discipline in the academic community.

Tacit knowledge is characterized as a personal knowledge that is learnt "by doing", and the dissemination of the knowledge is not easily achieved verbally or in written form. One example cited in common literature concerning tacit knowledge is the ability to ride a bicycle; one may be able to explain how to ride a bicycle, but controlling the machine takes "hands-on" experience to be proficient. In labour-intensive industries such as manufacturing or artisanal sectors, the knowledge is generally tacit and taught through "on the job training" (OJT). A different way to describe this is the "Doing, Using, and Interacting" (DUI) mode of learning (Jensen et al. (2007;162-163)). Jensen et al. (2007;162-163) also stress that this does not only mean individual tasks done by hand, but can extend to highly complex undertakings with large teams such as the creation of a new model of aircraft where many teams within the developing organization (whether internal or parts of a supply/value chain) have to interact and discover new insights or processes to revise the design or how to solve problems as they occur.

Explicit knowledge is codified and formalized. It can be written, taught, and then understood by others in such form without further explanation. An encyclopaedia is an example of explicit knowledge transfer. Much of the formal sciences education follows the explicit knowledge transfer methodology and is then generally followed by the formalization of professional accreditation in professions such as medicine and engineering through a type of apprenticeship and then qualification exams for licensing. Jensen et al. (2007;159-160) refer to this mode of learning and innovation as "Science, Technology, and Innovation" (STI). This mode is driven by codified technical and scientific knowledge.

The tacit and explicit knowledge types are not mutually exclusive, though. In most professional settings, a combination of explicit and tacit knowledge is required to be able to carry out employment duties. For example, in skilled building and construction trades training, a requirement of formal theory education during the apprenticeship period followed by qualification exams are required to become a licensed tradesperson (Government of Ontario, 2012). Tacit and explicit knowledge is combined to provide a way to demonstrate a minimum level of competency. In this way, both the "how" and the "why" are addressed, but at a level that is appropriate for the knowledge required to perform the expected tasks competently.

2.3 The Knowledge Economy/Learning Economy

How the Knowledge Economy has been viewed has changed over the course of time. In the 2005 Oslo Manual (OECD,2005;28), the "Knowledge-based Economy" was given a broad definition as being:

> *"The knowledge-based economy" is an expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors. Knowledge and technology have become increasingly complex, raising the importance of links between firms and other organisations as a way to acquire specialised knowledge. A parallel economic development has been the growth of innovation in services in advanced economies."*

By the time that the 2018 Oslo Manual (OECD,2018) was released, the term "knowledge-based economy" had vanished, and has been replaced by the terms: Knowledge, Knowledge-based Capital (KBC), Knowledge-capturing product, Knowledge flows, Knowledge management, and Knowledge network. Indeed, there doesn't seem to be one consistent definition that accurately encompasses what the "Knowledge Economy" actually is over time.

Brinkley (2006;3) attempted to establish a framework to be able to quantify and measure the "Knowledge Economy" to be able to test against data. Brinkley (2006;29-30) concluded that no single definition could be used to quantify every part of the "Knowledge Economy". International comparability and data sources lend more difficulty in having one comprehensive definition. Finding the link to innovation is difficult (Brinkley,2006;29-30) and when economies as a whole are examined, using limiting definitions; such as the OECD definition that included high-to-medium tech industries, finance, telecommunications, business services, education, and healthcare exclude sectors that are high-intensity ICT users such as energy supply, cultural and creative industries, and especially retail and logistics.

In 2009, Lundvall (2009) re-published a paper called "Why the new economy is a learning economy" in a special volume to honour the work of Carlota Perez. This paper originally was published as a working paper in the Danish Research Unit for Industrial Dynamics (DRUID) in 2004. Lundvall (2009;226) argues that the "Knowledge Economy" as Drucker coined it (Drucker,1969;263) is actually a "Learning Economy" because the new technology has to be learned, used, understood, and finally exploited for innovation. Lundvall (2009;226) found that Danish firms that did not combine the new technology with investments in employee training, change management, or training for management, and perhaps a change in the work organization, had negative effects on productivity that could last several years.

Arundel, Lorenz, Lundvall, and Valeyre (2007) examined the differences in the organization of work and innovation within the EU-15. Using European Working Conditions Survey data, they attributed the four different types of work forms; Discretionary Learning, Lean Production, Taylorism, and Simple/Traditional and their respective frequency in each of the countries. They found that the type of learning, at a national level, can be correlated with the type of innovations that the country will be able to produce. For example, countries that have high discretionary learning and lean production work forms tend to have high strategic and intermittent innovation modes where innovations are created "in-house" and are new-to-the-market innovations (Arundel et al.,2007;20-24). Those countries that have high levels of discretionary learning also have a negative correlation to the number of "non-innovators" in that country. Countries that have a high level of lean production present tend to be negatively correlated to “in-house” created innovations. Arundel et al. (2007;24) posit that EU countries have adopted lean production as a more efficient alternative to Taylorist forms, but have not used the J-Form model in the same way as the Japanese who generally tend to develop process or incremental innovations. Arundel et al. (2007;25) also note that in countries where there is a high level of employer-supported training, the levels of discretionary learning tend to be higher, and also the levels of “endogenous innovation” (Arundel et al.,2007;29).

Lorenz (2015) compared different EU countries in relation to work organization, how employees tend to learn at work, and the different labour market structures. Using 2010 EWCS data and 2005 EWCS forms of work organization results to correlate the frequencies of the four forms of work organization and the relation to innovation. Lorenz (2015;10-12) found that where there was a higher level of Discretionary Learning, the rate of innovation tends to be higher. Where Taylorist and Simple forms are the larger percentages of the forms of work, the frequency of innovation is lower. Lean Production as the most frequent type of work form, innovation is relatively weak, but still positive. Lorenz’s (2015;13-14) single-level regression analysis, somewhat contradictory, showed that Lean Production had the highest odds of being affected by process innovations, followed closely by Discretionary Learning, and then Taylorist, while using the Simple form of work as the reference. To explain the contradiction he found, Lorenz (2015;14-17) posits that, to paraphrase, generally Discretionary Learning types are more involved in the novel or experimental thinking to create an innovation, and those in Lean Production are likely to be highly constrained and learning is more about efficiency of existing processes and technologies. To this author, that tends to make sense as Lean Production workers tends to be working in a high-performance work system [HPWS], but as Arundel, Lorenz, Lundvall, and Valeyre (2007;23) note that European firms may have adopted the Lean methodology as a better version of Taylorism, but did not adopt the delegation of decision-making to the actual workers on the shop floor, thus in Lorenz’s 2015 findings, the Lean workers are not involved as much in creating the solutions or innovations, they are just involved in the changed environment that usually is treated as intellectual property or proprietary competitive knowledge and therefore not shared with other firms. Also, countries where the Discretionary Learning form of work is high, the correlation of having development/innovation partners outside the firm is higher. One may then look at this as a potential “Community of Practice” (Brown and Duguid,1991) where Discretionary Learning types are in a situation where shared information creates a knowledge form that crosses the boundaries of firms as co-operation or knowledge workers taking tacit/explicit knowledge with them to competitors or other co-operating firms.

Houghton and Sheenan (2000) wrote a high-level description of what the “Knowledge Economy” was and what should be done to meet the changing economic landscape. They state that the information revolution created the move towards codified knowledge, and from that, the share of that knowledge within individual economies globally, combined with the ability to transmit knowledge anywhere at low cost, effectively commoditizing knowledge (Houghton and Sheenan,2000;10). Organizations also changed from Taylorist to “Post-Taylorist” flexible organizations that combine “thinking and doing” such that workers are multi-tasked, use teamwork, and experience job rotation, thereby reducing middle management requirements for the firm. By doing this, firms can leverage economy of scale from the Taylorist side of things to then realize economies of scope (Houghton and Sheenan,2000;10). Because of the change in knowledge requirements, specialized tacit human skills such as conceptual and interpersonal management skills will be required, and enhanced by the use of ICT (Houghton and Sheenan,2000;11). Houghton and Sheenan (2000;13) also note that ICT and ease of communication do not make the physical clustering of “Centres of Excellence” to share understanding required, and promote DeVol’s (DeVol,1999;9) assertion that companies are essentially “renting” the individual knowledge of workers to be able to successfully carry out their business, which, like the connection Arundel, Lorenz, Lundvall, and Valeyre (2007:20-24) make in the paragraph above to Brown & Duguid’s (1991) “Community of Practice” theory.

2.4 Forms of Work Organization based upon learning profiles

Different firms will be organized in different fashions. The organizational forms listed below more-or-less align to the four types of organizational forms quantified in the 2009 Valeyre et al. *Working Conditions in the European Union: Work Organization* study that forms the foundation of the Review of EU Work Forms Research later in this paper, and although this section is rather lengthy, it is intended to draw the line that connects the different streams of organizational understanding to align with Greenan et al’s (2017) Programme for the International Assessment of Adult Competencies (PIAAC) learning results which are used in the Principal Components Analysis (PCA) in Chapter 5 and the hierarchical Cluster Analysis in Chapter 6.

The “J-Form” structure, which correlates to the Constrained Learning or Lean Production form of work organization is highly effective in making incremental improvements in existing products or processes, or even management structures. Lam (2004:18-19) indicated the structure does well in established technological or mature settings where incremental innovation is important. Newer technologies or where extreme dynamic innovations dominate the market sector, the incremental approach does not fare as well. Examples of dynamic fit of the J-form of structure are electronics and automobile manufacturing where there is a set and relatively stable market dynamic and the emphasis tends to be focused on incremental improvements related to cost leadership or changes in the Five Forces of the market (Porter, 2008;27). Industries where the J-Form does not fit as well are where corporate agility and dynamic decision-making are required to foster radical innovation or rapid change (Lam,2004; 11).

Professional Bureaucracies (Mintzberg,1980;333-335) can be paraphrased as organizations where specialized explicit knowledge is the basis of the firm’s service offerings such as engineering practices or accounting firms. Actors in this type of organization have a high level of autonomy, but are regulated by specific rules on professional conduct and are legally liable for the outputs of their efforts. The individual experts generally work within a specific subject matter domain and co-ordination between them cause challenges to innovation. In addition, Moore and Dainty (2001;559-562) found that “cultural non-interoperability” of professional bureaucracies created barriers to success, and by extrapolation, it can be posited to barriers to potential innovation, when dealing with separate discipline-specific firms a having to co-operate in a supposedly innovative delivery methodology. This form of organization can somewhat align with the Discretionary Learning as the outputs are usually unique or tailored to the client’s needs.

Machine Bureaucracies (Mintzberg,1980;332-336) have a high level of central control and limited employee autonomy as in mass-production firms. Machine bureaucracies are characterized as being designed for stable conditions with efficiency as the prime concern but are not well suited for addressing change. A parallel can be drawn between the Taylorist form of organization and machine bureaucracies for the centralization of control and setting the capacity of production.

Adhocracies (Mintzberg,1980;336–338) are organizations which are generally project-based structures assembled to perform a specific deliverable, and generally under conditions of uncertainty. The teams can be composed of members from differing business units within a firm or from many different firms. The membership of the team can also include many different disciplines or backgrounds, depending upon the nature of the problem to solve. Paraphrasing Lam (2004:19-20); Adhocracies are difficult to sustain in the long term as the flexibility required to solve immediate needs may lead to unclear or conflicting management decision making or the lack of unified strategic direction for project selection. Silicon Valley is an example of adhocracies in action, specifically within a local labour market, or community of practice. In Silicon Valley, due to the large specialized knowledge pool, immediate resourcing can be achieved through the high level of expertise available to fulfill a firm's requirements (Lam,2004:20-21). A negative aspect of an Adhocracy is that the team member's knowledge is generally tacit and may leave the organization when they do. In addition, Lam also notes that any explicit knowledge can become diffused through the industry due to the potentially temporary nature of employment or team membership. As with professional bureaucracies, this organization type tends to align with Discretionary Learning.

Simple structure (Mintzberg,1980;331-332) is generally where the control or leadership resides in either one or only a few people. The simple structure can be highly agile and quickly respond to any changes or opportunities in the market. Usually entrepreneurial in nature, the simple structure may also depend upon the quality of leadership decisions for success.

2.5 Designing an Integrated Organizational Learning Model

The challenge, as noted by Nonaka et al. and Lam, is focused on how specific individual's knowledge then becomes part of the enterprise knowledge and is then implemented across the firm to provide the maximum benefit, thus, strategic competitive advantage to the firm.

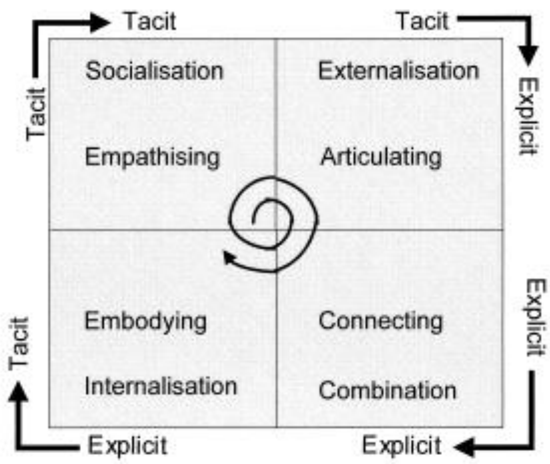


Figure 2.5.1 Nonaka's Learning Model
Source: Nonaka et al. (2000b:10)

Nonaka et al.'s (2000a:12) SECI learning framework and "middle-up-down" management (1994:29) and examination of the "J-Form" organization accentuates the transfer of tacit knowledge sharing and the inclusion of employees in the innovation process by allowing cross-disciplinary responsibilities or job rotation that allow the employee to learn more about the overall process used by the company or division, and then through socialization, externalization, and combination create organizational knowledge, and then externalize the knowledge to the firm's culture to formalize and implement the change into the processes or structure of the firm, making such knowledge explicit. Nonaka et al.'s (Nonaka et al.,2000b; 10) model is shown in the Figure 2.5.1 and also includes descriptors of knowledge transfer or learning in each quadrant.

In the organizational learning literature, there is the Community/ies of Practice school of thought that considers how groups or classes of workers perform their job and interact with others doing the same job or where they cross boundaries with those who have different responsibilities or expertise, and how the group(s) then learn and innovate within their milieu. Brown and Duguid (1991) expended upon Lave and Wenger's seminal 1991 paper "Situational Learning: Legitimate Peripheral Learning" to examine the differences between formal training/learning; what they called "canonical practice", and the on the job training [OJT] by experiential learning; "non-canonical practice". They also the set forth their perceived requirements and precursors for innovation within a community of practice and the corporate environment that the community has to perform within. Brown and Duguid (1991:41–47) outlined that formal guidelines, requirements, and procedures to carry out a job have to a balance with the experience of not only learning from those who are already doing the particular job, but actors also have to be able to communicate and learn through observation of the task being completed, of listening to other's experiences and stories of past situations; what they called "war stories", and also have a collaborative aspect of the completion of the work tasks. Brown and Duguid (1991:50–51) also addressed the pitfalls within a corporate structure that could curtail the effective dissemination of information gleaned from community member's experiences due to the perception that information sharing that is *ultra vires* to their specific duties is counterproductive. Within the next portions of this paper, the models and frameworks are all shown to require, at some level, a community of practice viewpoint within the sharing of both tacit and explicit knowledge.

Nonaka et al.'s later work focuses on the work environment, or "Ba" (Nonaka et al.,2000a;5–37). The notion of "Ba" is similar to the "Communities of Practice" put forth by Brown and Duguid, (1991;47), and Ba is less concerned with stopping at the learning of specific embedded tacit industry knowledge, Ba is considered the environment that can be the shared context for knowledge creation within a firm. The space does not have to be physical, but shared experiences, communications, and interactions have to able to be shared amongst the community. Ba is an evolving loose physical, mental, or virtual boundary that allows the socialization and externalization of knowledge within the firm milieu, which can lead to innovations by cross-pollination between actors or even groups within the space. Building upon the earlier work, Nonaka et al (2000a:14) the show the cyclical nature of knowledge creation, sharing, and learning that then continue the continuous improvement model where organizational learning not only continues, but flourishes through an atmosphere of corporate sustainability in the face of competition, and is shown in Figure 2.5.2. Attributed to the Lean Production or J-Form organization, Nonaka's model supports the incremental improvement that stable industries require for survival in their markets.

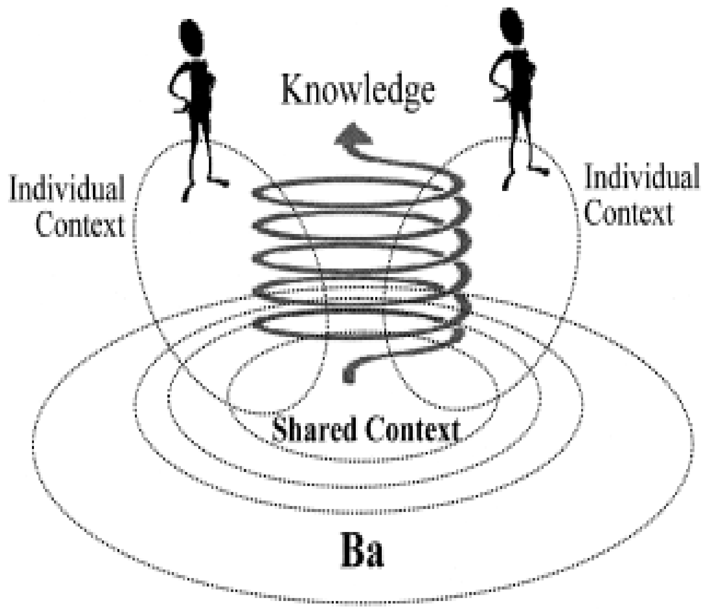


Figure 2.5.2 "Ba as Shared Context in Motion"
Source: Nonaka et al, (2000a:14)

Lam's (2000:506) model for organizational learning uses what she calls "Four Contrasting 'Societal' Models of Knowledge and Learning: The Role of Tacit Knowledge and Innovation". Using four base knowledge types, Lam builds a three-level model aligning the knowledge, learning, and organizational types best reflecting the type of knowledge and learning. The base types of knowledge are:

- Embrained: this knowledge is individual and explicit. Formal, abstract or theoretical knowledge is included in this category. The information is rational, contains universal principals or laws of nature, and is generally attributed to high occupational status as seen with professionals such as physicians, lawyers, and engineers (Lam,2000;492).
- Embodied: Individual and tacit, this knowledge is built by "doing" and is characterized by practical experience. (Lam,2000;492).
- Embedded: this knowledge is collective and tacit and resides in shared norms and organizational routines (Lam,2000;493) and is closely associated with Communities of Practice (Brown and Duguid,1991;53-55).
- Encoded; this knowledge is collective and explicit knowledge, this is information that can be transferred through signs, symbols, and formal learning or formal documentation as is the case with technical or procedural manuals, etc. Lam (2000;492-493) points out that encoded knowledge has the inherent drawbacks of being selective and fails to capture and preserve the tacit skills and judgement of individuals.

Lam (2000;494) then examines the organizational level of knowledge "control" based upon Mintzberg's (1980) organizational forms and on her classification [e.g. occupational community and organizational community models]. The professional bureaucracy has a high level of knowledge standardization and individual control and autonomy. High standardization of knowledge with organizational control is attributed to the machine bureaucracy typology. Operating Adhocracies have a low standardization of knowledge and work with individual control. Organizational control with low knowledge standardization is coined as the J-Form organization.

Structures of labour markets as they relate to the individual and the type of work they are suitable to perform; either through formal qualifications or work-related experience, are defined by Lam (2000;500-501) as "occupational labour markets (OLM)" or "internal labour markets (ILM)". The occupational labour market has a high level of job mobility available to those within the market. Formal education and related training are focused on the specific requirements for the industry/firm, or as Lam points out, can be "meta-competencies" encompassing a broad range of knowledge and training that reflect the requirements for the job. This allows inter-firm mobility, similar to Lam's commentary on Silicon Valley (Lam,2004;21) and the fluid labour market of highly trained individuals that exhibit high levels of job mobility. The internal labour market (Lam,2000;504) "are characterized by long-term stable employment with a single employer and career progression through a series of interconnected jobs within a hierarchy". Here, formal education allows the worker to qualify for a certain job, but then the actual work-related skills are on-the-job and tailored to meet the specific requirements of the firm. Lam (2000;504) points out two different progression streams; one broad-based where the employee learns a wide array of knowledge to understand the entire enterprise as is the case that Lam states in the J-Form organization. A narrower stream is where hierarchical control and tier boundaries: "siloed" or functional structure, may produce copious knowledge on a specific subject, but the overall knowledge and innovation are incremental. Whichever stream is present in ILM organizations, Lam (2000;504) notes the training is very specific and organization-oriented. Lam (2000;500) notes the following correlation between the degree of formalization and academic biases of education levels and mobility in labour markets: high formal education in the OLM is attributed to the professional model, lower education and training in the OLM is noted as the occupational community model, where high education and training is in the ILM its connected to the bureaucratic model, and low education in the ILM is the organizational community (see Figure 2.5.3).

Lam (2000;507–508) posits that the J-Form and Operating Adhocracy are the two most innovative organizational structures. Where the learning is cumulative in the J-Form organization, the organization tends to favour close integration of the overall organizational community through collective knowledge and procedures to create firm-specific proprietary knowledge, thus connecting back to Porter's (1996;3) theories of "Unique Value Proposition" and "Tailored Value Chain" by creating knowledge that market competitors do not have or creating cost leadership through innovation. J-Forms tend to be very good at incremental innovation, but not as well adapted to radical innovation or change. For radical change, the Operating Adhocracy more suited as it is constituted of a collection of actors within the specific occupational community, where sometimes individuals are added or deleted as the skill-sets are required or not required, and where individual expertise is the foundational element of the enterprise. The potential negative characteristic of the operating adhocracy is that in an occupational community environment, knowledge tends to be held by the individual and therefore not directly "possessed" by the firm, making competitive advantage through proprietary knowledge difficult to control unless legally protected through patents or other instruments. Figure 2.5.3 shows the three interlocking levels of Lam's thoughts on tacit knowledge, organizational learning, and societal institutions.

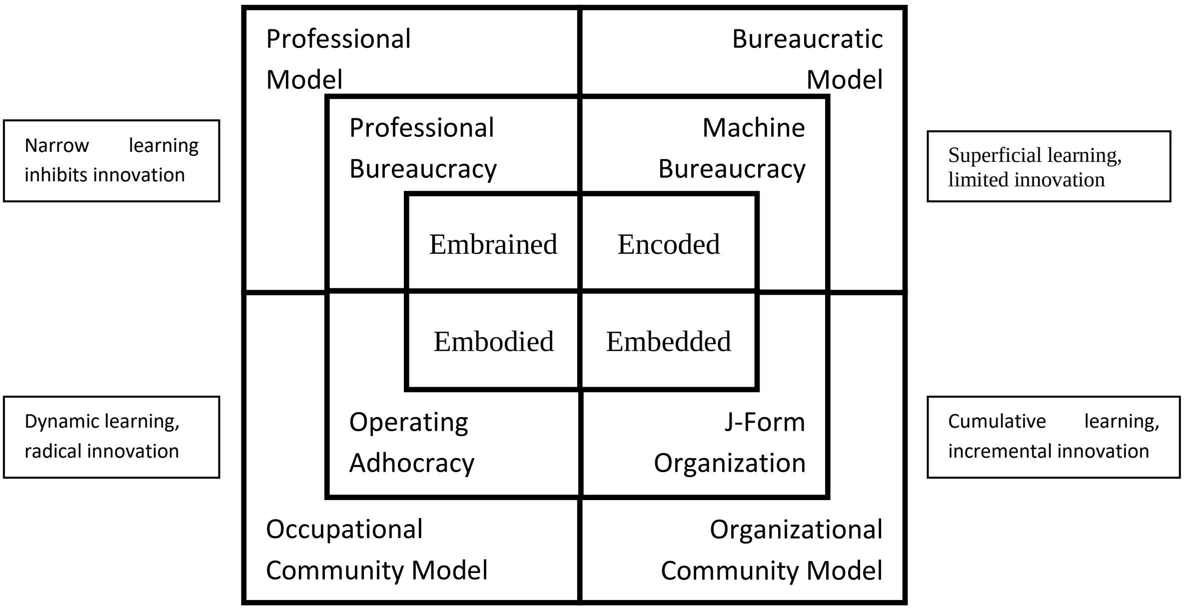


Figure 2.5.3 – Knowledge Organization and Institutions: Three Interlocking Levels
Source: Lam (2000;506)

Curado (2006;13) takes a more management-oriented view of organizational learning and how it fits into the business realm. Curado's view is that knowledge should be treated as a resource that the firm controls, and if not outright, owns. That view is further expanded to the position that the firm has to make a conscious decision regarding the knowledge and organizational learning that they want to create/facilitate/retain to enhance their strategic position and competitive advantage. The view of this framework is that there are two different paths to knowledge acquisition: external and internal. This concept married well with the research that outlines incremental internal innovation as in "J-Form" organizations and potentially in machine bureaucracies. The other is external acquisition, but there is a difference between the methods to externally acquire knowledge. One approach is to purchase it in the form of a takeover or merger of a smaller firm or direct market competitor. The other approach is aligned with the adhocratic approach where those people with the knowledge desired are hired to fulfill certain duties, and therefore can transfer some or much of their knowledge to other team members, and ultimately the organization.

Knowledge acquisition can also be seen as "Exploration", and the use of the knowledge to execute the work tasks is referred to as "Exploitation" (March,1991;71). New knowledge is created in various ways: research and development, and trial and error. Crossan and Berdrow (2003;1091) examined a "Feed-forward" and "Feed-back" loop for organizational learning.

- Feed-forward is the exploration per March's theory of learning where the information flows from the individual to the organization to then review and incorporate into the

- routines and policies and procedures of the organization. This correlates to Nonaka et al.'s "externalizing" and "combining" phases of learning. (Nonaka,1994;18-20).
- Feed-back is the exploitation of knowledge flowing from the organization to the individual to then apply to the tasks that are required of them to complete. This correlates with Nonaka et al.'s "internalization" and "socialization" phases of learning (Nonaka,1994;19).

The Nonaka, Lam, Curado, and March models are integrated in Figure 2.5.4 to show the general literature view of organizational learning and knowledge creation and management. The models do not precisely fit together; but no matter the model, the cyclical nature of the organizational learning framework is ubiquitous in the literature. How the process is explained depends upon the lens or frame of perception and reality that the researcher uses to define their framework structure.

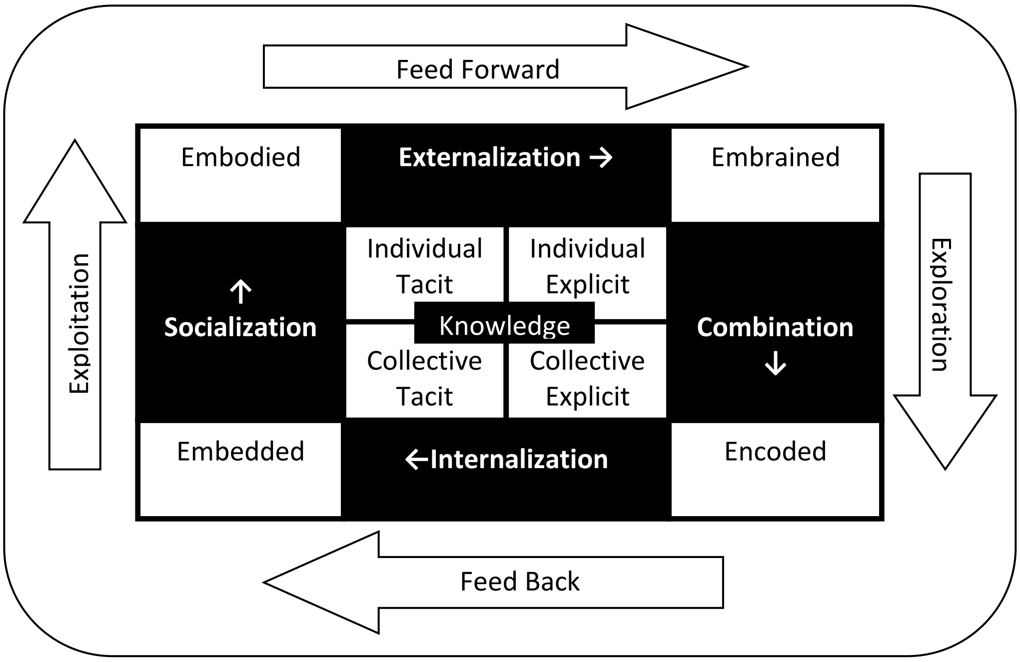


Figure 2.5.4, Integrated Organizational Learning Model
Source: Makó and Mitchell (2013a;15)

Makó and Mitchell (2013a;15) created an integrated model of organizational learning using the previous research of various authors in this literature review. The different frameworks reviewed in this paper are shown in the integrated model in Figure 2.5.4, there is a convergence with the work of Nonika et al., Lam, and Curado that takes the base approach of tacit and explicit learning and then shows the process by which it is transformed from one to the other and back within a cyclical framework of organizational learning.

In their 2006 work, Krings et al. (2006;94-95) commented upon the different ways that employees may use their tacit or explicit knowledge when engaged in labour relations or intra-team communication. Bargaining positions of different types of employees will be determined by what type of knowledge they are in possession of. Where employees, or as this author posits even contracted persons, who have a majority of tacit or non-codified knowledge which is not easily transferable [but in this case considered to be very valuable to the firm] may choose to negotiate as an individual. The premise of this argument is that these types of employees [or even contracted experts] would not benefit from affiliation or membership in a collective bargaining unit or a trade union. As well, those working in a team, especially a virtual team with remote workers or where non-codified or formalized knowledge or a high level of interaction with the Client may require a formal information sharing system to ensure the knowledge is diffused to those who need to use it in the delivery of services.

Organizational structures alone cannot induce organizational learning, no matter how well designed they may be for the market sector and the available labour force. Teece (1998;60) suggests that both internal formal (governance) as well as the external networks the firm has influence the rate and direction of innovation. The later connects with Porter's Five Forces (2008;27) where the relative power of each actor in the supply chain can affect the market performance and profitability of the firm, and that view can be attributed to internal value chains as well as external ones. Teece (1998;64) also identified two types of innovation: "autonomous" and "systematic". Autonomous innovation is described as innovation that can be introduced into the market without significant changes to existing firm processes or the associated products. This type of innovation can be aligned with the incremental systematic innovation found in the J-Form or Lean Production where cross-pollination and inputs from "the shop floor" are incorporated to affect positive changes. The "systemic" changes are major innovations that cause major redesign of existing internal processes and changes to various supplier or delivery processes.

The author posits that a synthesis of the literature review above reveals a number of issues that affect organizational innovation:

- Given the proper conditions, knowledge builds upon itself to create a more refined or elucidated knowledge that can contribute to competitive market advantage for a firm;
- Employees cannot be forced to be motivated, they have to be rewarded appropriately to satisfy their intrinsic or extrinsic motivations to then allow knowledge transfer, and thusly individual and organizational learning to occur;
- Through job satisfaction, creativity can be nurtured;
- Organizational design will dictate whether innovation is easy or difficult.

2.6 Interplay between Forms of Work Organization, Training and Innovation.

One of the areas of novelty in this research is the addition of Forms of Work Organization into comparisons of a country's level of innovation, and until recently, data on the United States and Canada was not available. Because "Forms of Work Organization" is one of the most important aspects of this research paper, this section is a fairly extensive review of the evolution of these organizational characteristics in various research from approximately 2005 to today to understand as much as possible how the five Forms of Work Organization have been arrived at over time.

2.6.1 Work Forms in the EU and North American Context: A Comparative Examination

The European Union conducts research into the differing forms of work organization within member states to understand the framework of the individual economies, and ultimately address member states' economic policies to promote economic expansion by elucidating the differences in work organization and distribution of the organization types across the EU. The two major reports that statistics and findings in this section are the "Work Conditions in the European Union: Work Organization" published by the European Foundation for the Improvement of Living and Working Conditions in 2009, and "Changes in Work in Transformation Economies" published under the auspices of Sixth Framework Programme of the European Union, also in 2009. Additional information has been obtained from the World Bank's Knowledge Indexes program and various Eurostat research papers.

The focus of this section of the paper is the different areas of the EU-28 as although there is a political union of sorts, the constituent parts of the whole are not homogenous. As the baseline of the comparison of work forms within the EU-28, Sapir's (2005;5-7) approach to groupings is used. Sapir (2005;7) quantifies four differing social policy models which are, in part, described in the Table 2.6.1.1:

The Four European Social Policy Models – Protection Against Labour Market Risks for Citizens		
Country Groupings	Employment Protection Regulations (EPR)	Unemployment Benefits
Anglo-Saxon (United Kingdom and Ireland)	Low	High
Continental (Germany, Belgium, France, Austria, and Luxembourg)	Medium	High (Generous)
Mediterranean (Greece, Italy, Spain, and Portugal)	High	Low
Nordic (Sweden, Denmark, Finland, plus the Netherlands)	Low	High (Generous)

Table 2.6.1.1, Sapir's Social Policy Models,
Source: Sapir (2005;7)

In addition to the Labour Market Risks for Citizens, Sapir examined the poverty rates versus employment rates, and an over-arching equity versus efficiency analysis that reinforced the groupings as related to their social policy approaches. Missing from Sapir's typology are the Post-Socialist Countries (Estonia, Latvia, Lithuania, Poland, Hungary, Czech Republic, Slovakia, Slovenia, Bulgaria, and Romania), and as such, are included as one separate grouping, although it can be argued within the grouping there are considerable economic, social, and structural differences, just as within Europe as a whole, but for the purposes of this paper, the groupings follow Sapir's work with Post-Socialist countries as a separate group.

In the introduction section of this paper, it was noted that the Resource-Based View (RBV) contends that a company's success depends upon its' possession and development of unique resources. Porter's What is Strategy (Porter,1996;3,17) examines the "Unique Value Proposition", "Tailored Value Chain", and "Continuity of Time" and all have direct connections to the continuous process of organizational learning in ensuring the survival of the firm.

Previous research by the author utilized information from the Working Conditions in the European Union: Work Organization (Valerye et al.,2009;12–14). The following section has been included because the Greenan et al. (2017) work did not have a breakdown of the occupation types for each form of work organization that the Valerye et al. (2009) research had, and in this author's opinion, a more fulsome understanding of the differences and "who" inhabits the various forms of work organization is important to having an understanding of the implications of the analyses in Chapters 5 and 6. The European research appears to have somewhat moved away from the four structures of work organization that Valerye et al. elucidated:

- Discretionary Learning: Characterized by high levels of autonomy in the work flow, learning, task complexity, and problem solving. It also has low occurrences of monotony, work-pace constraints, and repetitiveness. According to Valerye et al. (2009;12), this tends to be most present in "the work environment of senior managers, professionals, technicians, and services and sales workers". This work form can be aligned with Mintzberg's Adhocratic structure (Mintzberg,1980;336–338) where individuals have a high degree of professional freedom to choose the means and methods that will satisfy the requirements of specific tasks or outputs.
- Lean production: Attributes of Lean Production include job rotation, teamwork; autonomous and otherwise, multi-skilling and a high level of quality management orientation, demand-driven work-pace constraints, and employee learning and problem-solving. As Koplyay et al. (2015;40) used the Japanese tsunami of 2011 to point out that should the "lean-ness" of the supply chain become a fact, the impact it can have is enormous if adequate supply reserves are not available. This work form can be aligned with Nonaka et al's (2000a;12) "J-Form" organizational structure. Valerye at al.'s (2009;13) Work Forms study identified that only in the Skilled Worker category does this work form have a majority position from their study of European workers.
- Taylorist forms: Characterized by high task repetitiveness, a high level of work-pace constraints, low levels of autonomy in work, working methods, task complexity, low learning opportunities, and minimal assistance from the corporate structure or co-workers. This work form aligns closely to Mintzberg's Machine Bureaucracy (1980;332-336).
- Simple or Traditional: Generally non-codified or largely informal in how work is performed. Mintzberg (1980;331-332) also calls this a "simple organizational structure" where supervision is generally by one person or manager, but is highly adaptable, and teamwork indicators and task rotation indicators score highly in the description according to Valerye at al. (2009;14). Mintzberg (1980;331-332) notes that a classic example of this work form is a small entrepreneurial company.

The four organizational work forms in Valeyre et al.'s Work Organization research paper spans the broad scope of the employment spectrum. Employment positions are generally broken down to the level of education and the type of work that is completed by the individuals in the different classes (Valyere et al., 2009;19). The Work Organization study examined the various types of occupations and then correlated them to the four types of work organization, noted in the table in Figure 2.6.1.2.

Work Organization Classes				
Employment Description	**Discretionary Learning**	**Lean Production**	**Taylorist**	**Traditional or Simple**
Senior Managers	52.0	37.0	5.6	5.4
Professionals	59.7	26.8	5.2	8.4
Technicians	56.7	23.7	9.6	10.0
Clerical Workers	43.8	20.0	14.2	22.1
Service and Sales Workers	38.9	17.0	12.2	31.9
Skilled Workers	28.9	34.6	28.6	8.0
Machine Operators	15.3	24.8	40.5	19.4
Unskilled Workers	24.4	21.5	27.0	27.0
Average	**38.4**	**25.7**	**19.5**	**16.4**

Table 2.6.1.2 – Work Organization Classes
Source: Valerye et al. (2009;19)

Using the descriptions of the four types or models of work organization and the Figure 2.6.1.2 above, it is shown that senior managers, professionals, and technicians; those with relative higher levels of education; are generally working within organizations that exhibit traits of individual control of their work environments and conditions in Discretionary Learning organizational forms. As the educational level of the worker decreases, the ability for the individual to have control over the work processes decreases as exhibited in the increasing percentages of Lean and Taylorist organizational forms noted for Skilled Workers and for machine operators. Service workers tend to be concentrated at opposite ends of the scale with discretionary learning and simple management forms. Unskilled workers are almost evenly split amongst the four work classifications.

Distribution of Work Organization Classes				
Country/Description	**Work Organization Classes (%)**			
	Discretionary Learning	**Lean Production**	**Taylorist**	**Traditional or Simple.**
EU 27 (total)	**36.9**	**27.4**	**19.2**	**16.5**
Scandinavian	54.8	24.3	9.9	11.1
Continental	45.1	24.1	16.9	14.0
Anglo-Saxon	35.4	30.8	14.5	19.4
Mediterranean	29.7	28.2	23.4	18.7
Post-Socialist	30.4	29.0	22.6	18.0

Table 2.6.1.3 – Distribution of Forms of Work Organization
Source: Valerye et al. (2007;22)

Shown in the Table 2.6.1.3 above, as a grouping, the Scandinavian countries show the widest variation from the EU-28 average for work form distribution amongst the four categories. Scandinavia has more than half of their firms using a discretionary work form approach (54.8) and has the lowest (9.9%) level of Taylorist work forms in the EU. The Scandinavian

Discretionary Learning results is also the highest of any work form in any of the country groupings as no other work form dominated the others with more than 50% occurrence. The Continental countries have higher than EU average and the second-highest level of Discretionary Learning (45.1%), and lower than EU average results in the Lean Production, Taylorist, and Simple work forms. The Anglo-Saxon countries have higher than EU average Simple (19.4) and Lean Production (30.8) work forms, with the Discretionary Learning result within 1.5% of the EU average. Both the Mediterranean and Post-Socialist country groupings share the same characteristics for work forms and very similar results; the Discretionary Learning and Lean Production are below the EU average, while the Taylorist and Simple work forms are above the EU average; in fact, the results are all within 1% for each work form symbolizing, in some ways, that these economies could be considered very similar in many ways. The Post-Socialist countries had slightly more Discretionary Learning and Lean Production compared to the Mediterranean Countries, and less Taylorist and Simple work forms.

Makó et al.'s 2009a work, "Changes in Work in Transformation Economies", examined the European Union's new member states in relation to the forms of work organization. Using a logit regression (Makó et al.,2009a,;35-36) with the data from the four types of organizational work forms in the Working Conditions in the European Union (Valeyre et al.,2007;22) were amended [at a country level, not a regional level] to re-classify the countries from geographic regions to the characteristics of each country's organizational forms of work. This resulted in the following groupings: Discretionary Learning: Sweden and Denmark

- Lean Production: United Kingdom, Ireland, Poland, Romania, Latvia, Estonia, Slovenia, Finland, Luxembourg, Portugal, and Malta.
- Combination of Lean Production and Traditional (Simple): Lithuania and the Czech Republic.
- Combination of Taylorist and Traditional (Simple): Greece, Cyprus, Spain, Bulgaria, and Slovakia.
- No clear patterns of forms of work organization: Austria, Belgium, France, Germany, Italy, and Hungary.

With this grouping, Makó et al. (2009a;36) also note that even with each grouping created through the logit analysis, there were differences amongst the internal group members.

2.6.2 Evolution of the Working Conditions in the European Union Reports

The Working Conditions in the European Union: Working Conditions (Eurofound (Valeyre et al., authors), 2009) document was produced as a report linked to the data from the Fourth European Working Conditions Survey (Eurofound,2005). The areas of investigation and sub-report subjects have changed over time with each new EWCS survey, and have somewhat moved away from the four learning types to other research goals. The Table 2.6.2.1 outlines the evolution of the EWCS from a work description perspective.

European Working Conditions Surveys Associated Research Reports		
2005 – Fourth EWCS	**2010 – Fifth EWCS**	**2015 – Sixth EWCS**
• Working conditions in the European Union: The gender perspective • Working conditions of an ageing workforce • Employment security and employability • **Working conditions in the European Union: Work Organization** • Technology and working conditions • Convergence and divergence in Europe • A sector perspective on working conditions • Working time and work intensity	• Overview Report • Trends in Job Quality • Work Organization and Employee Involvement • Women, Men and Working Conditions • Convergence and divergence of job quality in Europe 1995 – 2010 • National Working Conditions surveys in Europe: A compilation • Policy lessons from the fifth EWCS: The pursuit of more and better jobs • Occupational profiles in working conditions: Identification of groups with multiple disadvantages • Quality of employment conditions and employment relations • Working condition and job quality: Comparing sectors in Europe. • Working time and work-life balance in a life course perspective • Health and well-being	• Working conditions in a global perspective • Working conditions and workers' health • Striking a balance: Reconciling work and life in the EU • Does employment status matter for job quality? • Women in management: Underrepresented and overstretched? • Working conditions of workers of different ages • Exploring self-employment in the European Union • Working time patterns for sustainable work • Working anytime, anywhere: The effects on the world of work

Table 2.6.2.1 – European Working Conditions Survey – Subjects Evolution Over Time Eurofound, 2005, 2010, and 2015, Compilation of Documents

Many of the common themes have continued through the evolution of the EWCS, but over time they have somewhat altered in their approach and terminology. Specifically, in the 2010 EWCS the report "Work Organization and Employee Involvement" (Eurofound (Gallie and Zhou, principal authors), 2013) used four different types of organization: High Involvement, Consultative, Discretionary, and Low Involvement to quantify types of organizations. Using a keyword search in all the associated EWCS reports for 2005, 2010, and 2015, only the Gallie and Zhou report (Eurofound,2013) used similar terminology. A review of the literature, including the work of Lundvall, Arundel, Johnson, Lorenz, and Valeyre did not find references to both the United States and Canada in the same analysis, leaving a gap in establishing comparisons between the North American Countries and the European Union.

OECD Programme for the International Assessment of Adult Competencies (PIAAC)		
2011 - 2012	**2014 - 2015**	**2017**
Canada, United States, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, the Netherlands, Poland, Slovakia, Spain, Sweden, and the United Kingdom.	Greece, Lithuania, and Slovenia.	The United States and Hungary
A note about data availability; the third round of the first cycle of the PIAAC will not be available until November 2019 from the OECD.		

Table 2.6.2.2 – PIAAC First Round of Surveys Schedule for Participating Countries
Source: OECD (2019a), Skills and Work, Adult Training, Participation and Non-Participation in the Job-related Learning, as downloaded by the author on August 2, 2019 from http://www.oecd.org/employment/skills-and-work/adult-learning/

Some research has been completed including Canada and United States in the same relative typology for learning situations at work, and using the Programme for the International Assessment of Adult Competencies (PIAAC) that is sponsored by the Organization for Economic Cooperation and Development (OECD). The first two rounds of data collection were completed in 2011-2012 and the second in 2014-2015. Both of these rounds have had their data updated and published. The third round of the first cycle was completed in 2017, but the data for the third round has not yet been released. The Table 2.6.2.2 below shows the participation of the OECD countries in North America and the EU in the survey data collection.

With the EWCS questionnaire moving away from work forms questions, the focus for some researchers changed to the PIAAC for employee learning. Lorenz, Lundvall, Kraemer-Mbula, and Rasmussen (2016;158) used the PIAAC Round One to examine the work organization, forms of employee learning, and national systems of education and training. Lorenz et al. note that the taxonomy uses the methodology that Lorenz and Valeyre developed in 2005 for the EWCS where the data is analyzed using a factor and cluster method to group the responses to 7 of the variables to create three groups of learning: Discretionary, Constrained, and Simple (Lorenz et al.,2016;156). The Table 2.6.2.3 following is taken from that paper (Lorenz et al.,2016;158) to show the results for occupations by work organization.

In Table 2.6.2.3, only Discretionary Learning and Simple are relatively the same descriptions when compared to the Valeyre et al. (2009;19) table [this section, Table 2.6.1.2] with four forms of work organization taken from the EWCS (2005) survey methodology, the three forms taken from the PIAAC methodology (Lorenz et al.,2016;158) have slight differences in the occupational descriptions. The Discretionary Learning results show that the percentages for Professionals, Technicians, Clerical Workers, Service and Sales Workers, remain relatively similar. Senior Managers percentage of Discretionary Learning increases versus Managers in the 2009 paper, as does Machine Operators. Elementary Trades decrease in the 2016 table, and there is no direct comparison for Craft and Related Trades in the 2009 paper. By losing the Lean Production category of work forms, the three categories appear to be re-allocated amongst Constrained Learning and Simple in the 2016 table, with no close approximation except for Managers in the Simple category where there was only a +/-1.2% change for Managers versus Senior Managers.

Forms of work organization by occupational category				
Occupations	Discretionary Learning	Constrained Learning	Simple	Total
Managers	72.18	21.2	6.62	100.00
Professionals	60.71	26.5	12.79	100.00
Technicians	55.42	31.82	12.75	100.00
Clerical Support Workers	44.15	32.09	23.77	100.00
Skilled Agriculture, Forestry & Fishery Workers	32.82	34.69	32.48	100.00
Craft and Related Trades	38.55	16.37	45.08	100.00
Plant and Machinery Operators	35.44	33.77	30.79	100.00
Elementary Trades	23.84	33.01	43.15	100.00
All Sample	18.96	26.59	54.45	100.00
	42.3	30.6	27.1	100.00

Table 2.6.2.3 – Forms of Work Organization,
Source: Lorenz et al. (2016;158)

Using the PIAAC data from the first two rounds of the first cycle, Greenan et al. (2017, 11-15) separate the working environments into five categories, not the four used previously in the EWCS (Lorenz et al., 2009;19) and the three used by Lorenz et al. (2016;158). The main difference is that the Lean Production work form is not included, but "Taylorist" work form makes a return, and the "Independent" work form is added. The Discretionary Learning, Taylorist and Simple/Traditional remain. The five forms of work organization and a brief description from their paper are:

- Discretionary Learning: high degree of autonomy of when and how workers perform their duties. There is a high level of solving complex problems (more than once a week). Discretionary Learning workers are second-highest of the five work forms in teamwork performance after Taylorist workers. They persuade or influence people on a weekly basis, collaborate with co-workers at least weekly, and share work information daily with others. They have to read instruction or directions weekly and also almost all receive on-the-job training of some sort. Greenan et al. (2017;13) point out that this resembles Arundel et al.'s (2007) grouping of the same name and Lam's (2004;19-20) "Operating Adhocracy".
- Constrained Learning: While this group also experiences the organization of their own time, shares work-related information daily, on-the-job training (over half of respondents), and read directions or instructions weekly, they are not able to plan their own work activities frequently, solving complex problems, not persuading or influencing people weekly.
- Independent: Below average reading instructions or directions (at least once a month) and also low for on-the-job training. The category is above the mean in the remaining job tasks with planning own time and activities, solving complex problems, sharing work information, cooperating or collaborating with co-workers, and persuading or

influencing people at least once a month but less than once a week. Greenan et al. (2017;13) note that the difference between Discretionary Learning and Independent are the learning opportunities and formalization of work.

- Taylorist: This category has the lowest of all the characteristics except high levels of teamwork and sharing of work information. Approximately a quarter receive on-the-job training. Greenan et al. (2017;13) describe this category as “performing simple tasks in a more structured organization than in the Simple form”.
- Simple/Traditional: Of all the listed tasks, this category performs them the least often, but is separated from the Independent category as almost 15% or workers receive on-the-job training.

This data is assembled in a different manner than the EWCS data that allowed specific questions regarding work characteristics. Greenan et al. built upon the earlier work of Valeyer et al. (2005) and Arundel et al (2007). The data Greenan et al. (2017;11) was from the PIAAC, but more importantly for this paper, it also included Canada and the United States. Greenan et al. (2017;11) used a hierarchical cluster analysis directly to the survey variables, not the factor analysis that Valeyre et al. used in the original EWCS survey. The PIAAC data also was not as detailed as the EWCS data in the questions asked regarding the organization of work in the respondents’ firms, it only queried about the respondents’ work duties and tacks.

From a research viewpoint, as the focus of the EWCS has shifted from organization of work at a firm level to the individual conditions that workers experience, data on the types of work organization is not easy to find outside of the PIAAC. While the American Bureau of Labour Statistics are starting to gather this type of information, in the email from Mr. Nikolay Lavenyuk from the Bureau of Labour Statistics dated May 28, 2019, he advises that the results of the “Organizational Requirements Survey (ORS)” are only going to be gathered during the 2019 survey period, and does not give an anticipated publishing date [see Appendix A]. As well, Statistics Canada is also gathering this type of information, but not at the level that the EU does and more recently the United States is starting per the email from Statistics Canada’s Mr. Teshin Medhi in response to my question regarding data availability for Canada [see Appendix B]. With this information, the best available information to advance this research is the Greenan et al. (2017) results. The Greenan et al. (2017) research is the only available research the author has found that uses the same typology and descriptors for results and also includes Canada and the United States, and is more current than the 2005 data. Greenan et al. were very kind in allowing me access to their data tables and graphics [but not their dataset used in their paper] to be able to use in this research. The PIAAC third round results, first cycle, which includes Hungary, will not be available until November 2019 according to the email from Ms. Sabrina Leonarduzzi from the OECD PIAAC Directorate For Education and Skills [see appendix C].

Notwithstanding the differences in methodology, the results for the three similar organizational forms (Discretionary Learning, Simple, and Taylorist) do show some similarities. In the Table 2.6.2.4, the black shaded boxes are results that are within 5% of each other, while the grey-shaded boxes are results within 10% of each other. Understanding that there was a six-year time gap between the collection of the EWCS survey that took place between September and November of 2005 (Eurofound,2019a) and the first round of the first cycle of the PIAAC data collection that took place in 2011 and 2012, and a global financial crisis that was still being felt during the PIAAC, 33 of the possible PIAAC 60 matches (3 x 20 countries, not counting the United States and Canada as they were not in the 2005 EWCS) are within 5%, and an additional 12 are within 10% of the 2005 EWCS results.

Acknowledging the differences in methodology and composition of some of the regional groupings, the three comparable forms of work (Discretionary Learning, Taylorist, and Simple) in the Greenan et al. (2017) PIAAC data and the Valeyre et al. (2009) EWCS results show that at a higher level of analysis, the 66% of the results are within 5% of the other study. Discretionary Learning decreased slightly for the EU from almost 37% to almost 34%, and both Taylorist and Simple decreased overall.

	PIAAC First & Second Cycles					EWCS 2005			
	Discretionary learning	Constrained learning	Independent	Taylorism	Simple	Discretionary learning	Lean Production	Taylorist	Simple
United Kingdom	51.42	7.05	20.25	13.96	7.32	31.70	32.40	17.10	18.20
Finland	47.23	5.63	29.08	9.09	8.97	44.90	29.90	12.60	12.70
United States	47.20	12.32	17.33	15.56	7.58	Not included			
Denmark	46.29	4.96	32.74	9.21	6.80	55.20	27.10	8.50	9.20
Netherland	44.13	4.92	24.95	15.29	10.70	51.60	24.30	11.40	12.70
Canada	42.79	11.54	24.58	12.33	8.77	Not included			
Ireland	42.69	6.45	20.47	20.68	9.71	39.00	29.20	11.30	20.50
Belgium	38.58	5.74	28.33	13.82	13.52	43.30	24.60	16.30	15.80
Estonia	37.62	3.70	37.57	8.64	12.48	40.70	33.40	11.20	14.70
Czech Republic	37.46	3.92	31.99	14.80	11.83	28.00	26.70	22.50	22.90
Sweden	34.79	3.96	41.83	12.03	7.38	67.50	16.00	6.90	9.60
Poland	34.40	5.63	34.30	14.61	11.07	33.30	32.60	18.90	15.20
Germany	32.87	22.90	16.80	18.28	9.14	44.30	19.90	18.40	17.40
Austria	30.63	4.48	32.47	21.23	11.19	47.30	22.40	18.30	12.00
Slovenia	30.08	13.12	20.62	30.33	5.85	34.90	32.10	16.70	16.30
Spain	27.99	8.81	31.08	16.52	15.61	20.60	24.60	27.50	27.30
Cyprus	27.77	9.33	31.73	17.49	13.69	26.40	27.00	21.20	25.40
Slovakia	25.27	7.50	30.48	26.09	10.66	27.20	21.00	33.80	18.10
Lithuania	22.05	4.52	37.20	15.21	21.02	23.50	31.10	22.00	23.40
Greece	21.47	7.16	31.03	22.37	17.97	24.00	29.10	22.60	24.30
France	21.44	7.69	36.49	19.47	14.92	47.70	23.80	17.50	11.00
Italia	21.39	7.55	38.64	14.48	17.94	36.80	24.10	24.60	14.60

Notes:
Note 1: The most up to date results have been included; i.e.: if a country was included in both cycles, the results from the second cycle are included. If the country was included only in the first cycle, those results are included.
Note 2: Countries not included are Malta, Luxembourg, Hungary, Romania, Bulgaria, Portugal, Croatia, and Latvia. Hungary was included in the 2017 PIAAC survey, but to date the results have not been released by OECD.
Note 3: Black boxes indicate overall 5% or less difference between PIAAC and EWCS results for the same classification.
Note 4: Grey boxes indicate an overall 5% to 10% difference between PIAAC and EWCS results for the same classification.

Table 2.6.2.4 – Comparison of PIAAC and EWCS for Work Organization
Source: Author's own tabulations

There does not appear to be a consistent relationship between the results of the 2005 EWCS and the later PIAAC results. Overall, the results for Discretionary Learning and Taylorist are similar, with the Discretionary Learning decreasing by approximately 3% and the Taylorist decreasing by 2.5%. The Simple is less prevalent in the PIAAC results, although still within the 5% difference. Considering the different times and slightly different methodologies, the results can be considered somewhat aligned.

2.7 Changes in Forms of Work Organization and Learning along the Corporate Lifecycle

Sections 2.2 to 2.6 in this chapter have elucidated learning environments that people experience at their workplace, and as a result also how organizations learn. The PIAAC first wave results (OECD,2011-2017) are about how workers conduct their occupational responsibilities. This does not mean that how a worker conducts their job cannot change to respond to certain conditions, nor does it mean that the company the worker is employed by has the same exact roles and responsibilities for every employee that the individual survey respondent experiences. This also does not mean that over time, organizations cannot or do not change.

Holm and Lorenz (2015) investigated the change in work forms from 2000 to 2010 using European Working Conditions Survey results. What they found was that, over time, Discretionary Learning has decreased in the EU (Holm and Lorenz,2015;3). They also found that there is a connection between economic conditions and prevalence of the work forms used in firms where, during a down-turn, firms tend to shift to more hierarchical control which then decreases Discretionary Learning in favour of Lean Production (Constrained Learning) as firms are focused on short-term performance (Holm & Lorenz,2015;32-33). In addition, during an economic upturn, Taylorist decreases while the Simple form increases, and visa-versa (Holm & Lorenz,2015;33).

Decker et al. (2016;24-26) found that business dynamism in the United States has decreased since the year 2000. They state that high growth young firms [start-ups] played a critical role in the employment growth and productivity growth [job creation] in the 1980s and 1990s which created a skewness towards younger firms for growth rate percentage increases in the U.S. economy (Decker et al,2016;2). Through their comparison of firm growth rates separated into the differences between growth rates of the 90th percentile compared to 50th percentile (90-50) and the growth rates of the 50th percentile versus the 10th percentile (50-10) to have been approximately 16% in 2000 compared to 4% in 2007, with the 90-50 comparison being the measure that decreased markedly, not the 50-10 comparison catching up to the higher group (Decker et al.,2016;2). Decker et al. (2016;25-26) do not draw causality conclusions, but raise points that the reasons could include: capital being substituted for labour by many firms, that credit market constraints [presumably after the dot.com crash in the early 2000s] have made it more difficult to be able to finance growth, or the most interesting theory, that young firms want to “cash out” and be acquired by older, mature firms (2016;26). Whatever the case, this author posits that it appears from Decker et al.’s work that younger firms are contributing less to employment growth and that the average age of firms in the United States is increasing.

Koplyay and Mitchell (2014a) found that some companies do not reflect Galbraith’s (1967;581) assertion that the leader intentionally picks the structure of the organization at the founding of the venture. The form and function of a firm can evolve over time by the firm’s experience and managerial preferences and can vary from their competitors (Koplyay and Mitchell,2014a;882-883). In entrepreneurial start-up firms, the structure generally starts as a flat, light, and agile structure that one could describe either as an Independent or a Simple form of work organization with the founding Entrepreneur(s) leading to be able to respond to market shifts, product or service developments, or respond to the actions of competitors. As the company experiences growth, it will also experience an increase in complexity within the organization, such that the structure may move from a Simple structure to a more formalized structure, depending upon the company and the market sector it is competing in, to any of the other forms of work organization.

Should a firm enter the maturity stage of the lifecycle, how it conducts business will depend upon the market sector and the products or services being offered. The author has personally experienced mature architectural consulting firms that do not vary greatly over time in their management approach as they are generally Professional Bureaucracies (Mintzberg,1980;333–335) constrained by legislation and membership requirements, but also a growth-phase Adhocracy (Mintzberg,1980;336–338) in the knowledge-intensive business services (project management services) sector that aligns more with the Discretionary Learning form of work organization. For companies that produce actual goods, the mature phase generally entails moving into a "Red Ocean" market (Kim and Mauborgne,2005;72-73) where cost leadership is an important consideration in taking market share from competitors [spilling the competitor's blood in the "water" of the market], resulting in choosing either a Taylorist or Constrained Learning (J-Form) structure to best deliver business results (Koplyay and Mitchell,2014a;884). In examining Koplyay and Mitchell's (2014a;881-883) market analysis, this author posits that while the choice of the manufacturing approach can set the form of work organization for one or more manufacturing divisions or business units, the other units that may deliver Marketing, Research and Development, etc., may be a different form of work organization that matches the strategic imperatives for the company.

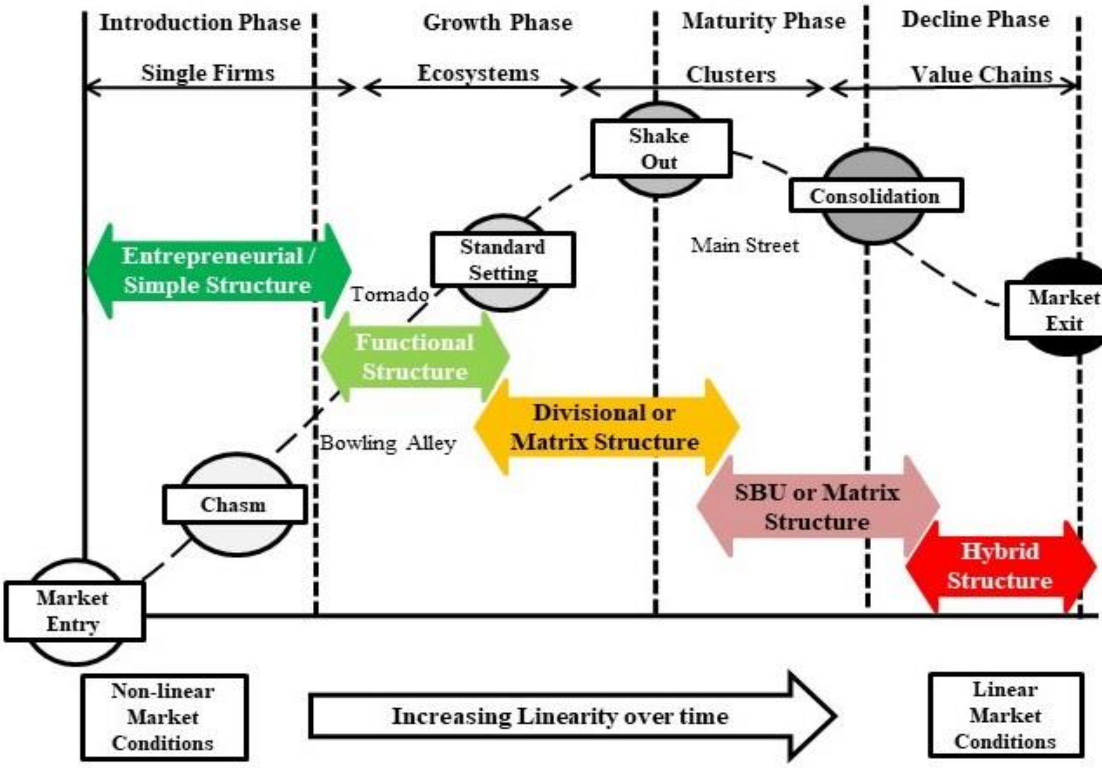


Figure 2.7.1, Structural Forms Along the Market Lifecycle
Source: Koplyay and Mitchell (2014a;884), as adapted from Rowe et al. (1999), Galbraith and Kazanjian (1986), and Moore (1991)

While the efficacy of an organization's learning and implementing that learning into action in some manner can be high, low, or somewhere in between, there can be times when what the organization has learned is of little value. Such occurrences could be a sudden economic downturn, entry of a new product or competitor into the organization's market sector, or regulations that change entirely how the sector has to conduct business [regulation versus deregulation as seen in the American logistics industry (Winston,1998;108)]. These sudden changes can create a situation where decisions have to be made in absence of information or learning that impact the future of the organization.

Koplyay and Mitchell (2014b;891-900) examined firm's structural forms in dynamic markets, specifically examining high-tech firms, but the author posits that the logic can be extended to any entrepreneurial start-up company in many ways. The Figure 2.7.2 indicates the various states as outlined by Moore (1991) in the high-tech market lifecycle that were adapted by Koplyay and Mitchell (2014b;892-893) to show the differences between Deterministic and Transient inputs at those times. There are steady-states that can be turbulent, but where actions occur that can generally be predicted, and there are transient states where the market can determine the outcome with the firm having little or no power to influence the result (Koplyay and Mitchell,2014b;892-893). In times of transient periods, stochastic inputs determine whether the firm will survive, fail, or have to adjust course to react to market changes, and previous learning may not inform the management as how to react.

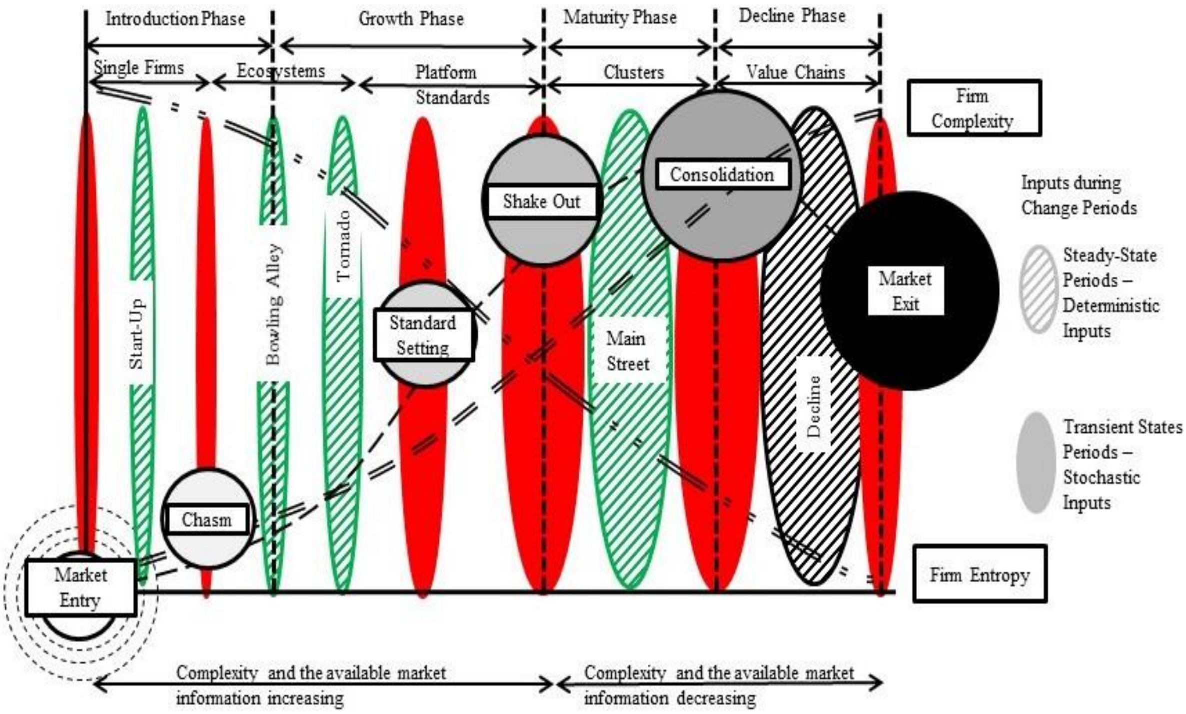


Figure 2.7.2, Steady and Transient Market States
Source: Koplyay and Mitchell (2014b;892), as adapted from Rowe et al (1999) and Moore (1991)

Figure 2.7.3 shows how Koplyay, Chillingworth, and Mitchell (2013) summarized the changing foci of management and how high-tech companies are managed through the corporate lifecycle. Early start-up companies are generally under Independent or Simple forms of work organization, but as the company grows and matures, the more formalized the management approach grows. If maturity is reached, the company tends to be largely Constrained Learning or even Taylorist in production or provision of services. These types of changes are supported in the literature. The small computer game design company that Hotho and Champion (2011;37-38) examined altered their approach from providing services to other companies to creating their own intellectual properties, the corporate culture changed from an open, collaborative approach to a more transactional style based on newly-formalized company values and business approach. Mayer-Ahuja and Wolf (2007;90-92) found that after the 2001 high-tech crash, the egalitarian working structures in many high-tech firms were replaced with more hierarchical management approaches and there was increased friction between managers and workers over such issues as the amount of time taken for lunch. Mitchell (2016;12-14) argues that small creative firms are able to keep the transformational management style needed to maintain innovation, but larger companies could use the lessons from the start-ups to maintain a "tight-loose" management approach, although the pressures of being a publicly-traded company having to meet quarterly revenue or profit forecasts and deal with stock prices may preclude this from certain firms.

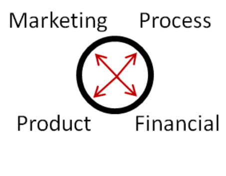
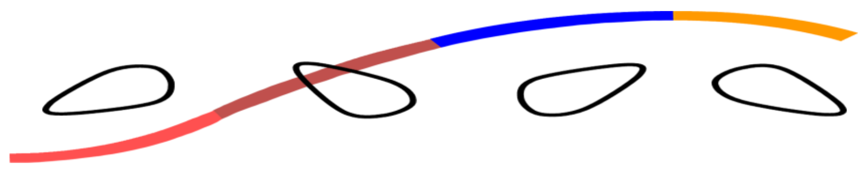
	Lifecycle Stage			
	Introduction	**Growth**	**Maturity**	**Decline**
Management Focus	**Product**	**Marketing**	**Process**	**Financial**
				
Leadership and Management Style	Outward looking; broad focus, cult of personality; selling the future	Outward looking; supportive, marketing focus; introduction of professional/ functional managers; return on investment	Inward looking; defense of market share; highly formal and hierarchical; department- or division-based; dictatorial	Inward looking; corporate value maximizing for sale or liquidation; disconnection from workforce
Innovation and R&D	Large technical gains; pursuit of any opportunities	Product and variant development; fit to existing channels; reliability enhancements	Incremental innovation in production or delivery; highly controlled; high levels of review and acceptance prior to implementation	Highly constrained; little or no R&D; potential to sell intellectual property; spin-off
Corporate Culture	Unstructured; achievement-based	Formalization of corporate identity and behavioural norms	Lean or Taylorist; task-based, individual-performance judged	Adversarial; rigid roles and job descriptions

Figure 2.7.3, The changing focus of innovation management through a firm's lifecycle
Source: Koplyay, Chillingworth, and Mitchell (2013)

From the preceding literature, it appears that employment growth of young firms has decreased over time, and with the maturing of the older firms, changes in the formality of management practices have also occurred. This is nothing new viewed through the lens of the corporate lifecycle in that as firms grow, they mature in many ways.

2.8 Training and Adult Education

To connect training and adult education to innovation and forms of work organization, this passage from Section 2.3 of this paper is re-stated:

> *"...Lundvall (2009;226) argues that the "Knowledge Economy" as Drucker coined it (Drucker,1969;263) is actually a "learning economy" because the new technology has to be learned, used, understood, and finally exploited for innovation. Lundvall (2009;226) found that Danish firms that did not combine the new technology with investments in employee training, change or training for management, and perhaps a change in the work organization had negative effects on productivity that could last several years."*

Makó et al (2011;64) studied Organizational Innovation and Knowledge Use Practice in the Hungarian and Slovakian service business sector which, in part, examined the use of formal versus experiential learning by "Knowledge Intensive Business Services" (KIBS) firms and found that "*Skills development and formal training are important preconditions for innovation*." As stated in this section's introduction referencing business strategy, organizational learning is key to the creation and retention of proprietary knowledge, and thus, competitive advantage for every organization, turning tacit knowledge to explicit knowledge back to tacit knowledge through training and education as employees are allowed to refine existing knowledge to innovate within their workplace. Following the academic business strategy literature stream from Penrose through Porter and the Resource-Based View, knowledge should be contained within the firm to ensure competitive advantage. Part of the containment, teaching, formalization, and application for gains or retention of the share of the market sector is the ability to retain the knowledge within the boundaries of the firm and not allow competitors to benefit from proprietary knowledge. The communities of practice example of Silicon Valley examined by Lam (2004;21) appears to be in direct opposition to the Resource-Based View in that the high-tech industries in Silicon Valley have a fluid workforce essentially sharing industry knowledge to further the aims of technical excellence and industry-wide commercial success. This approach allows the entire market workforce to access the fundamental knowledge of the market sector, the national-level training initiatives of individual firms in differing market sectors should be geared to knowledge creation, learning consumption, and application of the outputs by such firms which create the initial and subsequent knowledge to further the individual firm's market imperatives of profitability and corporate sustainability, thus ensuring their competitive placement in the national or global supply chain.

Makó, Mitchell, and Illéssy (2015;32-33) found that certain regions of the EU are lagging behind others in the prevalence of forms of learning in their forms of work organization, and the resultant capacity for continuing learning. Comparing the Hungarian and Slovak Knowledge-Intensive Business Services sectors, the connection to an international company network and percentage of market share in other countries were driving the implementation of a higher level of radical workplace reorganization with more robust learning practices.

The OECD (OECD,2019) training data in Figure 2.8.1 shows that the United States, Canada, and the Czech Republic are the leaders in training with 70% and higher of workers being involved in training in the last year. Spain and Sweden are in the next group with over 60% of workers engaged in adult learning/training. The majority of the other countries fit into a band between 45% and 59% engagement in training. Lithuania and Poland have just under one-third of workers engaged in learning. Greece has the lowest results with only 22% of workers having participating in learning. Most of the European Union countries have similar training results, the North American countries are the highest in the sample, and Poland, Lithuania, and Greece have the three lowest results.

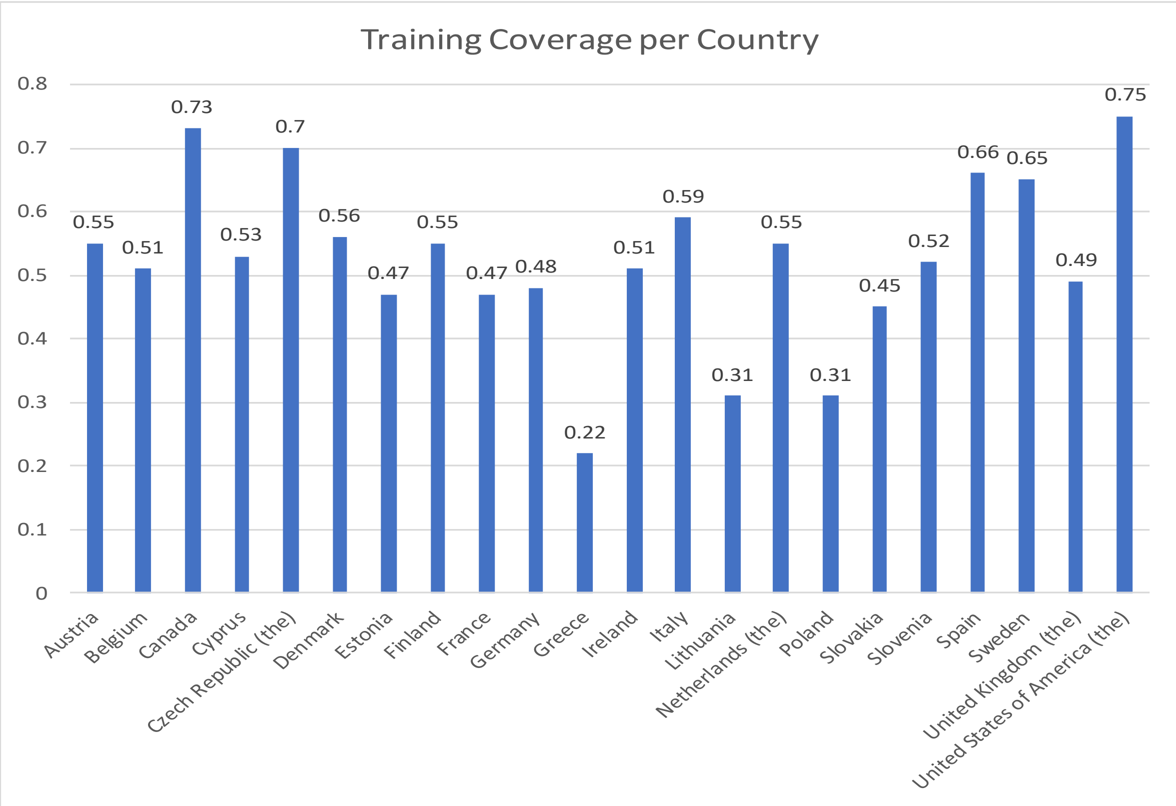


Figure 2.8.1, OECD Training Coverage per Country, 2019
Source: OECD (2019b), Dashboard on the Priorities of Learning

2.9 Chapter Summary

This chapter discussed the basis of the “Knowledge Economy” or “Learning Economy” and how management has viewed organizational learning from the “resourced-based view” (RBV) to the “knowledge-based view” (KBV) where the shift from manufacturing to service-based economies have made it imperative that firms create and leverage corporate knowledge. How tacit knowledge is converted to explicit knowledge, and the integrated model that combines many of the present frameworks into one model (Makó and Mitchell, 2013a;15).

The middle portion of the chapter discussed the interplay between forms of work organization, how forms of work and learning can change through the corporate lifecycle, and training. The evolution of the different forms of work organization starts with the four identified in the European Working Conditions Survey (Valeyre et al.,2009;19); Discretionary Learning, Lean Production, Taylorist, and Simple/Traditional. Later updates through new research data from the Programme for the International Assessment of Adult Competencies (PIAAC;2011-2017) and the resultant update to five types of forms of work organization: Discretionary Learning, Constrained Learning, Independent, Taylorist, and Simple Traditional (Greenan et al.,2017). While this evolution may be seen as a small step in understanding forms of work organization, and beyond the core intent of this research, the reader may observe that it may be a very important step when quantifying what the future impact of Artificial Intelligence and automation may be on specific countries due to the prevalence of said forms of work organization in their domestic economy, which will be addressed in the future research section of this document. Companies that grow from a small start-up to larger, more complex firms will experience changes in the forms of work organization. From potentially Simple, Discretionary Learning, or Independent forms of work organization, the firm may change to a Constrained Learning or even Taylorist organization depending upon the nature of their enterprise. Some larger, mature, divisional companies may have separate divisions that encompass all forms of work organization, depending upon what the individual division's responsibilities are within the larger company.

Training and adult education has been examined by many researchers (Makó et al.,2011, Lundvall, 2009, Brynjolfsson and Hitt;1994,2002) and the connection to innovation and/or increased productivity are recognized. Unfortunately, every country has different approaches to adult training and learning. The leaders in providing training are the United States and Canada, with the lowest three countries being Greece, Poland, and Lithuania.

All three subjects of this chapter are incorporated into the analyses in Chapters 5 and 6, and in particular, forms of work organization should be recognized for the importance of this to nations as it relates to Innovation.

3 Productivity

3.1 Introduction

The productivity gap between North America and the European Union has been examined in many ways by many different researchers in the course of the last two decades with far more experience and expertise than this author. This section will quickly review what productivity is and use data to show the performance of the sample countries over the recent past to give the reader a high-level understanding of differences in productivity amongst the sample. This section will also bring to the fore one finding that casts a very different light upon the generally accepted academic view that Europe was "left behind" in the productivity race from 1995 to 2007.

3.1.1 Productivity: The Definitions.

Briefly, the Organization for Economic Cooperation and Development (OECD) (Date undisclosed1; 1) defines "Productivity" as the "*…ratio between the output volume of inputs. In other words, it measures how efficiently production inputs, such as labour and capital, are being used in an economy to produce a given level of output*." The OECD definition goes further to state that Gross Domestic Product (GDP) per hour worked is one of the most widely used measures for quantifying productivity. Unfortunately, the OECD paper also mentions that although the GDP per hour worked is perhaps the most appropriate way to describe a country's productivity level, it can be difficult to obtain statistics from various countries as the collection methods may not adequately reflect the data from other countries.

Multi-Factor Productivity (MFP), also referred to as Total Factor Productivity (TFP), can be determined to elucidate the economic growth made by factors such as technical and organizational innovation (OECD, Date Undisclosed1; 1). In his literature review of ICT and Productivity, Biagi (2013; 4-5) notes that the *growth accounting model,* as devised by Solow (1957;312-320), uses weighted factor inputs to explain productivity increases. What the growth accounting model cannot do, though, is explain causality because a fully specified model would have to be used, and the challenges of that with the differing levels of statistical information available is untenable.

3.2 Productivity Overview.

This section reviews some of the literature on Gross Domestic Product (GDP) growth. The Timmer, O'Mahoney, and van Ark (2011) information has been left in the format of multiple GDP indicators to maintain the integrity of their work, albeit updated to the 2018 Conference Board revised data. When examining the time period of 2008 to 2018, which was beyond Timmer et al.'s (2011) original examination, only GDP percentage growth is examined to attempt to simplify the results and outline the recent past with the indicator used for the later exploratory analyzes.

Timmer, Inklaar, O'Mahoney, and van Ark (2011;6,7&9) [referred to as "Timmer et al. moving forward] examined GDP percentage growth between the EU and the US for the time periods from 1950 to 2009 using the then-available Conference Board "Total Economic Database" January 2011. In the sections following, the author cites the original data results used in the Timmer et al. paper (2011) and notes the updated data of the same database as of March 2018. The 2018 "Adjusted" "Total Economic Database" from the Conference Board database

(Conference Board, 2018) uses Byrne and Corrado's ICT Price Deflators methodology (Byrne and Corrado,2016;2-20) which adjusted for three countries with significant ICT production and trade; the United States, Japan, and China. In addition, because all the countries in the adjusted version of the database use the GDP deflator relative to the US GDP deflator, the GDP levels of every country are affected, thus the results in the adjusted version are slightly different from the numbers used in the Timmer et al literature. Where applicable, the author has noted in brackets the revised 2018 version of the database. Notwithstanding the slight differences in the original literature data values being cited, looking at Timmer et al. (2011;6-10) as the foundation to start this section, they quantify four definite time periods to compare the EU and the US, with the author adding the Canadian information as gleaned from the Conference Board revised "Total Economic Database" (Conference Board, 2018).

The time periods the Timmer et al (2011;5-10) examined were:

1950 – 1973: The European Catch-up,
1974 – 1995: Productivity Slowdown
1995 – 2007: Europe's Falling Behind
2007 – 2009: Global Financial Crisis

For the sake of simplicity, this research only examines the time periods from 1995 onwards. The Timmer et al (2011) literature looked only at the EU-15 and the United States. With the addition of the post-socialist and southern countries [Malta and Cyprus] joining over the time period after 1995, the results of only the EU-15 may not be indicative of the true difference between Europe, Canada, and the United States. Since inclusion into the EU, the Central and Eastern European countries [CEE] have experienced economic growth driven by Foreign Direct Investment [FDI] (Popescu, 2014;8161). One by one, the CEE countries are becoming high-income countries, with Hungary rejoining this group in 2014 (World Bank,2018). Bulgaria and Romania still have not been able to cross that hurdle. One would reasonably expect that with attaining or working towards the High-Income level, that productivity would have to increase as part of the process. The change from a central economy to a market economy resulted in an average GDP percentage growth for the 11 countries of -7.61 per year for the four-year period starting in 1990. The time period around the fall of socialism [1991] was the worst result for the time period with the CEE countries posting a -11.64 percent growth rate. Interestingly, though, from the lowest point in 1991, CEE countries as a group posted positive results from 1994 onwards until the Global Financial Crisis of 2007-8.

The 1996 – 2007 period is when Timmer et al. (2011;8) characterize as "Europe's Falling Behind". While this may be seen in the GDP per hour worked results, other GDP growth indicators appear to be a different story using the 2018 updated statistics from the Conference Board (Conference Board,2018), and especially when viewed through the lens of the entire EU and not just the EU-15. Timmer et al (2011;8) posit that even though there hadn't been a decrease in the relative skill level of the workforce in the EU even with increased employment measures in this time period, the GDP per hour percentage change decreased while the overall GDP percentage growth and GDP per capita both increased and were comparable if not higher than the United States during this period. The overall picture with the data from the entire EU, though, when examining GDP per hour worked indicates that the difference between GDP per hour worked is actually almost a full percentage point higher than Timmer et al note in their

2011 research and show comparable or better results than the US and Canada in this time period for GDP growth and GDP per Capita growth.

GDP Growth Results 1995 – 2007 (Conference Board 2018 Adjusted results)			
Country	**Annual GDP % growth**	**Annual GDP per hour worked growth**	**Annual GDP per Capita growth**
United States	3.57	2.47	2.50
Canada	3.10	1.39	2.11
EU-15	3.20	1.75	2.63
EU Total	3.81	2.18	3.16
Timmer, O'Mahoney, and van Ark's original 2011 Results			
Country	**Annual GDP % growth**	**Annual GDP per hour worked growth**	**Annual GDP per Capita growth**
United States	3.2	2.1	2.1
EU-15	2.4	1.5	2.0

Table 3.2.1 – GDP Growth Results

Source: Total Economic Database (Conference Board, 2018) as tabulated by the Author and Timmer et al.,2011;6

As the post-socialist economies emerged from the 1990s, they did so with new economic strength as far as GDP growth was concerned. While the average GDP per hour worked percentage growth for the CEE countries was 3.42 % for 1996 – 1999, the average for 2000 – 2007 was 5.26% [author's calculations]. This result was the highest of any of the discrete intra-EU country groupings as well as the US and Canada. The CEE results for the entire time period were an average of 4.65% compared to 1.75% for the EU-15, 2.47% for the US, and 1.39% for Canada.

With the revised 2018 Conference Board results, the GDP percentage growth rate for the entire European Union was 3.81%, twenty-four basis points ahead of the United States result of 3.57%. The EU-15 had the lowest average GDP percentage growth results in the 1995 - 2007 time-period compared to the US, Canada, and other EU regional groupings. While the EU-15 result of 3.20% trailed the United States result of 3.57%, Canada trailed both with a result of 3.10%. As with GDP per hour worked, the Central and Eastern European country group had dramatic results with an average of 4.82% growth per year in this time period. Only the North-western Countries [Ireland and the United Kingdom] had a better overall result with 5.10% average. When comparing the two country groupings, The Northwestern countries had outstanding growth from 1996-2000, but then dropped off after 2000 to have comparable results with the rest of the EU, even eventually falling behind the Continental countries in 2007. The CEE, on the other hand, had the lowest result of the country groupings in 1999 at 0.69% annual growth but still ended the time period with an average of 4.82% annual GDP growth.

GDP per Capita results in the 1995 – 2007 time period tend to mimic GDP percentage growth with the total EU having an average percentage growth per year in this time period of 3.16 percent. The CEE countries fueled this result having a yearly average of 5.22%, the EU-15 at an average of 2.63% average annual per Capita growth rate versus the United States at 2.50% and Canada at 2.11%. The CEE countries per Capita results showed the same dip in 1999, followed by remarkable growth from 2000 to 2007 with a 6.07% average per year.

3.2.1 2008 – 2018 Time Period

To simplify the economic analysis post-Timmer et al. (2011), this section will examine what has happened since 2008 using Gross Domestic Product (GDP) percentage growth, and again, using the Conference Board 2018 adjusted results.

Growth of GDP, percent change, 2008 - 2018												
COUNTRY GROUPS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
Canada	1.00	-2.95	3.08	3.14	1.75	2.48	2.57	0.94	1.47	3.00	2.10	1.69
United States	-0.03	-2.54	2.75	1.79	2.40	1.83	2.71	2.99	1.58	2.33	3.00	1.71
Total EU Average	1.17	-5.46	1.57	1.84	-0.28	0.56	2.34	2.73	2.59	3.48	2.96	1.23
European Regional Results, Growth of GDP, Percentage Change, 2008 to 2018												
EU-15	-0.08	-4.41	1.95	0.96	-1.11	0.14	2.02	2.14	2.08	2.72	2.46	0.81
EU-13	2.61	-6.68	1.13	2.87	0.68	1.05	2.72	3.42	3.17	4.35	3.53	1.71
Nordic	0.34	-5.53	3.06	2.06	-0.64	0.31	1.25	2.13	2.39	2.75	2.37	0.95
North-Western	-2.20	-4.41	1.75	2.22	0.76	1.85	5.69	4.83	3.54	4.29	3.10	1.95
Continental	0.39	-3.78	3.07	2.61	0.29	1.01	2.17	1.59	1.81	2.41	2.43	1.27
Southern	1.19	-3.43	0.50	-1.61	-2.92	-1.52	1.65	2.51	2.34	3.23	2.37	0.39
Central Europe	2.43	-7.51	0.90	3.23	0.85	1.36	2.60	3.20	2.97	4.21	3.71	1.63

Table 3.2.1.1. - GDP Growth, Percentage Change 2007 to 2018
Source: Author input of the Total Economic Database, Conference Board (2018)

The time period between 2008 and 2018 showed lower GDP growth for the United States, Canada, and the European Union. As seen in the previous section, all three subjects had average GDP growth results over 3% from 1995 - 2007. In the 2008 – 2018 time period, all three had results under 1.75%. The EU-28 had a result approximately 0.50% below Canada and the United States, which were virtually identical with results of 1.69% and 1.71%, respectively. The simple explanation of the Eurozone crisis negatively affecting the EU's results appears to be the most valid using only the overall results. The EU-28 had higher results than both Canada and the United States in 2008. In 2009, the global financial crisis negatively impacted all countries, but the EU was particularly hard hit with contraction of the GDP growth rate of – 5.46% versus -2.95% for Canada and -2.54% for the United States. From 2010 to 2014 the EU had lower results than both Canada and the United States in all five years except 2011 when the EU had a result of 1.84% and the United States result was 1.79%. From 2015 to 2018 the EU had higher results than one or both of Canada and the United States in every year. The EU-13 had an almost identical result to the United States [both show as 1.71% due to rounding of the Conference Board data].

3.2.2 A Slightly Longer View of Productivity

Re-interpreting the 2018 update to the Conference Board historical productivity data, the four Conference Board indicators show that if anything, it was Canada left behind in this twenty-four-year period. The four productivity indicators that the Conference Board uses are: GDP percentage growth, GDP per capita percentage growth, Labour Productivity growth per person employed, and Labour Productivity growth per hour worked.

The results showed that Europe was not left behind in the time period between 1995 and 2007, but the EU faced economic circumstances that the North American countries did not in the 2010's that created a situation where the EU has ended up only slightly behind the United States in GDP growth, ahead in GDP growth per capita, behind in Labour Productivity per hour worked, and ahead in Labour Productivity per person employed over the extended period. One may posit that perhaps the United States and the European Union took different trains to reach relatively the same destination.

Average Productivity Growth, Percentage Change, 1995 - 2018				
COUNTRIES/ GROUPS	GDP Growth, % Change	GDP Growth per Capita, % Change	Labour Productivity Growth per Hour Worked, % Change	Labour Productivity per Person Employed, % Change
Canada	2.46	1.42	1.16	0.97
United States	2.72	1.76	1.87	1.76
Total EU Average	2.63	2.19	1.7	1.96

Table 3.2.1.2. - GDP Growth, Percentage Change 1995 to 2018
Source: Author input of the Total Economic Database, Conference Board (2018)

The results in Table 3.2.1.2 preceding use the results from all the countries that presently constitute the EU-28, notwithstanding whether the countries were full members or candidate countries at the time period starting in 1995. The decision by the author to take this approach was to be able to examine the European Union with the understanding that whether countries had full membership or not, the full European economy was still intertwined in a way that untangling them may not show the reality of the trade and investment in Europe in a realistic way. The obverse is that Norway was not included even though they have a trade agreement with the EU, and no separate data was included in the Conference Board 2018 data for Greenland.

To summarize this section, while Timmer et al. (2011) considered that Europe "fell behind" from 1995 until 2007, and Gordon (2004) colourfully cites many reasons why *"...Europe was left at the Station when America's productivity locomotive departed*", but in view of the revised Conference Board (2018) data, and using the entire EU-28, Europe actually had better productivity results. Lengthened to the time period from 1995 to 2018, the results of the four productivity indicators used by the Conference Board showed similar results for both the EU and the United States, and this with the EU having to deal with an additional financial crisis in the form of the European Debt Crisis in the intervening time since the 2008 Global Financial

Crisis. If anything, Canada was left behind at the station for this twenty-four-year period with results for all four indicators behind both the United States and the European Union.

3.3 The evolution of ICT-related productivity research

> *"**A computer as a research and communication instrument could enhance retrieval, obsolesce mass library organization, retrieve the individual's encyclopedic function and flip into a private line to speedily tailored data of a saleable kind.**"* – Marshall McLuhan and Bruce Powers, a dialogue between McLuhan and Powers in 1978, as published in "The Global Village", Oxford University Press, 1989.

Growth accounting doesn't have a function to capture the changing prices of inputs fully; the same amount of capital invested in ICT technology in the present day will result in a much higher quality or quantity of equipment or software applications as compared to 5, 10, 15, and 20 years in the past, even with inflation or the discount rate taken into consideration. As well, because an argument can be made the ICT has become a "General Purpose Technology", or "GPT" (Bresnahan and Trajtenberg, 1995; 84-85), the impacts of equipment and uses can change and have unplanned or unimagined impacts through the dispersion and use of the technology once unleashed by a trigger event or market conditions that support great technological leaps (Bresnahan and Trajtenberg, 1995;95-96).

In addition, Biagi's OECD paper (OECD,2013;5) states that types of ICT investment have changed, and that the intermediate ICT inputs have changed with companies moving to cloud computing solutions and away from traditional hardware and software solutions. With this, there are also spillovers to other firms that may [or may not] affect economies of scale. The broader industry sectors and structures may also affect productivity, Jarzebowski (Jarzebowski,2013;176-177) found that in the Polish agri-food industry that larger firms were more efficient than smaller and medium-sized firms using both parametric and non-parametric measurements, although the results differed between the two approaches. Atkinson and Lund (2018b;35-36) found big business is the driver of the economy; by 2011, firms with more than 500 employees had 51.5% of employment where firms with under 100 employees had lost sales (-25%) and number of employees (-12%). In addition, Atkinson and Lund (2018b;35-36) firms with over 2,500 employees increased their share of total firms by 17%, share of sales increased by 20%, and their share of employment increased by 16%. The largest firms [over 10,000 employees] had a 27% increase in their share of employment.

Efficiency with technology, whether a country or sector is using "best practice", is also a concern when looking at inputs, specifically ICT investment. Meta-analyses compare country to country or region to region, but technological heterogeneity may not be the case. If taken as a single level of technological competence, inefficiency (vis-à-vis) productivity differences, may be identified as being higher versus the real issue of technology gap (Kumbhakar, 2006;56). Distance from the technological frontier within the country, and then the distance of the country's firms as a whole from the global meta-frontier will play a part in the relative levels of productivity of each country, and identify the technology gap that exists (Kumbhakar, 2006;57). Whether or not ICT is a General-Purpose Technology (GPT), it remains that the final outputs are affected by the knowledge of the persons inputting or using the technology. The distance from the technology frontier may cause important differences between a country's productivity performance even though the same technology is available to all.

3.3.1 ICT-influenced productivity Literature Review

Academics have used the oft-quoted Robert Solow (New York Times,1987;36) quip: "You can see the computer age everywhere but in the productivity statistics." from his review of the book The Myth of the Post-Industrial Economy by Stephen Cohen and John Zysman in the New York Times book review section in July 1987. Although the Google "Scholar" search engine lists only 7 official citations for the New York Times article (unattributed, Google, 2019; as searched by this author on April 13, 2019), the impact has been immense as many academic authors now just refer to it, un-cited generally, as the "Solow Paradox' or the "Productivity Paradox". Perhaps as computers have become a "general-purpose technology" in business and society, Solow's Paradox has become a "general-purpose theory" for less than stellar ICT productivity effects in economics.

Examining the thirty or more years of academics writing on the effect of ICT and productivity has shown great growth in how the subject has been viewed and analyzed, and how the real impact of ICT on productivity has been quantified. This author also posits how much of this growth in literature and study can be attributed to the increase in ICT availability and computing power, allowing academics to be able to test more and better data further in-depth to find better, or different, conclusions.

As researchers have continued to study the productivity paradox, the academic community has been able to delve further into the riddle. Polák (2014;19) conducted a meta-analysis and found that the paradox may be returning. One explanation that Polák elucidated is that because computer technology is now such a part of everything that is around us in any investment in production technology inherently has ICT connected to it, that the impact can no longer be easily separated to find positive effects on choosing ICT over non-ICT systems. Polák (2014;19) also found that there was a publication bias between working papers and published studies; the working papers presented higher estimates of the impact of ICT upon productivity than did the published scientific studies. This may be easily addressed by the sheer discipline of a peer-reviewed journal article versus the ideation of a working paper. That said, with the explosion of online publishing, one may also posit that working papers are far easier to access than through the "paywall" of publishers for peer reviewed papers.

There are a number of academics that have been studying the impact of computers on the economy and organizations since the late 1980s who are not, per se, looking at the classic growth accounting methods only, but are examining complementary forces impacting ICT investment on performance. Erik Brynjolfsson is one of them. As a professor at the Massachusetts Institute of Technology, he has been publishing papers following the arc of thought about how computers affect work and whether they have benefit to those who invest in ICT.

In 1994, Brynjolfsson and Hitt (1994;22-24) stated that Information Systems (IS) Capital and IS Labour made statistically significant contributions to the output of the 367 large American firms that they studied between 1988 and 1992. Examining Ordinary Capital, Computer Capital, R&D Capital, Ordinary Labour, and IS Labour as the production function inputs, the relatively small factor shares of IS Capital and IS Labour created gross rates of return that were very high. They did comment that there are a few factors that may contribute to this result; computer capital costs are very high, so the net returns could be smaller than the gross returns on this type of capital. Additionally, econometric models create correlation, but not causality, so there may be an unmodelled factor that impacts results. And thirdly, the study was of a short time period with much economic upheaval. Brynjolfsson and Hitt (1994;23-24) also hint that complementary innovations in business processes, management techniques, and organizational work forms that cannot be tracked may result in a "virtuous cycle of higher returns" over a number of years.

Brynjolfsson and Yang assembled a literature review in 1993 and revised it for publication in 1996 in the journal Advances in Computers. They identified five trends at that time (Brynjolfsson and Yang,1996;4):

- The price of computers decreased by approximately half every two to three years, attributed to the widely accepted Moore's Law (Moore, 1965;114-117).
- Investment in ICT had become approximately 10% of capital investment circa 1990. Thought was also given to the cost deflators per Moore's Law noted above, and that due to the price deflation, the "real" investment amount when benchmarking against a specific year dollar value from early in the reporting period would be much higher than the current-year dollar value indicates.
- Information "handling" has become the principal job task for approximately half of employed Americans [this author posits that the move to the service economy from a manufacturing economy, caused by off-shoring of manufacturing to low factor cost countries in the 1970's and 1980's, may be the cause. Although an interesting aside, this thought will not be pursued in this research, but could be seen as effect of the changing economy in developed countries].
- Productivity dropped from the early 1970's until the time the paper was written. [History now shows that the mid-1990's productivity increases followed the decline, followed by another decline starting approximately 2006 (Brynjolfsson, 2011;67-68)].
- White collar labour productivity remained approximately the same from 1970 to 1990.

While Brynjolfsson and Yang build on the themes of earlier papers in stating that the benefit lag is longer-term than immediate results, potential mismeasurement, redistribution, and mismanagement to explain the productivity paradox (Brynjolfsson and Yang,1996;42), they also point out that the economy may be in the transition period, similar to electricity that had a twenty-year lag between introduction [and seemingly mass adoption] until its impact on productivity was realized. One argument put forth was the need for industry to be able to fully comprehend the possibilities of the technology and develop complimentary processes and designs to optimize and adapt the places of work to increase productivity (Brynjolfsson and Yang,1996;40). Substituting new technology into the existing structure would not maximize benefit, redesigning the structure was required; the example they share is changes to industrial design away from static sources of power like a power-transmitting shaft or steam engine to focus on workflow efficiency [from this author's point of view, one may also posit that this type of change in industrial thinking allowed for the development of the assembly line and Taylorist and Fordist types of production; again, not part of this paper's research aims, but a potentially interesting connection to understand the lag between introduction and benefit for GPTs like ICT].

Brynjolfsson and Hitt's 1998 paper "Beyond the Productivity Paradox: Computers are the Catalyst for Bigger Changes" considered that some studies showed little evidence of ICT contributing to productivity, yet the explosion of computers in the workplace and the rise of "information workers" somehow led them to believe that there was a link to productivity. They acknowledged that conventional productivity measurement may be the reason. To explain their reasoning, they gave the example of the number of automated banking machines introduced reduced the number of cheques that customers wrote, thus decreasing the number of cheques processed, thereby actually decreasing productivity (Brynjolfsson and Hitt,1998;5) if traditional growth accounting methods are used. Some of the factors that traditional growth accounting does not use are; increases in quality, customer convenience, etc. Another realization from their investigation was that unless managerial or organizational change occurred to enhance the role of ICT in the workplace, the potential benefits of ICT investment may not be realized. Using firm-level data, and assigning a 2x2 matrix, their results showed that firms that coupled high ICT investment with decentralized work practices realized an on-average increase in productivity of 5% compared to those firms who did not combine the two factors (Brynjolfsson and Hitt,1998;9). The use of "re-engineering" of work organization and practices with the new ICT tools appeared to be the difference-maker to Brynjolfsson and Hitt (1998;11).

Brynjolfsson and Hitt were using the term "Organizational Capital" by their 2002 paper "Intangible Assets: Computers and Organizational Capital" (2002) when they expanded their dataset and econometric specifications to examine the link of firm market value, ICT use, and management structures and work organization. The results (Brynjolfsson and Hitt,2002; 175-176) confirmed the author's 2000 results (Brynjolfsson and Hitt, 1998;16) that firms who invest in ICT and a less traditional, more "flat" organizational design will have higher market value for each dollar invested in ICT capital, even holding all other non-ICT investments equal. As well, those firms that invest in ICT and non-Taylorist organizational characteristics, or both, have higher levels of productivity after the adoption/lag time has passed.

In 2003, Brynjolfsson and Hitt returned to firm-level data analysis augmenting their 1994 paper "Computers and Economic Growth: Firm-Level Evidence" that examined output growth to re-examine the impact ICT investment has on multi-factor productivity (MFP). Because ICT investment has the possibility to create spin-off effects to other areas of the firm besides being a capital substitution for labour (in some cases) or an equipment replacement/upgrade in other cases, the total impact of complementary innovations or business process changes, Brynjolfsson and Hitt (2003;4-5) argue that Multifactor Productivity can show that ICT investment creates benefits in excess of the capital cost. The hypothesis of their paper is that firm-level analysis will show the relative performance of firms versus their competitors when considering ICT investment, whereas taking the industrial sector average will hide such effects. Using a "long-run" regression for ICT benefits, Brynjolfsson and Hitt (2003;26) find that relative ICT investment provides approximately equal return as the factor share of ICT investment. The most prescient finding is that given a long-run analysis, ICT investment will generate between two-times to five-times as much output contribution compared to the original input share. The authors also state that the magnitude of the finding cannot be placed solely on the machines themselves, but are due to the complimentary organizational investment and cannot be attributed to omitted technical complements such as software (Brynjolfsson and Hitt, 2003;27). Included in their conclusion, Brynjolfsson and Hitt (2003;27) also posit that although their data sources in the study were from the late 1980s to the early 1990s, the findings may contribute to explaining the productivity surge in the late 1990s due to the long-run (gap) effect of benefit realization.

The year 2008 saw Erik Brynjolfsson team with Andrew McAfee, Michael Sorell, and Feng Zhu to write "Scale without Mass: Business Process Replication and Industry Dynamics". The paper examines the period between 1987 and 2006, with 1995 being the cut-off for examining each "half" of the time period. Brynjolfsson et al. (2008;18-23) used regression frameworks to determine if there was more turbulence [using rank change considering earnings before interest, taxes, and amortization (EBITA) and company sales] and industry concentration in ICT-intensive industries versus non-ICT-intensive industries. Their results indicated that ICT-intensive industries experienced more turbulence in the total time period than did non-ICT-intensive industries, nor was ICT-intensity strongly associated with market concentration. Examining the two time periods showed different results; before 1995, both types of industries became less concentrated but after 1995, ICT-intensive industries become more concentrated and their markets more turbulent (Brynjolfsson et al.,2008;21). In explaining these results, Brynjolfsson et al. (2008;23) tie the introduction of Enterprise Information Technology (EIT) to the results and increase in turbulence as companies can implement innovation or changes in business "best practices" across the entire company whereas in the past this methodology was much slower to occur. They also found that innovators can leverage their internally-developed or implemented best practices to rapidly gain market share. Once market share is gained, though, it requires constant innovation or refinement to be able to hold said market share as competitors imitate or better each other (Brynjolfsson et al.,2008;23). Monopolistic tendencies of concentration is also discussed, although with not as much detail in comparing how Walmart's competitive edge for data reporting drove their supply chain to better react to actual consumer behaviour and the replenishment requirements that meant the battle was lost for Kmart when two EIT initiatives failed, launching Kmart into bankruptcy in 2002 (Brynjolfsson et al.,2008;12). That knowledge-based competition creates a "winner take all" environment, and in many cases is the cause of industry concentration (Brynjolfsson et al.,2008;13). This author posits that this concentration through knowledge-based competition can be seen in the present economic environment where mega-companies such as Apple, Google, and Amazon have commanding positions in their respective industries in certain parts of the world.

In 2011, Brynjolfsson returned to ICT and Productivity, this time including innovation in the analysis (Brynjolfsson,2011;60-76) for a European Investment Bank paper. Brynjolfsson argues that the creation of knowledge encourages innovation, and ICT has *"…a unique role in augmenting, if not automating, creativity and discovery.*" (Brynjolfsson,2011,74). One may posit that the role of ICT investment allows the biggest spenders to create the most innovations and reap the rewards. One can logically accept the notion that those firms who spend the least on ICT investment in an industry where competitors spend more may not be able to compete. Brynjolfsson (2011;67-68) found that the interquartile [25th percentile to 75th percentile] gross profit margin grew from approximately 20% from the 1960s to the 1980s to approximately 35% from the mid-1990s to 2006. The Figure 3.3.1.1 (Brynjolfsson,2011;68) shows that the 31 highest ICT intensive industries saw their gross profit margin roughly double, whereas the 31 lowest ICT intensive industries were almost unchanged.

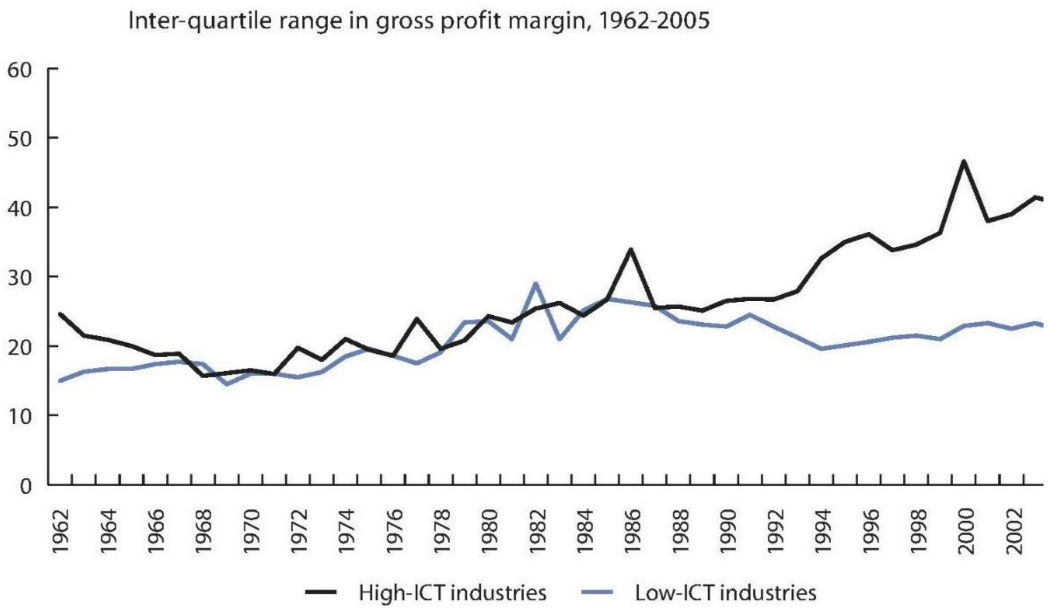


Figure 3.3.1.1 – High versus Low ICT-Using Industry's Profit Margin
Source: Brynjolfsson (2011;68)

From his research in this paper, Brynjolfsson (2011;68) argues that the ICT revolution, and those firms that leverage the opportunities associated with ICT investment and complementary organizational capital lead to four important trends:

- Improved real-time, fine-grained measurement of business activities,
- Faster and cheaper business experimentation,
- More widespread and easier sharing of observations and ideas; and,
- The ability to replicate process and product innovations with greater speed and fidelity.

Brynjolfsson (2011;74) concludes with the fact that the frontier firms are very far ahead of their mean industry shows that innovation has the potential to induce future productivity growth. With this paper having been authored in the shadow of the global financial crisis, Brynjolfsson also sees a hopeful future for innovation and increased productivity due to the fact that the 1930's depression saw more innovation than any preceding decade since 1850.

Turning their sights to what they found in their research, Brynjolfsson and co-authors moved into looking at how ICT was impacting business and productivity. Brynjolfsson, Rock, and Syverson (2017;33-34) argue that the opposite ends of the optimism/pessimism spectrum in the ICT debate are *"…talking past each other*." and are looking at different visions of technology. Whilst the optimistic side is expressing that there has never been a time with more innovation (Brynjolfsson et al., 2017;1) while the American Congressional Budget Office reduced their 10-year productivity growth forecast of 1.8% to 1.5% in 2017 (Brynjolfsson et al., 2017;6). Brynjolfsson et al. (2017;5) used the same base data as this author did in the preceding Section 3.2 Productivity and they were similar with the labour productivity rates declining and aligning in much closer results comparatively.

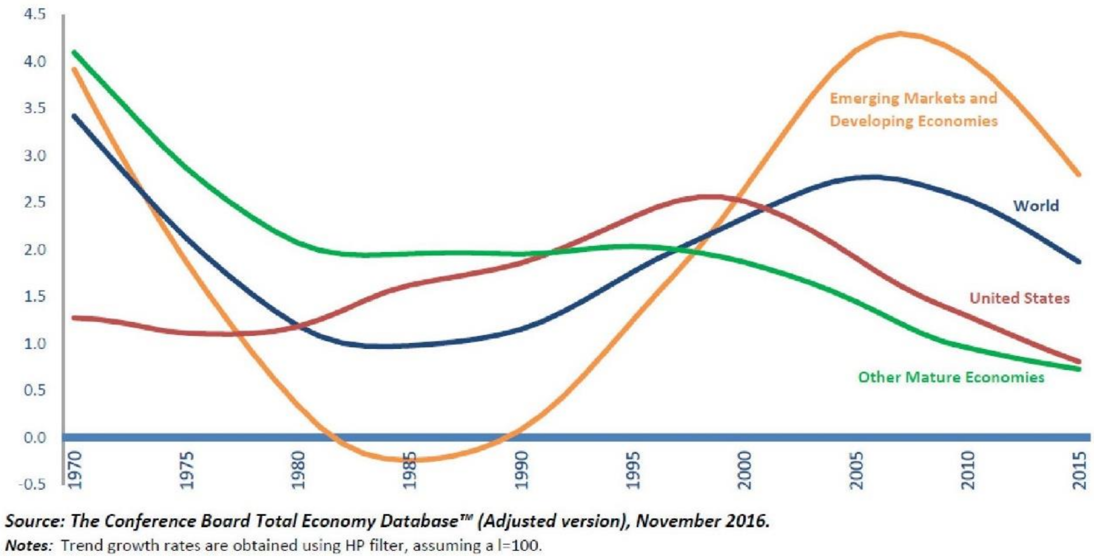


Figure 3.3.1.2 – Labour Productivity Rates Globally 1970 – 2015
Source: Brynjolfsson et al (2017;5)

Brynjolfsson et al (2017;6-13) posit that there could be four potential causes of Solow's Paradox continuing even though many academics consider ICT to be a general-purpose technology presently. The first of these arguments is that too much credence has been placed on the ability of ICT to increase productivity through "False Hopes". The authors give many examples of technology and effort that did not deliver on its original promise; essentially free electricity generated from nuclear power stations, flying cars, no more supersonic airliners since Concord, and the fact no one has returned to moon since 1972's last Apollo mission, nor has a human yet reached Mars. The second possible reason is the inability to accurately measure the impact of technology upon productivity. Brynjolfsson et al. (2017;8) do not support that theory as the low price of smartphones, social media, etc., may contribute substantially increased utility to users despite their low price and impact on GDP. As well, they theorize that past technological leaps may not have shown up in productivity results even though they may have contributed to increasing productivity as well. The third possible culprit was "Concentrated Distribution and Rent Dissipation", where the few companies that are realizing success with certain technologies seek to block anyone else from attaining the same level of benefit or potential benefit. Brynjolfsson et al. (2017;8-9) note that both productivity and profitability measures for the frontier firms are increasing while the bottom performers languish. With markets where there a small number of "superstar" firms gaining or defending large market shares (Apple, Google, Amazon, etc.), the wage levels of workers are connected to firm-level productivity differences and stagnating incomes. Brynjolfsson et al.'s (2017;9-16) fourth potential cause of the continuing paradox are implementation and restructuring lags that generally take longer for a technology or group of technologies to be developed, implemented through an almost trial and error approach to attempt to achieve real gain to processes, and the longer than expected time period to be able to combine all parts, including complementary innovations either technological or organizationally to see the real benefit of a GPT.

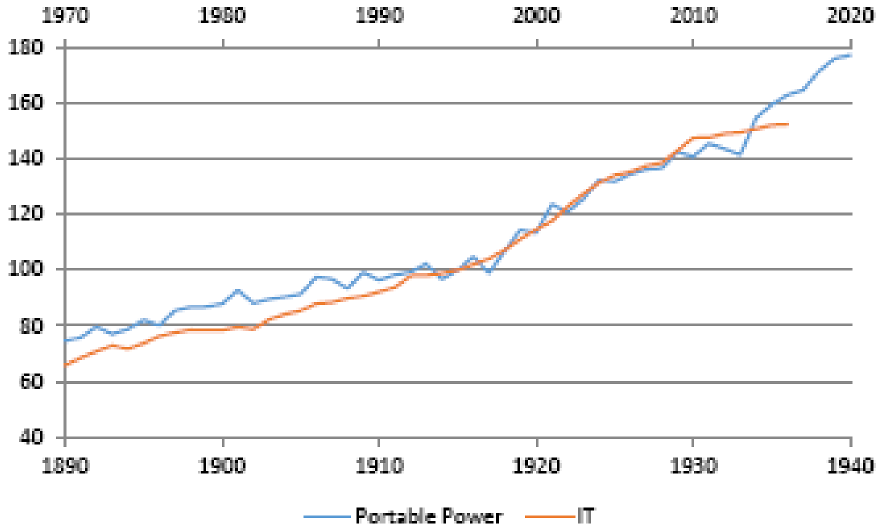


Figure 3.3.1.3 – Labour Productivity Growth in the Portable Power and IT Eras
Source: Brynjolfsson et al (2017;27)

Brynjolfsson et al. (2017;27) compared labour productivity growth of portable power from 1890 to 1940, and IT from 1970 to circa 2015. The comparison showed that it took an extended period for portable power to have a transformative effect upon productivity. While Brynjolfsson et al. only compares ICT to "Portable Power", the reader may want to consider noting Gordon's four "Great Inventions" (Gordon,2000;59-60) cited later in this section to determine if comparing ICT to only one of the four inventions Gordon noted is applicable.

Bart van Ark is another influential economist in the field of ICT productivity research. As the Chief Economist and Chief Strategy Officer at the Conference Board, and Professor of Economic Development and Technical Change at the University of Groningen, he is, perhaps, the pre-eminent academic in economics at this time. In the same way as Brynjolfsson's papers were reviewed, a sample of van Ark's papers on ICT investment and productivity [sometimes separate subjects] will be reviewed below. The reader may want to remember that while van Ark uses Conference Board data, if the cited papers were before 2018, the data does not reflect the ICT price deflator (Byrne & Corrado,2016) in the 2018 data revision.

van Ark, Inklaar, and McGuckin (2003a) examined the contribution of ICT-producing and using industries to productivity growth in the European Union, the United States, and Canada. Using data from OECD Structural Analysis Database (STAN) for national accounts, van Ark et al. divided the groups of industries into ICT-producing, ICT-using, and "Non-ICT" industries (van Ark et al.,2003a;57-58) by ranking the intensity of ICT use; based upon the premise that every industry uses ICT in some fashion, but to differing degrees, and using share of ICT capital to then consider the top half of the results to be ICT-using and the bottom half to be "non-ICT". The authors also used an ICT price deflator for the United States and adjusted for inflation in each country studied due to the data not being available for ICT pricing in many of the countries. The table below is taken from van Ark et al and modified to show the high-level results for productivity growth, contributions to aggregate productivity growth, and nominal GDP share (van Ark et al.,2003a;59). The lowest right-hand section (headings highlighted in grey) is this author's work to show the differences in the three industry clusters in the two time periods of the paper.

	Productivity Growth (percentage points)					
	1990-1995			**1995-2000**		
	Can	**US**	**EU**	**Can**	**US**	**EU**
Total Economy	1.3	1.1	1.9	1.8	2.5	1.4
ICT-Producing Industries	1.6	8.1	6.7	7.1	10.1	8.7
ICT-using Industries	2.0	1.5	1.7	3.2	4.7	1.6
"Non-ICT" Industries	1.0	0.2	1.6	0.8	0.5	0.7
	Contributions to Aggregate Productivity Growth					
	1990-1995			**1995-2000**		
	Can	**US**	**EU**	**Can**	**US**	**EU**
Total Economy	1.32	1.07	1.86	1.76	2.49	1.40
ICT-Producing Industries	0.08	0.51	0.33	0.42	0.74	0.46
ICT-using Industries	0.52	0.43	0.42	0.83	1.40	0.41
"Non-ICT" Industries	0.77	0.23	1.08	0.52	0.36	0.47
	Nominal GDP Share			Change in Productivity Growth (percentage)		
	2000			Delta 1990-1995 versus 1995-2000		
	Can	**US**	**EU**	Can	US	EU
Total Economy	100	100	100	+0.5	+1.4	-0.5
ICT-Producing Industries	6.4	7.2	5.8	+5.5	+2.0	+2.0
ICT-using Industries	27.1	30.7	27.0	+1.2	+3.2	-0.1
"Non-ICT" Industries	66.5	62.1	67.2	-0.2	+0.3	-0.9

Table 3.3.1.2 – Change in Productivity Growth 1990 to 2000
Source: Author's own tabulations from data in van Ark et al (2003a;59)

The results of van Ark et al. (2003a;59) indicate that the EU fell behind the United States and Canada in Productivity, and specifically the productivity of the ICT-using industries after 1995. Where the EU held an edge in overall productivity growth from 1990-1995, they fell behind both Canada and the United States from 1995-2000. In one of the few articles this author could find that included Canada with the EU and the United States, van Ark et al. (2003a;60) showed the productivity increases and decreases were not the same for each country during the time period 1995-2000. The graphic below shows the average contributions in percentage points for each country and the ICT-using Industries. The United States had the highest results in Wholesale Trade, Retail Trade, and Securities Trade, but trailed the EU in Professional Services, and Canada in Research and Development, Banks, and Renting of Machinery. Canada had a very similar result in Wholesale Trade, which the author posits may be due to the closeness of their economies and a shared common language.

The reader should consider that the EU results that van Ark et al. (2003a) use only include Austria, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden, and the United Kingdom. Van Ark et at (2003a;59) state the eleven countries represent 90% of the GDP of the EU at that time, which may be a valid point as has been seen in the Timmer et al. (2011) work that only included the EU-15. This author was not able to determine whether there was new and updated data to compare to the 2003a van Ark et al. research, but in the context of establishing the perception that Europe had fallen behind the North American countries, the van Ark et al. research supported what appears to have been the established academic view.

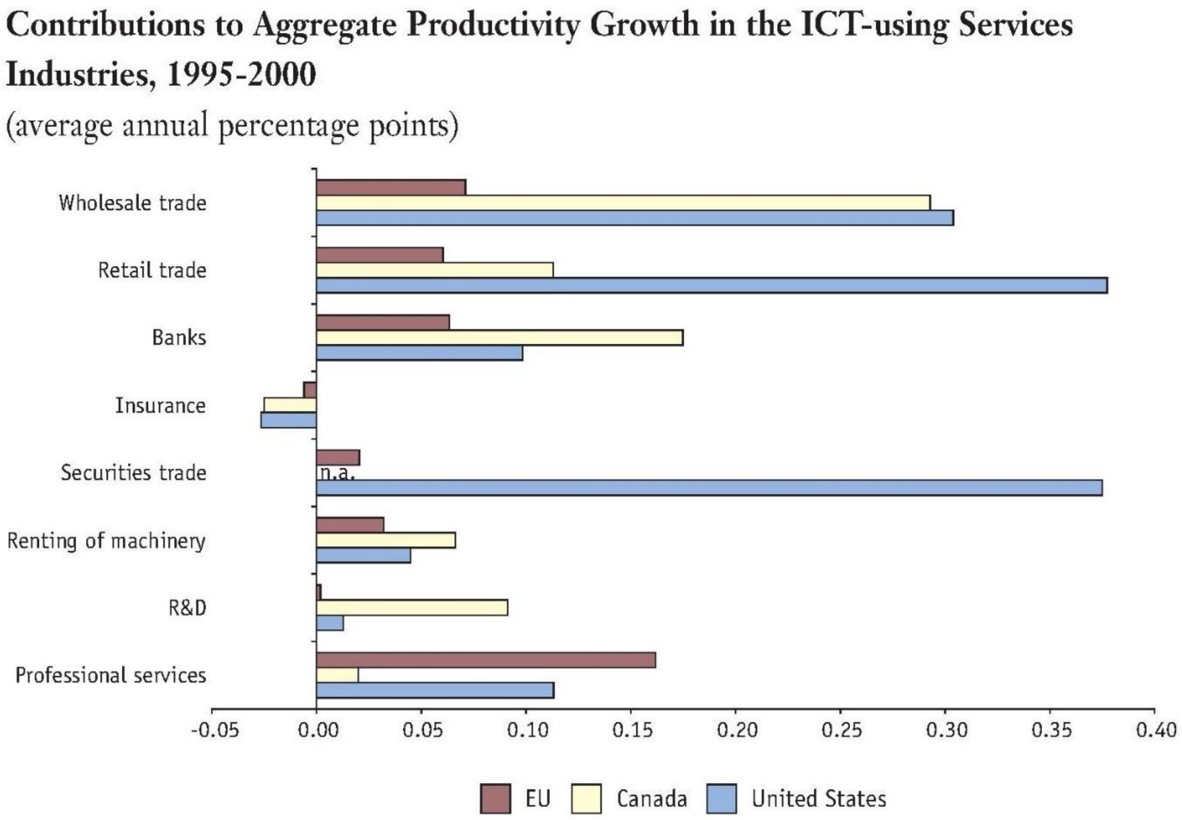


Figure 3.3.1.4 – Average Contribution to Productivity Growth by ICT-Using Industries Source: (van Ark et al,2003a;60)

van Ark, Inklaar, and McGuckin used the 2003b paper to further investigate the differences between the United States and European Union productivity results in their second 2003 paper (van Ark et al.,2003b). They found that the United States had larger ICT investment during the mid-1990s and the EU's productivity growth slowed during the 1995-2000 time period. The principal difference they identified was the productivity growth in the American Wholesale trade, Retail trade, and Securities sectors, which were in the ICT-using services sector (van Ark et al.,2003b;13). With ICT and the available technologies globally available, there should be no reason that supply would be an issue. While van Ark et al. argue (2003b;14) that more restrictive regulations for labour, transportation, and customer access because of shopping hours limits may be some of the causes for lower European productivity, such restrictions do not totally explain why Europe lagged behind the United States.

Van Ark, O'Mahoney, and Timmer (2008) continued their comparison of American and European productivity and examined the time period from 1980 to 2004 using EU KLEMS data (van Ark et al.,2008;26) and ventured further into the reasons behind Europe's productivity decline. Pressing the finger of blame at slower multi-factor productivity growth in the trade, finance, and business sectors of the European economy as better managed American retail chains and logistics industry deregulation combined with technological advances in ICT technologies such as barcode scanners, inventory trackers, transaction processing software (van Ark et al.,2008;41) and the managerial techniques (van Ark et al.,2008;42). The authors also touch upon the employment initiatives taken by many European countries in the late 1980's and early 1990's to increase the active workforce. With more labour available and that labour's wages stagnating, the lure of capital substituting for labour may have decreased (van Ark et al.,2008;31). One other note concerning this article is that the EU KLEMS data was only used for 10 of the EU-15 countries as Greece, Ireland, Luxembourg, Portugal, and Sweden were not included as no industry-level accounts were available from 1980 onwards. This author also posits that not including the EU-13 countries, and especially the former socialist countries who all experienced labour productivity per hour worked increases from just below 4% to over 5.5% from 2000 to 2004 (Conference Board,2018) may also have resulted in lower than actual productivity being used in the comparisons.

In 2016, van Ark commented upon the shift from ICT investment to ICT services when examining the "New Digital Economy" and the perceived second round of the productivity paradox. When comparing labour productivity growth in the time periods of 1996 to 2006 and then 2007 to 2014, he found that the latter period showed significant decreases of the ICT-Producing and ICT-Using industries contributed to the majority of the productivity growth slowdown in the United States, the United Kingdom, and Germany (van Ark,2016;5-6). In addition, while ICT investment prices have continued to decrease, the level of ICT investment has decreased, but the use of ICT services [such as cloud computing, data storage, etc.] has increased drastically (van Ark,2016;11). Circling back to the mismeasurement concerns every economist seems to touch upon when discussing ICT connected productivity results, van Ark mentions that there are many ICT-related or enabled digital products that are low or no cost of use, but increase consumer benefits like Uber and ride-sharing for available automobile capacity, Airbnb for sharing spare housing capacity, or social media platform-enabled access to free content that are not able to be measured at the moment. In addition, the new digital economy has found producers facing market pressure to maintain low prices unless significant additional consumer benefit is added to the products (van Ark,2016;9). Of the three countries that van Ark used in this paper, only Germany invested more in research and development due to their dominant manufacturing sector than in Knowledge-based assets (KBA) since 2010 (van Ark,2016;13-14). Van Ark explains that one reason that the KBA encompasses a firms' investment in computer software, R&D, any innovative product or service design, and firm-specific training or organizational change that act complementary to capital investment and, while related but perhaps not proven causative yet, there are strong positive relationships between KBA spending and the historical patterns of ICT investment and productivity gains in the "Old Digital Economy" of the 1980s and 1990s (van Ark,2016;13-14). Van Ark considers the period the paper was written to be in the "installation" period of the new digital economy, and with any new installation there are unrealistic expectations of what the new technology can really do, followed by a bursting of expectations which cleans up over-investment, but the deployment phase will ensue to see wide-spread adoption of the technology and potential productivity gains (van Ark,2016;15-16). The historical parallels that van Ark sees between the first half of the 1990s and the present post-global financial crisis period are strong and point to the potential for similar growth, but cannot be described or forecast at this time (van Ark,2016;16).

Robert Gordon has had a long and distinguished career as an academic and writer, and interestingly follows the pessimism about ICT's impact upon productivity akin to his Ph.D. advisor at M.I.T., Dr. Robert Solow (Wellisz,2017;31). In summing up his examination of labour productivity, Gordon (1999;22-23) argues that the gains made between 1995 and 1999 could be contributed to three causes: the changes in the measurement of the GDP deflator, the procyclical growth in labour productivity when output grows faster than trend, and the staggering productivity gains made by the ICT production industry. On the third point, Gordon states that the ICT producing sector [the non-farm durable manufacturing sector], which encompassed (at that time) 1.2 percent of the total American economy but was responsible for almost all of the labour productivity gains.

Not everyone supports the idea that ICT has become a General-Purpose Technology (GPT). Gordon (2012;2) argues that ICT has run its course as an innovation producing GPT, and that the main remnants of the computer revolution are improvements in entertainment and communications devices. Earlier, Gordon (2000) had questioned whether ICT would fulfill the potential to be the next great technological breakthrough that creates a "second wave" of productivity gains similar to the first wave from 1891- 1972, and particularly between 1928 and 1950 (Gordon,2000;32-33), that brought the "first great wave" of productivity to the United States (Gordon,2000;33). Gordon is a pessimist about ICT's true impact and bases his argument on the fact that the great leap forward from 1891-1972, productivity came from the conflagration of four innovations occurring within a few decades of each other, and the iteration of those technologies through the exploration period of the economy's learning period. This is similar to March's "knowledge acquisition", and can be seen as "Exploration", and the use of the knowledge to execute the work tasks is referred to as "Exploitation". (March, J.G. 1991; 71)]. Gordon's four "Great Inventions" (Gordon,2000;33-34) are:

- Electricity. With the advent of electric light, longer working hours were available to the economy. The electric motor caused the portability of power and locomotion away from large fixed installations such as watermills. Gordon makes an interesting observation that this author had not considered previously; after an "exploration lag", portable electricity meant that refrigeration and air conditioning was created, and opened a large portion of the southern regions of the United States to economic development, as well basically ending food spoilage.
- Internal combustion engines. The transportation revolution through the internal combustion engine allowed the development of the automobile, mobile transportation (trucks), and air transportation. Gordon also notes that the opening of transportation systems led to the creation of the supermarket.
- Petroleum and processes to "rearrange molecules" that developed from the discovery of oil. This is tied to the internal combustion engine (without petroleum, the engine may not have been developed), but Gordon separates them as petroleum can be made into plastic and other materials, and also replaced coal as a fuel in many applications.
- The combination of communication, entertainment, and information innovations that started with the telegraph, moved to the telephone, cinema, large circulation print media, television, and recorded music.

Gordon (2000;35) states:

> "*… The "Group of Four" inventions, in turn, created an increase in per-capita income and wealth that allowed an improvement in living standards even in those aspects of consumption where inventions did not play a major role, particularly the ability of families to afford many more square feet of shelter (and in the suburbs more land surrounding that shelter).*"

The accumulation of the wealth Gordon (2000;38-40) believes occurring in the "one great wave" of American productivity increase is based upon the American approach of limiting immigration and becoming more isolationist in international trade after the First World War.

In 2004, Gordon wrote about his hypothesis as to why Europe had fallen behind the United States in productivity and did not experience the same growth between from 1995 to 2003. Again, the reader should bear in mind that the revised Conference Board data (2018) explained in Section 3.2 of this paper paints a different picture of productivity, but this information is included to explain the widely-held perception that the EU did not perform as well as the United States for the time period in question. Using data from twelve of the fifteen EU members (excluding Greece, Portugal and Spain) updated to the OECD results for private industry, Gordon shows that Europe had closed the productivity growth gap to 94% of the United States level by 1995, but had dropped back to 84% by 2003 (Gordon,2004;3-4). Retail, wholesale, and securities trading industries led the American productivity increases instead of classified as ICT-producing or ICT-using (Gordon,2004;7), whereas the same European sectors experienced deceleration at a rate greater than the rest of the European economy during the same period. Gordon cites many reasons why *"...Europe was left at the Station when America's productivity locomotive departed*". The first factor Gordon notes in the more restrictive real estate development regulations in Europe; densification in urban centres versus the suburban or exurban development experienced in the United States (Gordon,2004;15). The second issue Gordon addresses (Gordon,2004;16-31) is the drag on European innovation due to labour and institutions that are more protectionist and allow established, mature approaches to be protected from new technology or new market entrants. Additionally, American privately and publicly-funded universities and research and development exist in a competitive environment for attracting both the best students and government research grants in a peer-reviewed manner rather than traditional hierarchies that are rewarded for longevity instead of merit. In substantiating the educational advantages of American schools, Gordon (2004;21-22) mentions that the co-location of certain innovation hubs generally occur near noted Universities; Silicon Valley's proximity to Stanford University in California, and the hardware, software, and biotech industries surrounding M.I.T. and Harvard in Massachusetts. Easier access to capital markets and financing in the United States allows for more rapid business development (Gordon,2004;26-27), and the less-restrictive competitive regulations and cultural approaches to capitalism (Gordon,2004;13-14) enhances the dynamism of the productivity environment in the United States.

Gordon (2013) determined that American manufacturing productivity has been an excellent performer, but is burdened with a declining employment share and the share of nominal GDP (Gordon,2013;1-2). The output per hour since 1972 for the manufacturing sector has outpaced the non-manufacturing results on a routine basis, although the overall productivity growth has slowed since 2004 to 1948 - 1972 levels. The data in the table below is taken from Gordon's calculations (Gordon,2013;2), with emphasis added by this author.

United States, Total Economy, Manufacturing, and Non-Manufacturing Output per hour (percent average yearly rate of change)			
Time Period	Total Economy	Manufacturing	Non-Manufacturing
1948-1972	2.82	2.46	2.95
1972-1996	1.55	2.69	1.29
1996-2004	2.90	**4.60**	2.63
2004-2011	1.59	2.52	1.47

Table 3.3.1.3 – American Output per Hour, 1948 – 2011
Source: Gordon (2013;2)

Gordon (2013;15) also addresses the observation that capital deepening appears to not have an effect on the American economic growth over the time period between 1891 and 2011. The same relative ratio between Labour Productivity and Multifactor-Productivity of 1 to 0.75 changes in the 2004 – 2011 time period to relatively 1 to 0.50. Gordon (2013;16) attributes this to the declining impact of inventions in this "third industrial revolution (ICT-induced)" as compared to the second industrial revolution. This direction harkens back to his 2000 work that put forth the single invention of ICT versus the conflagration of the four different inventions that drove economic growth between 1891 and 1950. Gordon's pessimism also extends to the standard of living for Americans which sees the falling education level, which he forecasts to drive a falling productivity level, growing income inequality between the top 1% and the rest of the population, debt burdens, and very real possibility that any future inventions will not have the same impact to the world economies that past ones have, means a potential return to a long-term productivity growth level between 0.2 and 0.5 percent; mimicking that best current estimates of the results between the years 1300 and 1700 in the United Kingdom.

Gordon argues that by 2006 the productivity impact of the "third industrial revolution – the digital one" had waned as the technology had reached maturation (Gordon,2018;8). In this paper, Gordon elevates his view of economic and productivity trends to consider other factors impacting the productivity slowdown in the United States and the EU-15 beyond ICT-driven productivity growth, and additionally uses data from the countries of "Developed East Asia" [Japan, Hong Kong, Taiwan, South Korea, and Singapore], with occasional Canadian statistics added for comparison to the United States. This author reminds the reader that in the context of using only the EU-15 data, Gordon's findings are valid, yet, the reader should balance this with the findings that when the total EU-28 are included, the results are that the EU-28 has had stronger growth than the United States. The stagnation of American productivity growth after the 1996-2006 leap forward for both the United States and Developed East Asia have decreased to below 1970-1996 levels (Gordon,2018;8), with the EU-15 trailing the United States by almost a half a percentage point and East Asia by almost a full percentage point. As his arguments pertain to the impact of ICT-based productivity gains, Gordon (Gordon,2018;8) supports the view that the demand for cognitive skills will decrease after the crest of investment has passed. Basically, to paraphrase Gordon, ICT development and productivity gains through investment has reached a point where it has plateaued and the level of knowledge and cognitive skills required to perform work has decreased due to the assistance of technology. At the same time as the demand for cognitive skills has decreased, the growth in the educational level attained in the United States has also decreased; following average growth of high school graduation growth rate of 3.3% from 1915 to 1980, but only 0.2% from 1980 to 2016. Growth of four-year college degrees fell from 3.7% annual growth between 1925 and 1980 to 1.3% growth from 1980 to 2016 (Gordon,2018;6). Even with declining growth in educational attainment, there are indications that over-skilling is increasing in the job market; where those who have four-year degrees are underemployed (Gordon,2018;7), which connects with the decrease in demand for cognitive skills mentioned earlier. While productivity growth numbers have decreased in recent years, they are still positive, but some areas of the economy are more troubling to Gordon. Prime-age labour force participation for males aged 25 to 54 has decreased from 98% in the 1950s to 88% in 2018, and for those without a high school diploma, it decreased to 84% (Gordon,2018;4). In addition, the mortality rates for white, non-Hispanic males with less than a high school education has increased by 1.6% from 1999 to 2016 (Gordon,2018;3). Birth rates have declined from a replacement rate of 2.1 in 2007 to 1.8 in 2015, which is significant to the available labour pool in the future, and to which Gordon (Gordon,2018;3) attributes to the decreased labour participation of prime-aged males either without a high school diploma or those college educated males who are underemployed comparative to their education levels, and the ability of women to be more independent than the past due to expanding employment opportunities. Having a labour pool that is stocked by individuals [i.e.: population growth] has also fallen due to decreased immigration (Gordon,2018;4). The annual increase in foreign-born individuals living in the United States has decreased by almost half from 0.37% for the time period of 1990 to 2000, to 0.20% for the time period of 2010 to 2016. High unemployment in the U.S. due to the global economic crisis, improving conditions in Mexico, and forced deportations were cited by Gordon as factors in the decrease of Latin-American immigration, whether legal or illegal. Innovation, in the context of patent applications, is one area where there has not been a decrease in growth over time; the number of patents issued in the United States from 1996 to 2006 grew by 24.2% as compared to the 2006-2016 increase of 27.9% (Gordon,2018;8-9). Patents generally point to innovation, but Gordon (2018;9-10) observes that the forecast 'Fourth Industrial Revolution" as predicted by many pundits is in its and though robotics and artificial intelligence may supplant human worked and create huge job losses in the future, the technology has not advanced to that point. Gordon views the future job losses from technology to be more evolutionary than a sudden revolution, taking much more time than the technology optimists forecast.

3.3.2 Canadian Productivity Research

Rao and Tang (2001) compared the differences between the ICT contribution to productivity growth in both Canada and United States during the decade of the 1990s. Canada's ICT-manufacturing sector has a labour productivity growth rate of 5.3% from 1990 to 1995, and 5.8% from 1995 to 2000 in comparison to the Unites States results of 19.7% and 45.2% in the respective time periods (Rao and Tang,2001;11-12). The results of the Canadian productivity growth in the latter period outstripped the overall economy which was 1.7%, but the American result of 45.2% contributed more than half of the overall economy labour productivity rate of 2.5%. Rao and Tang (2001;14) also note that the United States' lead in labour productivity in manufacturing was due to the ICT-producing industries, and the electrical and electronic equipment manufacturing sector grew at an average 20.4% which was almost 2 and a half times the result of the same Canadian sector. Table 3.3.2.1 below is taken from Rao and Tang (2001;11).

Relative Labour Productivity Levels in ICT Manufacturing Industries (1992$)						
(Aggregate Manufacturing = 1.00)						
Industry	Canada			United States		
	1989	1995	2000	1989	1995	2000
Computer and Office Machine	0.5	1.5	3.3	0.7	2.0	9.2
Communication and other electronics	1.3	1.2	1.8	0.8	2.0	8.7
ICT Manufacturing*	1.1	1.2	2.2	0.8	1.9	8.4
*Excluding instruments						
Sources: Compilations based on data from Statistics Canada, U.S. Bureau of Labour Statistics, and Federal Reserve						

Table 3.3.2.1 – Relative Labour Productivity levels in ICT Manufacturing Industries, Canada vs. United States
Source: Rao and Tang (2001;11)

Khan and Santos (2002) used a simple growth accounting method to investigate the contribution of ICT to labour productivity growth in Canada versus the United States in two time periods: 1991 to 1995, and 1996 to 2000. They note that while the average growth rate of computer hardware capital stock has been generally high in both countries, the growth rate in Canada was moderate compared to the United States in the latter part of the 1990s. While ICT contributed 0.53 percentage points to Canada's 4.75 percent productivity growth in the business sector for an overall 11% of total growth, the United States result which was 23% of total growth (Khan and Santos,2002;7-8). Through the 1990s, Canada's composition of ICT contributed growth changed; capital ICT hardware deepening increased while software and telecommunications contribution was marginally lower whereas the United States showed increases in capital deepening for all three factors while increasing labour productivity from 1.5% to 2.5% from the early 1990s to the late 1990s (Kahn and Santos, 2002;8-9). Similarly to the European Union, the late 1990's productivity surge the United States experienced did not spill over to Canada.

Dirk Pilat from the Organization of Economic Cooperation and Development (OECD) expanded their examination of member state's productivity with a special view of Canada versus the rest of the OECD in 2005. Pilat found that in the period between 1990 to 1995 many OECD countries' labour utilization fell while labour productivity grew strongly, while in the time period between 1995 and 2003 labour productivity growth fell while labour participation grew, and these countries were mostly in Europe, and comparatively, both Canada and Ireland increased both measures (Pilat,2005;25). Pilat commented that this would indicate that there does not have to be a trade-off between the two measures as it indicates a well-functioning labour market which allows for the reallocation of workers which is important during technological and economic change. Canada actually had marginally higher GDP per hour worked growth in the 1990 to 1995 time period, but less between 1995 and 2003; this was the time period where many EU countries experienced the same effect while the United States grew at a much quicker rate (Pilat,2005;27-28). ICT capital investment between Canada and United States shows a large difference, but compared to other OECD countries, Canada's ICT investment performance was ninth of nineteen countries, placing Canada in the upper half of results (Pilat,2005;30). In the same section, Pilat points out that countries that have higher productivity and levels of income tend to have larger incentives to invest in technologies or equipment that will increase efficiency versus lower labour factor countries. As well, Pilat posits that countries that have larger average firm sizes and service sectors are likely to have larger ICT investments, which may explain Canada's smaller relative ICT investment. ICT manufacturing is different amongst countries, and the United States has a high level of ICT production (Pilat,2005;32-33) and due to this, countries with lower levels of ICT production did not reap the benefits of the multi-factor productivity growth that the United States achieved; although during the time periods examined by Pilat [1990-1995 and 1995-2002], Japan, Sweden, Finland, Ireland, Korea, and in the 1995 to 2002 time period Hungary as well exhibited labour productivity growth that in some ways out-stripped the United States. In his conclusion, Pilat (2005;42-43) states that ICT-driven productivity impacts different countries in different ways, which are dependant upon the structural composition of a state's economy. In Canada's case, the small ICT-producing sector and smaller firm sizes mean that catching up to other OECD countries in productivity growth from ICT investment in ICT-producing and ICT-using sectors did not appear to be a possibility.

Sharpe (2006) studied Canadian Productivity and ICT investment for the Canadian group the centre for the Study of Living Standards up to the year 2005. A wide-ranging review of ICT investment, use, literature, and differences with mainly the United States. He found that ICT investment benchmarks may not show the entire story concerning the efficacy of ICT investment, the comparison to the United States as the most important trading partner for Canada was the most used benchmark, but may not tell a complete story unless other country's results are also included to see whether there are nuances in Canada's results. Using OECD data, Sharpe (2006;42) notes that Canada ranked ninth out of nineteen countries overall in non-residential fixed capital ICT investment in the total economy, but lagged the leader United States by about 30%. While Canada's performance against the Unites States would be compared as lacklustre, in the section Sharpe is careful to point out that while Sweden, the United Kingdom, Belgium, Finland, Australia, and Denmark all spent a higher percentage of GDP on ICT investment, the countries that were below Canada are not economic laggards; the consisting of Ireland, the Netherlands, Germany, Italy, Japan, and France. Sharpe also comments (2006;39) that the connection between ICT capital investment and labour productivity is nuanced and not straightforward and can be negatively impacted by R&D intensity, business cycles, profitability, and industry-specific factor pricing. ICT investment in the business sector were also areas where proportionally were higher in the United States (Sharpe,2006;43-45). As a share of total investment in 2005, Canada's ICT investment was 18.3% compared to the 29.5% in the United States. ICT investment as a percentage of the business sector's GDP was 2.65 in Canada and 3.87 in the United States. The third 2005 indicator that Sharpe examined was ICT investment per worker, where Canada invested $1,756 USD versus $3,242 USD for the United States. Concluding the paper, Sharpe (2006;77) states that ICT has been the driving force behind productivity growth in Canada and the United States since 1996, but Canada has not fully exploited the potential of ICT as of the publishing of the research.

Using a novel approach to identifying technological change and impacts, Alexopoulos and Cohen (2012) tracked the difference in Canadian and American effects of computer technologies. The argument for the paper was based upon the dates of commercialization of various ICT hardware and software products, and then the number of new book titles on computer-related subjects and computer science held by libraries in the both Canada and United States as a proxy of technological change as evidence of the market seeking knowledge about the technical advance, and that more publications are printed on important advances than on minor advances (Alexopoulos and Cohen, 2012;18-19). They find that there is a correlation between adoption of new technologies and increases in productivity (Alexopoulos and Cohen,2012;23-24), but that there were differences in the number of titles held in Canadian libraries versus American libraries.

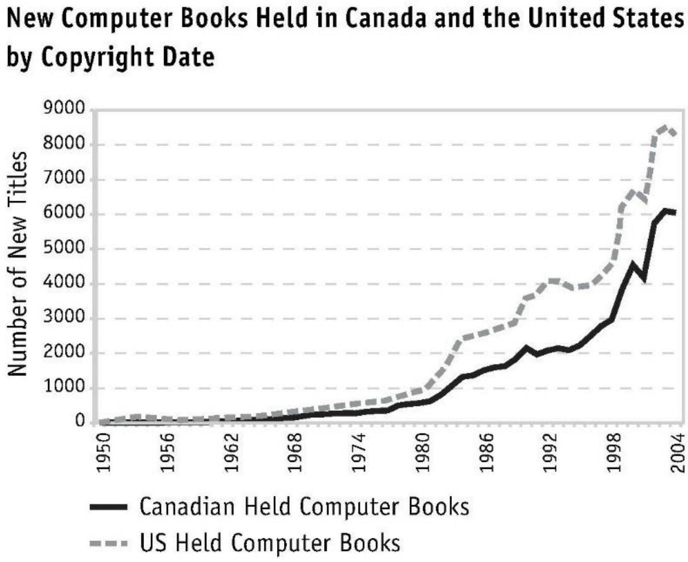


Figure 3.3.2.1 – New Computer Books Held in Canada and the United States by Copyright Date
Source: Alexopoulos and Cohen (2012,27).

While Alexopoulos and Cohen (2012;28) found that technology shocks led to increases in Total Factor Productivity and Gross Domestic Product, and hours worked in both Canada and the United States, they could not find causality of why the lagging of Canadian libraries acquiring new titles of technical literature fell behind the United States and connection to the productivity gap that appears to occur about the same time, taking adoption lags into consideration.

Sharpe and Tsang (2018) completed an analysis of both labour productivity and total factor productivity (TFP) for Canada from 1980 to 2016. They found that Canada experienced the same general trends that the European Union and Developed East Asian countries experienced in relation to productivity growth from 1980 to 2016 where the time period since 2000 has seen slower productivity growth; whereas the average growth in output per hour was 1.6% until 2000, since that time, it has been 0.9% average (Sharpe & Tsang,2018;52). The Table 3.3.2.2 below is a compilation of the data from Sharpe and Tsang showing the various industry sectors and the productivity growth performance (Sharpe & Tsang,2018;62-65).

Canadian Labour and Total Factor Productivity Growth 1981-2000 and 2000-2016						
	Labour Productivity Growth Average %			Total Factor Productivity Growth Average%		
Industry	**1981-2000**	**2000-2016**	**Delta**	**1981-2000**	**2000-2016**	**Delta**
Accommodation and Food Services	-0.54	0.27	0.81	-0.04	-0.02	0.02
Agriculture, Forestry, Fishing, and Hunting	2.79	2.83	0.04	0.18	0.09	-0.09
Arts, Entertainment, and Recreation	-2.16	0.36	2.52	-0.04	0	0.05
ASWMRS	-0.14	0.68	0.82	-0.09	-0.01	0.08
Business Sector Industries	1.7	0.88	-0.82	1.6	0.91	-0.69
Construction	0.23	-0.64	-0.87	0.02	-0.1	-0.13
Finance, Insurance, and Real Estate (FIRE)	1.55	1.45	-0.1	0.25	0.26	0
Information and Cultural Industries	2.1	1.91	-0.18	0.09	0.07	-0.01
Manufacturing	3.34	1.12	-2.22	0.8	0.18	-0.62
Mining, and Oil and Gas Extraction	2.31	-1.04	-3.35	0.18	0.03	-0.14
Other Private Services	-0.13	0.64	0.76	-0.06	0.02	0.08
Professional, Scientific, and Technical Services	0.79	0.8	0.01	0.02	0.05	0.03
Retail Trade	2.21	1.64	-0.56	0.16	0.08	-0.08
Transportation and Warehousing	1.5	1.56	0.05	0.09	0.1	0
Utilities	1.33	0.56	-0.77	0.03	0	-0.02
Wholesale Trade	3.41	2.84	-0.87	0.18	0.21	0.03
Information taken from Sharpe & Tsang (2018), pages 63-64. Rounding errors may be present from original Statistics Canada data Table 36-10-0208-01 used by Sharpe & Tsang.						

Table 3.3.2.2 – Canadian Total Factor Productivity
Source: as combined by the author from Sharpe & Tsang, 2018;63-64.

Canada’s productivity peaked around the year 2000, but the overall slowdown in productivity growth was the sixth-smallest of 33 OECD countries, but this points out that Canada’s productivity growth was fairly weak through the 1981-2000 time-frame ranking 30th of 33 countries (Sharpe & Tsang,2018;71). What cannot be accurately measured or attributed is why total factor productivity decreased, but Sharpe & Tsang (2018;71) note that while causality is not certain, that result does not appear to be connected with decreased human capital or capital intensity growth for the time period. Analyzing Sharpe & Tsang’s data in Table 3.3.2.2, Manufacturing experienced the second-largest labour productivity decrease, losing 2.22% between 1981-2000 and 2000-2016; while this may be concerning, growth remained positive during the latter time-period, even if the growth was low. Of those sectors that experienced more than three-quarters of a point labour productivity loss, Business, Utilities, and Wholesale Trade remained with positive growth, whereas Construction and Mining/Oil and Gas Extraction experienced negative growth after 2000. Arts, entertainment, and recreation had the largest percentage gains in labour productivity at just over 2.5%, but Accommodation and Food Services, ASWMRS (administrative support, waste management, and remediation services), and Other Private Services all experienced positive growth from 2000 to 2016 after average negative growth from 1981 to 2000. While not referenced earlier in the paper, Sharpe & Tsang (2018;72) note that research and development funded by business enterprise research and development (BERD) funding decreased from 1.2% of GDP in 2000 to 0.7% of GDP in 2016, and that this was almost entirely attributed to reduced spending in the Manufacturing sector, which consequently experienced the largest productivity decrease.

Mollins and St-Amant (2019) updated the Bank of Canada’s view on ICT contribution to productivity. Using three time periods; 1993 to 2000, 2000 to 2008, and 2008 to 2014, the authors use two different approaches, a simple two-sector approach (STS) (Mollins & St-

Amant,2019;6-7), and one combining use, production, and price effects (CUPP) (Mollins & St-Amant,2019;9-11). Both regression analyses results show relatively the same results for the contribution of ICT to productivity using data from Statistics Canada. Table 3.3.2.3 below is created from Mollins and St-Amant's aggregated data (Mollins & St-Amant,2019;18).

ICT Contribution to labour productivity growth (Mollins & St-Amant, 2019;18)							
Time Period	ICT Contribution to Productivity Growth - STS (% points)			ICT Contribution to Productivity Growth - CUPP (% points)			Labour Productivity (%)
	Use Effect	**Production Effect**	**Total Contribution**	**Use Effect**	**Production Effect**	**Total Contribution**	
1993-2000	0.42	0.15	0.57	0.34	0.15	0.49	1.92
2000–2008	0.37	0.10	0.47	0.67	0.10	0.77	0.86
2008-2014	0.02	0.04	0.04	0.10	0.04	0.14	1.19

Table 3.3.2.3 - ICT Contribution to Productivity Growth
Source: Mollins & St-Amant (2019;18)

Mollins and St-Amant (2019;21-22) found that ICT still contributes to productivity growth, but weaker ICT contribution has been the cause of approximately 30 percent of the decrease in productivity. They also found that the decrease in ICT's contribution and the slowdown in productivity did not occur at the same time; productivity slowed in the early 2000s, the ICT contribution did not lessen until after the 2008 Global Financial Crisis and recession. Of note, Mollins and St-Amant (2019;22-23) point to the issue of technology change in being able to compare ICT contributions of the past with more recent results. ICT moving to web-based services and cloud storage may not be adequately quantified in the productivity statistics, especially if the services are procured from another country, and a second point that intangible capital may be taking the place of ICT capital investment in some cases.

Section Summary:

This section started with McLuhan and Powers' correspondence (1989) with somewhat prophetic implications about what the computer will do to work and society. What ICT investments were first thought to be by academics may have changed, certainly how the impact of ICT has been perceived and studied has changed. From Solow's Paradox (1987) of seeing computers everywhere except in the productivity statistics to Solow's protégé Gordon (2018) arguing that ICT has run its course as an innovation, there are those who do not believe that ICT will have a large an impact upon society as previous inventions.

Whether you believe ICT is "golden arrow" or a "lead penny", researchers like Polák (2014) question that way that ICT is measured because of its all-encompassing impact on our daily work and personal lives.

Researchers like Brynjolfsson and Yang (1996;42) found that measuring ICT impact was becoming more difficult through the 1990s as declining prices, organizational support and innovations acting as "intangible assets" (Brynjolfsson and Hitt,2002,16), a substitute for labour (Brynjolfsson,2003;3-4) and the need for complementary organizational investment (Brynjolfsson and Hitt,2003;27). In a somewhat defeatist reflection, Brynjolfsson, Rock, and Syverson (2017) identify four possible reasons that Solow's Paradox continues as: False hopes created by the potential returns on investments, inaccurate measurement methodologies of ICT impact, Concentrated Distribution and Rent Dissipation where the spoils are taken by the successful, and finally, implementation and restructuring lags from implementation to impact.

Van Ark and his various co-authors identified the differences in contribution to productivity growth through various business sectors (van Ark et al,2003a;60) to argue that growth in the American Wholesale trade, Retail trade, and Securities sectors, which were in the ICT-using services sector, made the difference in American and EU-15 productivity assisted by deregulation in the United States, at the same time the EU-15 was hindered by more restrictive regulations on development, retail access, and labour laws (2003b;14). In 2016, van Ark revisited the subject while considering the "New Digital Economy" of cloud computing [and while left unsaid by van Ark, this author posits perhaps artificial intelligence as well] and draws parallels to the installation period of the "Old Digital Economy", but an accurate forecast cannot be made at this time (van Ark,2016;16).

Gordon (2000;33-35) makes what appears to his baseline ideology that the "Third Industrial Revolution" [ICT-induced] has fizzled out, and historically cannot be compared to the four great inventions/innovations that allowed for the great expansion to take place from 1891-1973: electricity, Internal combustion engines, Petroleum processing, and the combination of communication, entertainment, and information innovations. Gordon (Gordon,2003;15) cites the same causes as van Ark with more restrictive regulations in the EU-15 compared to the United States. The most interesting argument [to this author] that Gordon (2018;4-10) has made is that the living standards of the average American has decreased over time and are related to declining birth rates, the high cost of tertiary education, a decrease in the labour participation of prime-aged males, and decreased immigration. Gordon (2018;9-10) observes that the forecast 'Fourth Industrial Revolution" as predicted by many pundits is in its and through robotics and artificial intelligence may supplant human worked and create huge job losses in the future, the technology has not advanced to that point. Gordon views the future job losses from technology to be more evolutionary than a sudden revolution, taking much more time than the technology optimists forecast.

In Canadian ICT-influenced productivity research, Rao and Tang (2001;14) also note that the United States' lead in labour productivity in manufacturing was due to the ICT-producing industries, and the electrical and electronic equipment manufacturing sector grew at an average 20.4% which was almost 2 and a half times the result of the same Canadian sector. Canada's much smaller ICT-producing sector performed well, but while ICT contributed 0.53 percentage points to Canada's 4.75 percent productivity growth in the business sector for an overall 11% of total growth, the United States result which was 23% of total growth (Khan and Santos,2002;7-8). Pilat found that in the period between 1990 to 1995 many OECD countries' labour utilization fell while labour productivity grew strongly, while in the time period between 1995 and 2003 labour productivity growth fell while labour participation grew, and these countries were mostly in Europe (Pilat,2005;25). Comparatively, both Canada and Ireland increased both measures (Pilat,2005;25). Mollins and St-Amant (2019;21-22) found that ICT still contributes to productivity growth, but weaker ICT contribution has been the cause of approximately 30 percent of the decrease in productivity. They also found that the decrease in ICT's contribution and the slowdown in productivity did not occur at the same time; productivity slowed in the early 2000s, the ICT contribution did not lessen until after the 2008 Global Financial Crisis and recession.

While the summary above does paint the picture of productivity between the United States and the EU-15 with relative correctness, the revised Conference Board data (2018) and taking into account the entire European Union paints a different picture for the EU as a whole. The low levels of productivity for EU-15 should be a major concern for the EU as the EU-15 has approximately 80% of the EU's population, but excluding the EU-13 does not allow one to examine the entire chess board. Figure 3.3.2.4 shows the results for the time period from 1996 to 2006 that most articles use to argue that "Europe was left behind". The EU-15, with the revised Conference Board data (2018) still trails the United States, but taking into account the EU-28 results, it may very well be Canada that has been left behind with an average GDP growth rate of 1.35% from 1996 to 2006 and 0.61% from 2008 to 2018 [refer to Table 3.2.1.1].

Gross Domestic Product Growth per Person Employed, 1996 - 2006												
Country	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Average**
Canada	0.57	2.26	1.60	2.47	2.83	0.84	0.53	-0.36	1.41	1.66	1.04	1.35
United States	2.61	2.58	3.42	3.61	3.23	1.45	2.56	2.80	2.90	2.00	1.07	2.57
EU-28	2.18	3.27	2.66	2.10	3.91	2.20	2.80	2.49	3.53	2.61	2.86	2.78
EU-15	1.62	2.44	1.43	1.92	2.30	0.60	1.01	1.04	2.25	0.92	1.60	1.56
EU-13	2.82	4.22	4.08	2.31	5.78	4.05	4.87	4.16	5.00	4.57	4.30	4.20
Nordic	1.97	2.50	2.22	2.12	2.74	0.15	0.61	1.74	3.72	1.53	2.02	1.94
Northwestern	2.78	4.18	1.95	2.85	3.67	2.15	3.14	1.78	2.22	1.50	1.15	2.49
Continental	0.75	2.02	1.33	1.77	1.80	-0.07	1.15	0.42	1.79	0.78	1.73	1.23
Southern	1.69	2.51	1.82	2.12	3.21	0.78	0.78	0.80	1.03	0.55	1.32	1.51
CEE	3.06	4.36	4.01	2.10	5.73	4.77	5.39	4.75	5.85	5.17	4.82	4.55

Table 3.3.2.4 - GDP Growth per Person Employed 1996 to 2006
Source: Author input of the Total Economic Database, Conference Board (2018)

3.4 Patents and Research and Development (R&D) Investment

Much of the literature that this author reviewed included both Research and Development (R&D) and Patents at the same time. While the investment in R&D can be seen as the input, Patents [for innovations or new products] can be seen as the output of the investment.

Intellectual property protection is very important for firms when creating new products, processes, or technology. Created in 1967, the World Intellectual Property Organization operates through a convention that brought together existing historical agreements and new aspects to protect inventors and creators of *"…literary, artistic, and scientific works, performing arts, music, broadcasts, inventions in all fields of human endeavour, scientific discoveries, industrial designs, trademarks, service marks, commercial names and designations, and protection from unfair competition*" (WIPO, 1967).

Griliches (1989;3) notes that the number of patents issued in the United States decreased in the 1970's, following the decreasing productivity trend that also occurred during that time period. Griliches, though, does point out that patents are not a "constant-yardstick" to indicate inventive input or output. Even though the paper is somewhat historical in nature [1989], Griliches does make salient points regarding patents: numbers of patents will not remain constant over time (Griliches,1989;21), and will be entirely dependent upon the nature of the invention, the market reach of the invention, how the invention impacts different geographic markets may vary, and ultimately this will determine how the patent may impact productivity (Griliches,1989;20-21), and with long, or at least, variable lag (Griliches,1989;22).

Farre-Mensa, Hegde, and Ljungqvist (2016;30-31) found that start-up firms that have patents granted will create more jobs, experience faster growth, be more innovative, and have increased potential to become a public company or be subject to a merger or acquisition. Their research used data from the United States Patent and Trademark Office (USPTO) and also showed a potential negative impact from submitting a patent; depending upon the time required for review as there were resourcing issues identified within the USPTO (Farre-Mensa, Hegde, and Ljungqvist (2016;31-32).

Raghupathi and Raghupathi (2017;15-16) found that nations with low economic indicator rankings generally have to depend upon Foreign Direct Investment or collaborations that result in higher foreign ownership of Patents in the native countries. The product of this foreign ownership equation is that the host country does not reap the reward of the taxation on the patents (Raghupathi and Raghupathi, 2017;18). These authors also found some OECD countries use R&D investment to increase growth, whereas other countries use spillover effects from foreign investment, and due to the differences in approaches, R&D investment alone cannot be considered a singular measure of innovation.

Ketteni, Mamuneas, and Pashardes (2017;14-15), using simple regression techniques, found that R&D and Patents [in what they further explain as both product and process innovations] have a positive and statistically significant effect on the growth of productivity. They also found that both ICT capital investment and human capital [enrollment in tertiary education] also had positive influence upon productivity, while Foreign Direct Investment (FDI) did not appear to have a significant effect upon the growth of productivity.

Ortega-Argiles, Piva, and Vivarelli (2014;1362-1363) found that structural differences between the United States and the EU meant that not only were the EU countries investing less in Research and Development than the United States, they were getting less return on their investment; approximately 60% of the American result, but when examining the non-High-tech Manufacturing sector, the EU has a slight advantage compared to the United States, but when considering the High-tech Manufacturing and Services sectors, the United States has a sizable advantage. These authors cite not only the lower R&D investment, but also perceived lower levels of human capital or a lag in the impact of organizational changes that are required compliments to productivity growth.

Kijek, Matras-Bolibok, and Rycaj (2017;152) found that Public investment in R&D carried out by Private companies caused an increase in the investments that the Private firms then make. While government support is important in increasing overall R&D investment, the level of regional economic development may impact the effectiveness of Public investment. Moreover, they found that the EU provides slightly more financial support to businesses than the United States (32% of R&D funding versus approximately 30% for the United States). For more information on Government support of R&D, please refer to Section 4.2 of this document.

3.5 A brief comment about Artificial Intelligence (AI)

This appears to be an appropriate location in this research paper to very briefly address Artificial Intelligence and the potential impacts upon innovation, employment, and productivity. There appears to be a large amount of uncertainty surrounding the impact that AI will have upon the global economies and what AI will actually mean to employment. This section starts with the fears of certain notables and ends with one of the more balanced views of the impact AI will have on society as a whole.

Since the minds of science fiction writers started exploring the machine with power over man in main stream media in 1920s films such as Metropolis (Lang,1927) and even earlier with Butler (1863):

> *"…Day by day, however, the machines are gaining ground upon us; day by day we are becoming more subservient to them; more men are daily bound down as slaves to tend them, more men are daily devoting the energies of their whole lives to the development of mechanical life. The upshot is simply a question of time, but that the time will come when the machines will hold the real supremacy over the world and its inhabitants is what no person of a truly philosophic mind can for a moment question.*"

Noted academics and others have also made predications about AI that may, or may not, be based upon nothing more than their opinion. Stephen Hawking told the BBC (Cellan-Jones,2014) that "*...The development of full artificial intelligence could spell the end of the human race.*". James Barrat (Barrat,2013;223) challenges readers to use their own perceptions when judging whether IBM's Watson thinks or not. Elon Musk told the Washington Post (McFarland,Washington Post,2014) that:

> "*I think we should be very careful about artificial intelligence. If I were to guess like what our biggest existential threat is, it's probably that. So we need to be very careful with the artificial intelligence. Increasingly scientists think there should be some regulatory oversight maybe at the national and international level, just to make sure that we don't do something very foolish. With artificial intelligence we are summoning the demon. In all those stories where there's the guy with the pentagram and the holy water, it's like yeah he's sure he can control the demon. Didn't work out.*"

AI experts see the future in a much less threatening way. Atkinson (2018a;5) says that no matter the power of the computer and the artificial intelligence created, it will not have the problem-solving ability that a three-year-old child has. In fact, even if it becomes possible to have massive arrays of computer chips in a super-computer to be able to carry out simple tasks while being sentient, the affordability of such machines to do this is not realistic (Atkinson,2018a;9-10) as even exponential growth will not solve the S-curve of slowing growth in maturity that is every technology's ultimate fate. Brooks (2015;111) states that while AI has made great strides, it does not have the ability to understand what it is doing beyond the task programmed into it, and that humans using "suitcase" words that imply something in general knowledge to us cannot be applied to the learning machine, such as discerning an intact image of a complete person versus a collage of disparate parts; the machine would identify both as a person. In addition, Brooks states that:

"…*people are making category errors in fungibility of capabilities. These category errors are comparable to seeing more efficient internal combustion engines appearing and jumping to the conclusion that warp drives are just around the corner*."

Atkinson (2018a;3) takes a view of the fear of the impact of AI upon human life as being part of the "Technology Panic Cycle". Figure 3.3.1 illustrates Atkinson's view of the phenomena. Atkinson states that, in his opinion, the United States is in the "Rising Panic" stage of AI discovery and adoption.

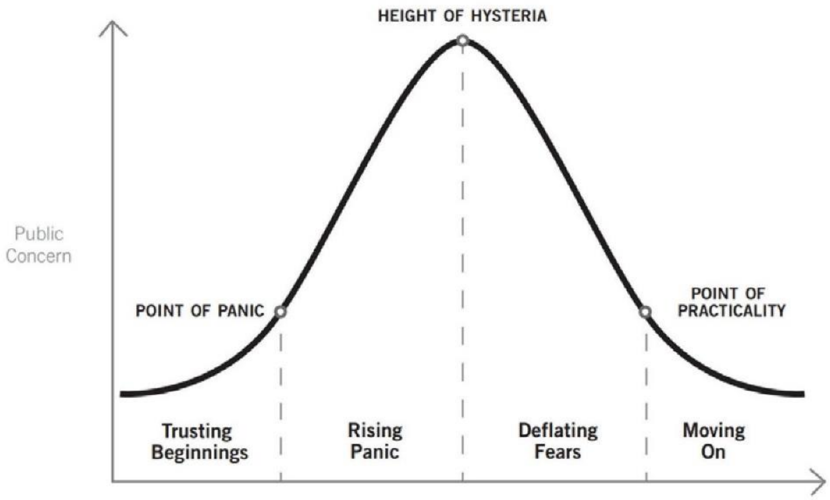


Figure 3.5.1. Technology Panic Cycle
Source: Atkinson (2018a;3)

Alasoini et al (2018;50) remind their readers that AI does not learn the same way as humans and has no conceptual understanding whether what it is learning is morally correct and also the difference between statistical truth versus absolute truth.

Artificial Intelligence will take over some repetitive tasks or certain analyses of data or patterns that is difficult for humans to do by themselves as noted in Figure 3.5.2 (McKinsey and Company,2017;6). There are other jobs that will not be able to be automated or have robots perform such as legislators, massage therapists, athletes, pre-school teachers, firefighters, barbers, and trial lawyers (Atkinson,2018a;7-8). Järvensivu et al. (2018;14) state that jobs at the top and bottom of the employment distribution will be maintained or even expand through implementation of AI: those jobs that require a personal approach, have few routines, require flexibility, problem-solving ability or creativity because these traits are difficult to digitize. One issue in Järvensivu et al.'s (2018;19) policy recommendations is to ensure that there are not skill shortages at the top [expert] levels as those with lower educational levels cannot find jobs. Should this occur, this researcher can envision a situation where elitist [expensive] education freezes out many students that would normally be in the middle of the employment distribution but are not able to afford it, thus being shunted into the lower distribution creating an increased level of social inequality. In addition to the specific people-oriented or non-routine tasks that will not be easily replaced, Vuorenkoski et al. (2017;39) also put forth that jobs that require extensive use of background information or general knowledge will also not be easily replaced by AI.

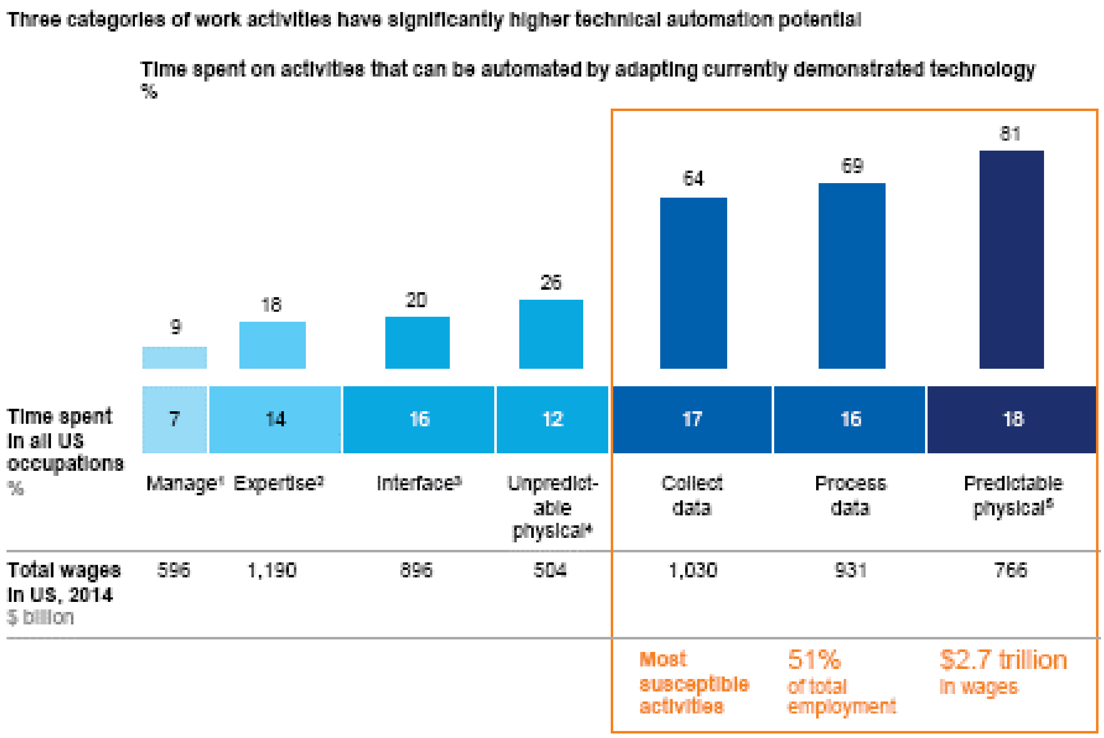


Figure 3.5.2 – Task Automation Potential
Source: McKinsey and Company, (2017;6)

Because AI hasn't exploded into the economy replacing jobs everywhere, all at the same time, and exhibiting the troublesome characteristics that the AI-negative pundits espouse, the estimates of the impact on employment vary greatly from researcher to researcher. Atkinson (2018a;10) states that automation will likely lead to redefinition of jobs for workers in the near and medium-term versus outright destruction of jobs. Miller (2013) estimates that 20% of U.S. jobs might be automated within a decade or two, but 50% of jobs will be difficult to automate with the 30% of jobs remaining being extremely difficult to automate. Nedelkoska & Quintini (2018;47) say that 14% of jobs in 32 OECD countries have a risk of automation between 50% and 70%. That researchers have moved from saying a certain percentage of jobs will be lost to AI to now framing the potential future with a percentage of jobs and probabilities shows how the view of AI is changing, and perhaps how the understanding of AI is changing amongst those who are not computer scientists but who look at work organization. The McKinsey report on "A future that works" (McKinsey,2017;27) examined the functions and capabilities to perform certain jobs and found that while only 5% of occupations could be totally automated, approximately 60% of all occupations have at least 30% of the job that could be automated.

The potential pathway to AI adoption quickly is the challenge due to technological iterations to create the actual tools and equipment to automate jobs, design and implementation, coupled with the requisite changes in occupations that will be required will need to have the same exploration-adoption-learning-adaption-exploitation cycle (Makó and Mitchell,2013a;15) that creates a "lag" effect that any normal organization experiences with any change. As shown with the rise of the ICT "revolution" that still has not totally fulfilled the hype of the technology (Brynjolfsson et al., 2017;6-8), AI adoption and the true impacts may take some time to be realized. The question of which employment sectors are going to be negatively impacted by human job losses by AI may be a matter of what AI can actually produce early in the implementation of the new technologies. Other factors may well play into the equation as firms may not have the appetite or financial ability to carry out a major reorganization of their firm and how they do business (Järvensivu et al.,2018;14-15). Those firms that have the ability to move quickly into AI implementation, especially in view of the global marketplace, may be able to create monopolies and increase the possibility of uneven income distribution (Järvensivu et al.,2018;15).

One of the potential positives of AI adoption is that future jobs that cannot be anticipated as yet will be created (Vuorenkoski et al.,2018;37). Brynjolfsson and Mitchell (2017;1531) [please note the "Mitchell" referred to here is not this author] state that machine learning has only been able to replace jobs where the work is routine, repetitive, and highly structured, and therefore the arguments that AI may not have the catastrophic impact on jobs that has been forecast. In fact, Brynjolfsson and Mitchell (2017;1531) suggest that even where there are jobs that are partially automated, there will remain complementary job tasks or total jobs that will remain in the realm of human-only performance.

Acemoglu and Restrepo (2018;32) developed a framework to measure the impacts of automation on the economy. They found that although automation will have an initial negative impact on employment, create a change in the skills required to find employment, and likely create a significant capital deepening, they also find that historically there has always been countervailing forces that create new tasks where labour has the advantage, thus replacing "old jobs" with "new jobs". Acemoglu and Restrepo (2018;32-33) do caution that the adjustment process could be longer than expected due to the time it takes for education or vocational training to be able to identify what skills are required and institute learning that satisfies the new skills needs in the economy.

Connecting back to the start of this section, AI has caused fear amongst many who see machines making decisions, and decisions that may impact human health or safety (Alasoini et al., 2018;48). Smith and Shum (2018;9) at the end of the passage below ask what this author considers to be the most prescient question concerning AI:

> *"In computer science, will concerns about the impact of AI mean that the study of ethics will become a requirement for computer programmers and researchers? We believe that's a safe bet. Could we see a Hippocratic Oath for coders like we have for doctors? That could make sense. We'll all need to learn together and with a strong commitment to broad societal responsibility. Ultimately the question is not only what computers can do. It's what computers should do.".*

For a future that will benefit humans through AI-based decision-making, Alasoini et al (2018;48-52) state that transparency, responsibility, and extensive social benefits are the three values that should direct the development of AI. Transparency will allow for openness in understanding [and perhaps deciding] how and what data is accumulated and how it will be used, the aim of the algorithms in assisting human decision-making or outright decision-making by the machine, and ensuring transparency so that biases and data integrity are able to be identified and addressed prior to using the algorithm. Protection, both of health and safety and legal, should be paramount in any application of AI for decision-making. Clarity will also be required when outputs of AI are actual decisions or when they are merely predictions to be used by humans to make the decisions. As well, when tax-payer dollars are used to create the AI applications or solutions, those taxpayers who lose their jobs due to AI should be supported by their society so as not to become authors of their own demise. Lastly, Alasoini et al (2018;51-52) recommend that an equilibrium be found between AI development and application to economic activity and the job losses that may occur due to said development.

One point of argument that this author has not been able to find much conjecture on is which economies will be impacted by AI first, and how will that impact the spread of AI. The McKinsey Report (2017;9) outlined the impacts on a few selected economies, but not a broader understanding of the countries included in this research from European Union, although in some cases the United States, and Canada were included. The McKinsey Report (2017;15) does state that advanced economies with aging workforces could benefit from productivity increases due to rapid automation adoption. Further commentary on AI-driven impact will be made in the Conclusions.

3.6 Chapter Summary

This chapter examined productivity in the broad sense, and also what impacts Information and Communication technologies have had upon productivity. Perhaps the most interesting finding is that the perceived falling behind of Europe versus the United States that permeated literature during the 2000s may not be quite correct in view of revised data. The 2018 Conference Board adjusted productivity data shows that, when the entire European Union is taken into account rather than just the EU-15, Europe (as a whole) was not "left behind at the station" as Gordon (2004;1) and conventional economic thought had dictated, but there should be concern over the EU-15 performance that is trailing both Canada and the United States. Timmer et al.'s research (2011) used Conference Board data from 1950 to 2009 for the United States and the EU-15 to reach their conclusions. There are a couple of caveats in this review of Timmer et al.'s work, or for that matter any of the researchers from that era examining the subject, that are very important to consider when examining their results and the revised 2018 Conference Board data. One is that Timmer et al. (2011) used the best available data at that time. In addition, their review using only the EU-15 may have been warranted as the Central and Eastern European New Member States had experienced what can be considered to be a massive transition from planned economies to free market economies, and Timmer et al. (2011) may have wanted to use "like for like" results for advanced economies. When the EU-13 countries are included in the analysis, the EU outperformed the United States in two of the three indicators originally used by Timmer et al. (2011). Canada had lower results than the EU and United States in GDP per hour worked and GDP per capita growth, yet had a higher result for annual GDP percentage growth in the 1995 – 2007 time period examined, please refer to Table 3.2.1. Certainly, finding that Europe, as a whole, did not trail behind the United States in productivity and subsequent critique is not intended to be an indictment on the approach the authors took, but rather in light of a new interpretation of the data, it is an updating of the results. It is worthy to note that Timmer et al.'s 2011 echoed the tone for economic thought in the economics literature at that time [see Gordon,2004 and van Ark, Inklaar, and McGuckin (2003b), both described in this chapter as examples].

Robert Solow is credited with the now ubiquitous quote that "you can see the computer age everywhere but in the productivity statistics" (Solow,1987) in a New York Times book review. While Brynjolfsson and his various co-authors tended to be optimists about the impact ICT upon productivity, van Ark and his various co-authors tended to use the productivity statistics to discern what had happened to the economies of the EU, the United States, and not as often, Canada. Gordon has tended to be an ICT pessimist in his approach to minimizing the impact

ICT as a “general purpose technology” (GPT) that does not compare to the impact the four GPTs that shaped the ‘Golden Age of Productivity” from 1891–1972: electricity, the internal combustion engine, petroleum and the processes to “rearrange molecules”, and the combination of communication, entertainment, and information systems all developed during that period. It is of interest to note that Gordon was Dr. Solow’s Ph.D. students at M.I.T (Wellisz,2017;1). Another interesting observation the reader should consider is that even the optimist Brynjolfsson (Brynjolfsson et al.,2017) acknowledged that Solow’s Paradox (1987) was, indeed, true, but remained optimistic that ICT would ultimately have more positive impact than we perceive at the moment.

There is a perception that Research and Development and Patents are proxies for “Innovation” (Acs et al., 2002;1). The penultimate section of this chapter examined literature that supported the premise that patents are a positive indicator of innovation, increased employment, and increase productivity (Farre-Mensa et al.,2016; Ketteni et al.,2017), but that Foreign Direct Investment does not increase the benefit to host countries if the Patent is not registered in the host country (Raghupathi and Raghupathi,2017). R&D investment [posited to be the input to the process where patents are the output] funded by government will increase the private investment then made in R&D (Kijek et al.,2016). Ortega-Argiles et al (2016) found that the United States has a sizeable advantage on the EU in both R&D investment and return on such investment even though the EU supports R&D slightly more than the United States.

The final portion of this chapter was a review of small portion of the Artificial Intelligence and Automation literature presently available. This subject is not directly a part of the research of this dissertation, but it is innately part of the larger discussion around the future of employment, jobs, and forms of work organization such that it cannot be ignored. It appears that there is a wide gulf between the literature about what will happen to employment and jobs in the future. McKinsey and Company predict that the most impact on employment will occur in jobs that are routine physical, collecting data, and processing data (McKinsey and Company,2017;6). While the types of tasks identified by the McKinsey report seem to be fairly straight-forward, Brynjolfsson and Mitchell (2017;1531) [please note the “Mitchell” referenced here is not this author] suggest that even where there are jobs that are partially automated, there will remain complementary job tasks or total jobs that will remain in the realm of human-only performance. How AI and Automation impact the economy and employment remains to be seen.

4 Innovation

4.1 Defining Innovation

Innovation is an easy concept to understand. From the OECD's Oslo Manual 4th Edition (OECD,2018;20-21), the definitions are noted in the Table 4.1 below.

OECD Innovation Definitions	
Innovation	*"...is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)."*
Innovation activities	*"...include all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm."*
A business innovation	*"...is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm."*
A product innovation	*"...is a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market."*
A business process innovation	*"...is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use by the firm."*

Table 4.1 – OECD Innovation Definitions
Source: The Oslo Manual, 4th Edition (2018;20-21)

As elucidated in the table above, an innovation is something new, and that "something" can be almost anything connected to the firm's processes or products. And if the entire national or supra-national economy is innovative, conventional theory would conclude those economies would be globally competitive. The previous edition of the Oslo Manual (Third Edition, OECD/Eurostat, 2005) quantified four types of innovation: product, process, organizational, and marketing. To note, the most recent Oslo Manual (OECD,2018;20) consolidated the previous manual's approaches to categorizing Innovation into two broad categories:

- Innovation of products or services offered.
- Business process innovation.

4.2 How Governments Support Innovation

On the whole, governments tend to look at innovation as something that they fund to support economic development. The paragraphs below are taken from the websites of the two countries and the supra-national state being examined in this dissertation.

The European Union, through the European Parliament, has enacted the EU policy on research and technological development (RTD) to influence how the EU government will support the economy through a multi-annual framework programme. The Europe 2020 Strategy" supports (European Parliament,2019):

- Make Europe a world-class science performer;
- Remove obstacles to innovation – like expensive patenting, market fragmentation, slow standard-setting and skills shortage – which currently prevent ideas getting quickly to market, and;
- Revolutionize the way the public and private sectors work together, notably through the implementation of Innovation Partnerships between the EU institutions, national, and regional authorities and business.

To achieve the expected outcomes of the RTD policy, the EU has:

- Created the "Innovation Union" which intended to make financing research and innovation easier for business to support employment and economic growth. The initiative has created both the Innovation Union Scoreboard and the Regional Innovation Scoreboard to be able to track changes to the Innovation landscape and also track public opinion on the innovation policy and programmes;
- Horizon 2020 which funds the Innovation Union initiatives;
- The Cohesion policy which administers the European Regional Development Fund for innovation and research, and;
- Financial instruments to increase venture capital investments such as loans for research and development projects, demonstration projects, and supporting the competitiveness of Small and Medium Enterprises (SMEs).

The Canadian Government (Government of Canada,2019) supports innovation and research through a number of government departments. The 2019 federal budget outlined a number of new programs and initiatives per Figure 4.2.1. There is no single overarching program for innovation per se, but funds allocated through various programs where the Departments are considered the government experts for that area.

For example, tax credits for R&D are dealt with by the Canada Revenue Agency, support for business innovation through Innovation Canada, technology innovation through the National Research Council, sale of innovative products or services to the government through Public Services and Procurement Canada, development of industry super-clusters through Industry Canada, initiatives through various Crown Corporation regional development funds, and many more programs (Government of Canada Innovation Funding, 2019). In addition to the federal funding, individual Canadian Provincial or Territorial Governments may contribute to innovation programs either partnered with the federal government or independently as they see fit. The Province of Ontario, for example, has programs for research Excellence, Research Infrastructure, Low Carbon innovation fund, Early Researcher Awards, support through International Research projects, and the Ontario Network of Entrepreneurs (Government of Ontario, 2019).

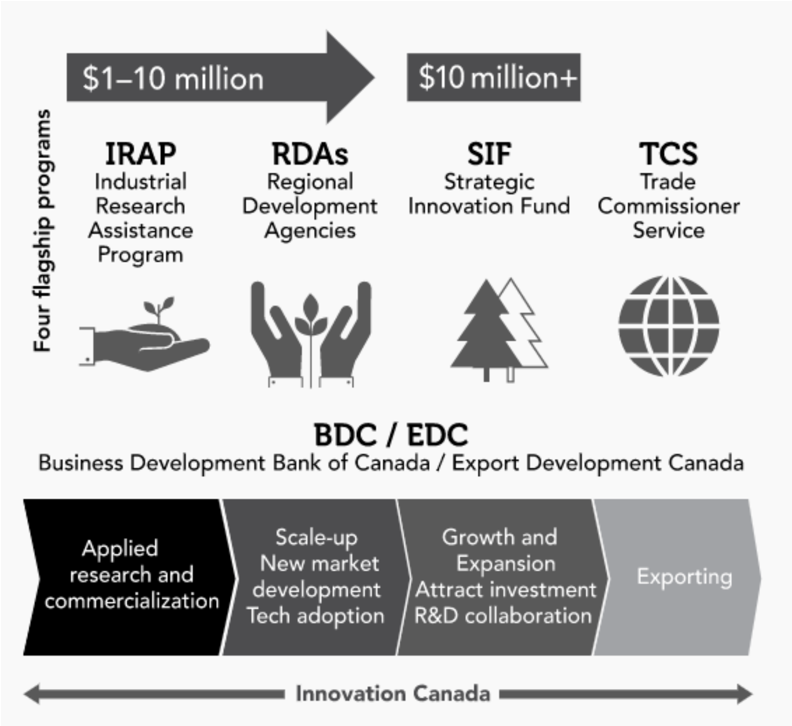


Figure 4.2.1 – Government of Canada Innovation Financial Support
Source: Government of Canada, Innovation Funding website (2019),
https://www.canada.ca/en/services/science/innovation/funding.html

The American 2019 Budget for Research and Development (Whitehouse,2019;234) notes that traditionally the majority of funding for American R&D comes from the private sector. They state that their latest estimate of American R&D spending is $495B USD, and the United States Government 2019 budget for R&D funding is $118.1B USD spread across various sectors. The specific sectors identified in the document (Whitehouse,2019; 235-238) are:

- Protecting the Homeland from Physical and Cyber attacks.
- Improving preparedness for and response to natural disasters.
- Expanding human exploration and commercialization of space.
- Harnessing artificial intelligence and high-performance computing.
- Combating drug abuse and the opioid overdose epidemic.
- Stimulating biomedical innovation for American health.
- Integrating autonomous and unmanned systems into the transportation network.
- Leveraging biotechnologies for agriculture and rural prosperity.
- Unleashing an era of energy dominance through strategic support for innovation.

The United States, notwithstanding that the Whitehouse states that the majority of the R&D funding in America is from non-governmental sources (Whitehouse,2019;234), clearly funds at a higher value per person than Canada and the European Union, 14% and 12% higher respectively. While not a primary investigation of this paper, the level of R&D funding per country will be a variable in the statistical investigation.

4.3 How National Innovation is Measured Presently

With technical/product innovation as the main focus of governments, we return to the Oslo Manual and the thought of organizational innovation.

With the Oslo Manual (OECD,2018;20-21) definition of Innovation firmly planted in the reader's mind as being "something new", how various governments and other organizations perceive and measure "Innovation" creates a myriad of different results depending upon the lens of the Innovation Index that is used. Some examples of Innovation Indices are:

- Global Innovation Index (Cornell/INSEAD/World Intellectual Property Organization)
- International Innovation Index (Boston Consulting Group and National Association of Manufacturers)
- Bloomberg Innovation Index (Bloomberg)
- European Innovation Scoreboard (European Commission)
- Global Competitiveness Report (World Economic Forum)
- Information Technology and Innovation Foundation (ITIF) Index
- Innovation 360 (World Bank)
- Innovation Capacity Index (Independent Professors)

There are also a number of national-level innovation indices, but as this paper is focused on international comparisons, they will not be considered. In examining the various indices, the variation between them are based on what this Author views as the focus of those organizations that are publishing the individual Index. The three indices chosen for comparison in this research are: The Global Innovation Index, The European Innovation Scoreboard, and the Global Competitiveness Report. Table 4.3.1 briefly compares the three reports.

Comparison of Innovation Indices			
	Global Competitiveness Report (World Economic Forum)	European Innovation Scoreboard (European Commission)	Global Innovation Index (INSEAD/Cornell /WIPO) (2019)
Categories	4	4	2
Sub-categories	12	10	7
Indicators	98	27	80

Table 4.3.1 - Comparison of Innovation Indices
Source: Authors tabulation from each Index (EIS,2018, GII,2019, and GCR, 2019)

4.3.1 European Innovation Scoreboard

As mentioned earlier, the goal of any research is to bring light certain aspects of the subject. The European Innovation Scoreboard was prepared for the European Commission by the Maastrict Economic and Social Research Institute on Innovation and Technology (Hollander, Es-sadki, and Merkelbach, 2018) at Maastrict University in the Netherlands. The scoreboard is composed of 27 straightforward indicators (EIS,2018;8). Notable is the lack of inclusion of GDP or other macro-economic "results" in the actual measurement framework. While there are measures that examine employment in the innovative sectors and exports of medium and high-tech products and knowledge services, the overall national economic indicators are included only as contextual comparative tables that show the subject country and compare to the EU (as a whole) for a number of indicators that are included in the other indices, but they are not included in the scoring. The European Innovation Scoreboard uses:

1. Framework Conditions: Human Resources, Attractive Research Systems, and Innovation-friendly environment.
2. Investments: Finance and Support and Firm Investments.
3. Innovation Activities: Innovators, Linkages, and Intellectual Assets.
4. Impacts: Employment Impacts and Sales Impacts.

4.3.2 Global Innovation Index 2019

The Global Innovation Index (GII) 2019 was prepared by the World Intellectual Property Organization (WIPO) [a United Nations specialized agency], Cornell University SC Johnson School of Business, and INSEAD [Institut Européen d'Administration des Affaires] and has been published on a yearly basis since 2007. To rank countries innovation capacity, the GII uses 80 indicators in five Input categories and two Output categories:

1. Institutions: Political Environment, Regulatory Environment, and Business Environment.
2. Human Capital and Research: Education, Tertiary Education, and Research and Development.
3. Infrastructure: Information and Communications Technology, General Infrastructure, Environmental Sustainability.
4. Market Sophistication: Credit, Investment, Trade, Competition and Market Scale.
5. Business Sophistication: Knowledge Workers, Innovation Linkages, and Knowledge Absorption.
6. Knowledge and Technology Outputs: Knowledge Creation, Knowledge Impacts, and Knowledge Diffusion.
7. Creative Outputs: Intangible Assets, Creative Goods and Services, and Online Creativity.

4.3.3 Global Competitiveness Report

The index that has the largest number of indicators is the Global Competitiveness Report. The twelve different Pillars span:

1. Institutional,
2. Infrastructure,
3. ICT Adoption
4. Macroeconomic Stability
5. Health
6. Skills
7. Product Market
8. Labour Market
9. Financial System
10. Market Size
11. Business Dynamism
12. Innovative Capability

4.3.4 Analysis

Upon analysis, the three indices are quite different in the composition of their indicators. In addition to the number of indicators, what the individual index authors considered import is vastly different, as is their data sources. Table 4.3.4.1 shows the number of indicators in each of the separate categories that the author used to elucidate the differences.

	EIS 2018	GII 2019	GCR 2018
Government and Societal	0 (0%) [0]	7 (9%) [0]	35 (36%) [18, 18%]
Educational and Skills	7 (26%) [1, 4%]	11 (14%) [0]	11 (11%) [6, 6%]
Innovation	12 (44%) [5, 19%]	20 (25%) [4, 5%]	10 (10%) [6, 6%]
Business and Economy	7 (26%) [1, 4%]	29 (36%) [2, 2.5%]	24 (24%) [10, 10%]
Infrastructure	1 (4%) [1, 4%]	2 (3%) [0]	12 (12%) [4, 4%]
ICT and other technology	0 (0%) [0]	8 (10%) [0]	6 (6%) [0, 0%]
Environment	0 (0%) [0]	3 (4%) [0]	0 (0%) [0, 0%]
Totals:	**27 [8, 30%]**	**80 [6, 7.5%]**	**98 [44, 45%]**

Notes:

1. Each indicator shows the absolute number of occurrences in each category, the (percentage) of those occurrences versus the total number of indicators for each index, and then the number of indicators [using an opinion survey, and the percentage of opinion survey indicators to the total number of indicators in the index].
2. Occurrence of opinion survey indicators are the author's own calculations.
3. Percentages indicated are rounded, thus may not total 100%.

Table 4.3.4.1 – Comparison of Innovation Indices Indicators
Source: Authors tabulation from each Index (EIS,2018, GII,2019, and GCR, 2019)

The European Innovation Scoreboard (EIS) uses four categories for indicators; education and skills, innovation, business and economy, and infrastructure, although the infrastructure category has only one indicator; broadband penetration. Roughly half of the EIS indicators are focussed on innovation, with education and skills and business and economy comprising roughly a quarter each of the remaining indicators. The Global Innovation Index concentrates on business and economy (36% of indicators) and Innovation (25%), and then almost evenly spreads the second tier between Education and Skills (14%), ICT and other Technology (10%), and Government and Societal (9%), with a third-tier comprising of Environmental (3%) and Infrastructure (2%). Only the Global Innovation Index contains indicators reflecting environmental concerns with three indicators. The Global Competitiveness Report only had ten percent of indicators attributed to innovation, with Government and Societal (36%) and Business and Economy (24%), with Education and Skills 11% and Infrastructure 12%.

The Global Competitiveness Report (2018) uses indicators heavily focused on Government and Societal and Business and Economy and very few actual "Innovation" indicators. The European Innovation Survey (2018) focuses on Innovation, Education and Skills, and Business and Economy. The Global Innovation Index is focused on Business and Economy and Innovation, with Education and Skills as the second tier of Categories. The differences tend to make sense to the Author when who the organization is identified as the sponsor is for the various indices. The EIS 2018 is funded through the European Commission, and therefore, by the EIS (European Commission,2018;6) states that the EIS "… *provides a comparative assessment of the research and innovation performance of the EU Member States and selected third countries*…". The Global Innovation Index is not governmental in nature, but is a research-based index completed by two universities and a United Nations organization, so has no outward connection to a national government nor business beyond WIPO being an organization that administers global treaties concerning the protection and support of Intellectual Properties. The Global Competitiveness Report is funded through the World Economic Forum, which is touted as being a "…a not-for-profit foundation…" that is the "… international organization for Public-Private Cooperation…" (WEF,2019). The GCR, by analysis of the types of indicators, is far more focused on business and the impact of governmental regulation and societal effects in various countries than innovation itself. The Global Innovation Index appears to fall in the middle of the spectrum between the EIS and the GCR sharing many indicators, but also providing a broader scope of indicators across more categories.

Another caution to the reader is that the composition of the data points used are also open to some interpretation or potential skewing due to the data sources. The 2018 EIS uses 8 of 27 (~29%) discernable data results from surveys, the 2019 GII used 11 of 80 (~14%), and the GCR used 44 of 98 indicators (~45%) from the World Economic Forum's Executive Opinion Survey (GCR, 2018;40). Whilst the methodology of the Executive Opinion Survey is not challenged by this author, the contention that it is unbiased certainly should be forwarded to the reader. In the Appendix "B" of the GCR (GCR,2018;623), the Executive Opinion Report is called "*The voice of the business community*". The description automatically incites a concern about impartiality of results, as popular anecdotal evidence would suggest that governments want more rules and restrictions to assert control/fairness where the business sector wants to have minimal governmental control and bureaucratic impediments to "doing business". Another notable query about the survey is that while the scale is a seven-point scale with 1 as "worst in the world" and 7 as "best in the world", there can be little argument that individual perceptions will skew the results, especially if the respondent has little extra-national or has a specific opinion regarding their national rules and regulations. The Global Innovation Index does use 5 of their 11 indicators from the Executive Opinion Report (GII,2019;349-365).

4.4 Chapter Summary

In this chapter, the different ways Innovation scoring and monitoring have been reviewed. The Oslo Manual 4th Edition (OECD,2018) has simplified the "types" of innovation to two:

- Innovation of products or services offered.
- Business process innovation.

By simplifying the number of categories, OECD has added the stipulation that both types of innovation have to be significantly different from what the firm has previously produced or services provided (OECD/Eurostat, 2018;20).

There are concerns that innovation indices are generally skewed to a certain type of innovation that is weighted towards a narrow focus on research and development, patents, etc., and not a broad approach focused on organizational or employee-driven innovation (Makó, Illéssy, and Warhurst, 2016;26-30). The narrow approach tends to provide policy-makers with what appears to be simple answers to a very complicated problem (Makó, Illéssy, and Warhurst, 2016;31). The other concern identified by this author is that the use of opinion surveys may not bring unbiased variables to the indices, thus opening them to skewness that empirical data would bring, but, it is a balance for the indices authors as they attempt to incorporate variables that are targeted to either their audience or their sponsors.

5 Analysis of Indicators

5.1 Chapter Introduction

Examining Innovation, Productivity, and Forms of Work Organization together are a challenging multi-disciplinary exercise. Bringing the Programme for the Assessment of Adult Competencies (PIAAC) learning results together with economic and business statistics breaches much of what this researcher has been able to find in the academic literature on these separate subjects. Yet, all of these elements meshed together are part of how the global economy works in practice. Even if a country is blessed with above-average resources in one category, if not managed correctly, and continuous learning is not encouraged, only limited benefit to the country may be realized.

As stated by this author in the Introduction, due to the novel nature of this line of enquiry, much of the research was inductive, examining different data combinations and determining which variables from the individual Oslo Manual groupings would ensure that an acceptable Kaiser-Meyer-Olkin measure of sampling adequacy was achieved. Notable challenges in finding congruence amongst the data is first and foremost due to the limited number of countries that data is available for in each category of an indicator. With a limited sample of countries (n=22) for PIAAC Learning Styles results, the ability to use a large number of variables is limited. For that reason, the selected variables from specific subject groups were tested for fit in the Principal Components Analysis.

5.2 Forms of Work Organization Variables

Section 2.5, Models of Work Organization based upon learning styles gives a very detailed overview of the Forms of Work Organization. To briefly recap, the variables taken from Greenen et al. (2017;11-15) are listed below.

- Discretionary Learning: high degree of autonomy of when and how workers perform their duties. There is a high level of solving complex problems (more than once a week). Discretionary Learning workers are second-highest of the five work forms in teamwork performance after Taylorist workers. They persuade or influence people on a weekly basis, collaborate with co-workers at least weekly, and share work information daily with others. They have to read instruction or directions weekly and also almost all receive on-the-job training of some sort. Greenan et al. (2017;13) point out that this resembles Arundel et al.'s (2007) grouping of the same name and Lam's (2004) "Operating Adhocracy".
- Constrained Learning: While this group also experiences the organization of their own time, shares work-related information daily, on-the-job training (over half of respondents), and read directions or instructions weekly, they are not able to plan their own work activities frequently, solving complex problems, not persuading or influencing people weekly.
- Independent: Below average reading instructions or directions (at least once a month) and also low for on-the-job training. The category is above the mean in the remaining job tasks with planning own time and activities, solving complex problems, sharing work information, cooperating or collaborating with co-workers, and persuading or influencing people at least once a month but less than once a week. Greenan et al

(2017;13) note that the difference between Discretionary Learning and Independent are the learning opportunities and formalization of work.

- Taylorist: This category has the lowest of all the characteristics except high levels of teamwork and sharing of work information. Approximately a quarter receive on-the-job training. Greenan et al (2017;13) describe this category as "performing simple tasks in a more structured organization than in the Simple form".
- Simple/Traditional: Of all the listed tasks, this category performs them the least often, but is separated from the Independent category as almost 15% or workers receive on-the-job training.

These variables were the basis for the selection of the countries included in this research as the Innovation Variables were readily available for all countries.

5.3 Innovation Variable Selection for Principal Components Analysis

The selection of Innovation and ICT variables was based upon the 2018 Oslo Manual (OECD/Eurostat, 2018). The previous edition of the Oslo Manual (Third Edition, OECD/Eurostat, 2005) quantified four types of innovation: product, process, organizational, and marketing. To note, the most recent Oslo manual consolidated the previous manual's approaches to categorizing Innovation into two broad categories:

- Innovation of products or services offered.
- Business process innovation.

Both types of innovation have to be significantly different from what the firm has previously produced or services provided (OECD/Eurostat, 2018;20). In Chapter 4 (OECD/Eurostat, 2018;87-91), the Manual identifies eight categories that can be used to identify innovation being carried out by a firm:

- Research and experimental development (R&D) activities
- Engineering, design, and other creative activities
- Marketing and brand equity activities
- IP-related activities
- Employee training activities
- Software development and database activities
- Activities related to the acquisition or lease of tangible assets
- Innovation management activities

Due to the small number of innovation-related variables that can be used to complete the principal components analysis and dendrogram compared to the various innovation indices, only one of the categories from the Oslo Manual will not be used: Activities related to the acquisition or lease of tangible assets. One indicator, Patents, shares two categories: the IP-Related Activities and also the Engineering, Design, and other Creative Activities. Through iteration using SPSS, the indicators that were chosen as the representative variables for the analysis were in order; indicator name, category (Oslo Manual or General Economy), the measurement unit of the variable, and the source of information:

- Government Expenditure on Education, General Economy, Education Commitment, % of GDP, UNESCO Institute for Statistics, UIS online database, data for 2015.

- Researchers, Full-Time Equivalent, Oslo Manual, Research and experimental development (R&D) activities, Number of researchers per million population, UNESCO Institute for Statistics, Eurostat Main Database, and OECD, Main Science and Technology Indicators MSTI Database, 2019.
- Information and Communication Technology (ICT) Use, General Economy, Technology Diffusion, Weighted composite index produced by the Global Innovation Index (GII, 2019;353) using national data from the International Telecommunications Union with equal weighting for 1) percentage of individuals using the internet, 2) Fixed broadband internet connections, and 3) active mobile broadband subscriptions, International Telecommunications Union data, aggregated by the Global Innovation Index (GII,2019; 353).
- Employment in Knowledge-Intensive Services, Oslo Manual, Innovation management activities, Percentage of Workforce, International Labour Organization, ILOSTAT database of Labour Statistics (2009-2018), www.ilo.org/ilostat , as calculated by the Global innovation Index 2019 9GII,2019;357).
- Extent of Staff Training, Oslo Manual, Employee training activities, Workers receiving training in the last year, Percentage, Organization for Economic Cooperation and Development (OECD), Dashboard on Priorities for Adult Learning, as retrieved by the Author on July 28, 2019 from: http://www.oecd.org/employment/skills-and-work/adult-learning/dashboard.htm
- Total Computer Software Spending, Oslo Manual, Software development and database activities, Percentage of GDP spent on Software, HIS Markit, Information and Communication technology Database.
- Labour Productivity percentage increase per person employed, General Economy, Percentage increase of Productivity, The Conference Board, Total Economy Database (2018 Adjusted Version), as retrieved by the Author on March 27, 2018 from https://www.conference-board.org/data/economydatabase/index.cfm?id=27762
- Trademarks, Oslo Manual, Marketing and brand equity activities, Number of trademarks applied for at national office, per billion $PPP GDP, 2017 data, World Intellectual Property Office (WIPO), Intellectual Property Statistics; International Monetary Fund, World Economic Outlook Database, October 2018, https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx
- Patents, Oslo Manual, Engineering, design, and other creative activities, and IP-Related Activities, Number of patents applied for at national office, per billion $PPP GDP, 2017 data, World Intellectual Property Office (WIPO), Intellectual Property Statistics; International Monetary Fund, World Economic Outlook Database, October 2018, https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/index.aspx
- Gross Expenditure on Research and Development by Business, Oslo Manual, Research and experimental development (R&D) activities, Gross expenditure of Research & Development, Percentage of GDP, UNESCO Institute for Statistics, Eurostat Main Database, and OECD, Main Science and Technology Indicators MSTI Database, 2019.

- Regulatory Quality, General Economy, Intellectual Property Protection Measures, Regulatory Quality Index, 2017, World Bank, Worldwide Governance Indicators, 2018 Update, https://databank.worldbank.org/source/worldwide-governance-indicators#

5.4 Data Review and Checking

5.4.1 Missing Data

The majority of the data was complete, the only variable scores missing was that of the OECD Training Participation for Cyprus and Greece. These scores were imputed using SPSS multiple imputation with no weighting of the variable to arrive at a score to be used in the analysis.

5.4.2 Outliers

Using the SPSS Descriptive Statistics with histogram and stem-and-leaf graphics, the variables were reviewed and any outliers were winsorized (Tukey,1962;17-19). Where there was more than one outlier, the data were winsorized using the plus one method where the second-highest or lowest value were assigned winsorized values plus one of the third largest or smallest variable for the set, and the highest or lowest plus one of the transformed value. Once winsorization was complete on the non-normalized values, the SPSS descriptive statics were again used to review outliers and relative normality of the variables. Using the Biagi et al. (2013;11, and 31) approach for normality for small data sets, the Skewness bounds were set between -2 and +2, and the Kurtosis bounds were set as no greater than -3.5 to +3.5. The data, once normalized, had a maximum skewness value of 0.946, and a maximum kurtosis value of -1.211, each falling within acceptable limits.

5.4.3 Normalization

Following data winsorization, the author used a Min-Max normalization to produce values between 0 and 1 for all variables within the indicator scores to create comparable scales for each variable in the analysis.

5.5 Multi-variate Analysis

5.5.1 Principal Component Analysis

Using SPSS Version 26, the Principal Components Analysis was conducted to determine which variables have the most influence upon the dataset.

As stated earlier in this research, combining the multi-disciplinary data into one investigation is the novelty of this research, but the small size of the sample due to data availability creates some challenges in completing an all-encompassing and exhaustive analysis. As also stated, this is deductive and investigative research as there appears to be very little literature on the combined subjects.

The Multivariate Principal Component Analysis was completed using SPSS Version 26 and the first tests for applicability were acceptable. While the Kaiser-Meyer-Olkin test for sampling adequacy was just below 0.700, it was above the absolute lower limit of 0.500. The Bartlett's Test shows that the statistical significance is <0.001, thus the Null Hypothesis is rejected.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.626
Bartlett's Test of Sphericity	Approx. Chi-Square	276.785
	df	120
	Sig.	.000

Table 5.5.1.1 – KMO and Bartlett's Test
Source: Author's calculations using SPSS Version 26

The Communalities of the selected variables were all high with only four being below the 0.800 level. Discretionary Learning work form, Independent work form, Trademarks, and Research and Development funded by Business were all highly correlated above 0.900 level, and the remainder are between 0.700 and 0.900.

Communalities

	Initial	Extraction
Discretionary Learning	1.000	.930
Constrained learning	1.000	.837
Independent	1.000	.917
Taylorism	1.000	.824
Simple	1.000	.839
Expenditure on education	1.000	.801
Researchers	1.000	.902
ICT use	1.000	.789
Employment in knowledge-intensive services	1.000	.798
OECD staff training	1.000	.615
Total computer software spending	1.000	.899
TED Labour Productivity increase per person employed	1.000	.795
trademarks	1.000	.915
Patents	1.000	.874
Regulatory Quality	1.000	.809
GERD By Business	1.000	.878

Extraction Method: Principal Component Analysis.

Table 5.5.1.2 – Communalities
Source: Author's calculations using SPSS Version 26

The Principal Component Analysis determined that there are five principal components that comprise 83% of the total variance. That Principal Component 1 explains over 42% of the variances will focus more attention in the following discussion on it. Principal Component 2 explains approximately 15.8% of the variances, Principal Components 3 and 4 explain 10.1% and 9.3%, respectively, and the final Principal Component explains approximately 6.5% of the total variance.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.725	42.031	42.031	6.725	42.031	42.031	4.368	27.297	27.297
2	2.534	15.839	57.870	2.534	15.839	57.870	3.100	19.373	46.671
3	1.625	10.156	68.026	1.625	10.156	68.026	2.566	16.036	62.706
4	1.503	9.396	77.421	1.503	9.396	77.421	1.764	11.024	73.730
5	1.036	6.478	83.899	1.036	6.478	83.899	1.627	10.169	83.899
6	.704	4.397	88.297						
7	.607	3.791	92.088						
8	.415	2.595	94.683						
9	.261	1.629	96.312						
10	.182	1.137	97.450						
11	.160	1.001	98.451						
12	.073	.459	98.910						
13	.068	.428	99.338						
14	.055	.347	99.684						
15	.038	.235	99.919						
16	.013	.081	100.000						

Extraction Method: Principal Component Analysis.

Table 5.5.1.3 – Total Variance Explained
Source: Author's calculations using SPSS Version 26

5.5.2 The Principal Components

Whilst Principal Components (PC) cannot determine direct causality, they can point the researcher in the direction of what subjects are import in understanding the relationship between variables.

5.5.2.1 Principal Component 1:

This PC exhibits strong positive relationships with Regulatory Quality (0.848), Researchers (0.843), Employment in Knowledge-Intensive Services (0.836), Patents (0.826), ICT Use (0.816), Discretionary Learning (0.801), and R&D Financed by Business (GERD) (0.775). To a lesser extent, Expenditure on Education (0.709), Computer Software Spending (0.539), and Staff Training (0.535) we also positively correlated. Employee Training and Software Spending are less related but still positively correlated. In characterizing all of these variables together, one may say that they reflect Education and Level of National Development as researchers, knowledge-intensive jobs, discretionary learning, and relative infrastructure development are all hallmarks of a highly developed country and society. During early data investigation and review, this researcher found that many of the variables in the Global Innovation Index describing what could be considered to be "good governance and societal development" scores were highly correlated with each other, and in some ways one broad category such as Social Development (Education, Infrastructure, etc.) may be able to act as proxies for the levels of education.

The highest negative relationship to PC1 was Simple work forms at -0.653. Taylorist work forms were next highest at -0.477. Of interest to the reader, PC 1 was also slightly negatively related to Labour Productivity per person employed (-0.340), Independent work forms (-0.276), and Trademarks (-0.279). One may posit that the negative connection with Simple and

Taylorist work forms would be intuitive as these generally are more restrictive or non-formalized than Constrained Learning or Discretionary Learning work forms for those employed in such jobs.

The negative relationship between Labour Productivity growth per person is somewhat perplexing, although one may consider that higher productivity could mean lower employment, or the continued growth in productivity by the Central and Eastern European countries, which is in stark contrast to the stagnating EU-15 results. Should this be a product of less employment, it could be reinforced by the fact that American Productivity in GDP per Hour Worked actually increased during the 2008 Global Financial Crisis as productivity growth in total for 2007 to 2009 for the EU-15 GDP per hour worked fell to -0.7 percent [2018 adjusted: -0.73] while the American GDP per hour worked increased at an average of 1.6 percentage points [2018 adjusted: 1.84], and markedly by 2.5 percentage points [2018 adjusted: 3.13] in 2009."

5.5.2.2 Principal Component 2

The Independent work form (0.857), Expenditure on Education (0.430), and Simple work forms (0.402) were the only positively associated with PC2 above the score level of 0.300. The two highest negatively related variables were Constrained Learning and Taylorist work forms at -0.849 and -0.531, respectively. Only Computer Software Spending was greater than the -0.300 level at -0.449, implying a negatively, but not strongly negative relationship.

It is somewhat difficult to characterize this Principal Component easily, but "independence" may be the only description for it. The strongest positive relationship is with the Independent work form, and the highly negative relationship with Constrained Learning and the weaker negatively correlated Taylorist work forms which share the traits of: "not being able to plan their own work activities frequently, do not solve complex problems, and not persuading or influencing people weekly" appear to support the hypothesis. The majority of the other variables are very weakly related, both positively and negatively, to this component.

5.5.2.3 Principal Component 3

This PC has many weak relations with variables, and truly only one medium relationship in both positive and negative, and only one strong negative correlation, that being the -0.703 for Labour Productivity per person employed growth rate. Discretionary Learning (-0.424) was weakly negatively related, where Simple work forms (0.460), Software Investment (0.432), Patents (0.335), GERD financed by Business (0.321), and Independent work forms (0.309) were weakly positively related. This PC may be characterized as "Small Business" with a positive connection to Simple work forms.

5.5.2.4 Principal Component 4

There were no highly negative relationships to PC 4 as the largest negative results of Computer Software Spending (-0.468) and Discretionary Learning (-0.302) were both weakly correlated. On the positive side, Trademarks was the highest at 0.842, followed by Taylorism (0.343) were greater than the 0.300 level of significance.

Component Matrix[a]

	Component				
	1	2	3	4	5
Discretionary Learning	.801	-.131	-.424	-.302	.034
Constrained learning	-.055	-.849	-.025	.278	.187
Independent	-.276	.857	.309	.035	.099
Taylorism	-.477	-.531	.280	.343	-.345
Simple	-.653	.402	.460	-.164	.113
Expenditure on education	.709	.430	.030	.291	.165
Researchers	.843	.149	.153	.147	-.352
ICT use	.816	.215	.009	.099	.259
Employment in knowledge-intensive services	.836	.115	-.179	.163	-.165
OECD staff training	.535	-.259	.049	-.096	.500
Total computer software spending	.539	-.449	.432	-.468	.038
TED Labour Productivity increase per person employed	-.340	.243	-.703	-.054	-.352
trademarks	-.279	.012	-.183	.842	.307
Patents	.826	.098	.335	.222	-.143
Regulatory Quality	.848	.069	-.266	-.076	.097
GERD By Business	.775	-.092	.321	.228	-.337

Extraction Method: Principal Component Analysis.

a. 5 components extracted.

Table 5.5.2.4.1 – Component Matrix of Principal Components
Source: Author's calculations using SPSS Version 26

5.5.2.5 Principal Component 5:

The smallest of the PCs at approximately 6.5% of variances explained has positive connections with Employee Training (0.500), but there were no other positive correlations above the 0.300 level. There were a number of slightly negatively correlated variables in PC5: Labour Productivity per Person Employed Percentage Growth and Researchers were both -0.352, and Taylorism was -0.345. All others were not above/below the +/-0.300 level.

5.6 Principal Component Analysis Chapter Summary

Innovation has does not appear to have "one silver bullet" that will make a company or a country more innovative than their competition, and this can be supported with the Principal Component analysis completed in this section. Principal Component 1 had several highly correlated variables that all supported the "Good Governance and Societal Development" aspects of a country. Discretionary Learning, Researchers, ICT Use, Employment in Knowledge-Intensive Services, Patents, Regulatory Quality, and R&D Financed by Business (GERD) were all above the 0.750 threshold. To a lesser extent, Expenditure on Education, Patents, Computer Software Spending, and Staff Training, we also positively correlated. Employee Training and Software Spending are less related but still positively correlated. Simple and Taylorist work forms being the highest negative correlations also support the "Good Governance and Societal Development" by having the characteristics of forms of work organization that have the least control over tasks and pace of work being negatively correlated. While there were many variables between the 0.700 and 0.899 level, there were none above the 0.900 level which would be very highly correlated to certain variables. This appears to indicate that Innovation and everything connected with it is so very interconnected that no one single element would be able to increase a country's level of innovation alone.

6 Hierarchical Analysis

6.1 Chapter Introduction

As Chapter 4, Innovation and Innovation Indices Review established, there are as many ways to perceive Innovation as there are researchers and organizations that want stakeholders and the general public to perceive Innovation in a certain way, generally their way or the way their funding agencies want them to see it. "Real World" complications appear to be part and parcel of Innovation, Forms of Work Organization, and Productivity as we know it today. This chapter looks to addressing the Hypothesis 1: Innovative countries share more characteristics than less innovative countries. To achieve answering the Hypothesis 1, a simple hierarchical cluster analysis will be used by the author. Whilst there may be more sophisticated tools to complete this task the small sample size and small number of variables fit to this method.

6.2 Data Description and Cluster Analysis

The hierarchical analysis uses the same data as the Chapter 5 multi-variate analysis for sake of simplicity, continuity, and comparability. Again, SPSS Version 26 is the statistical program used for the analysis, using "Between Groups Linkages" method and "Squared Euclidian Distance" to establish the groups membership.

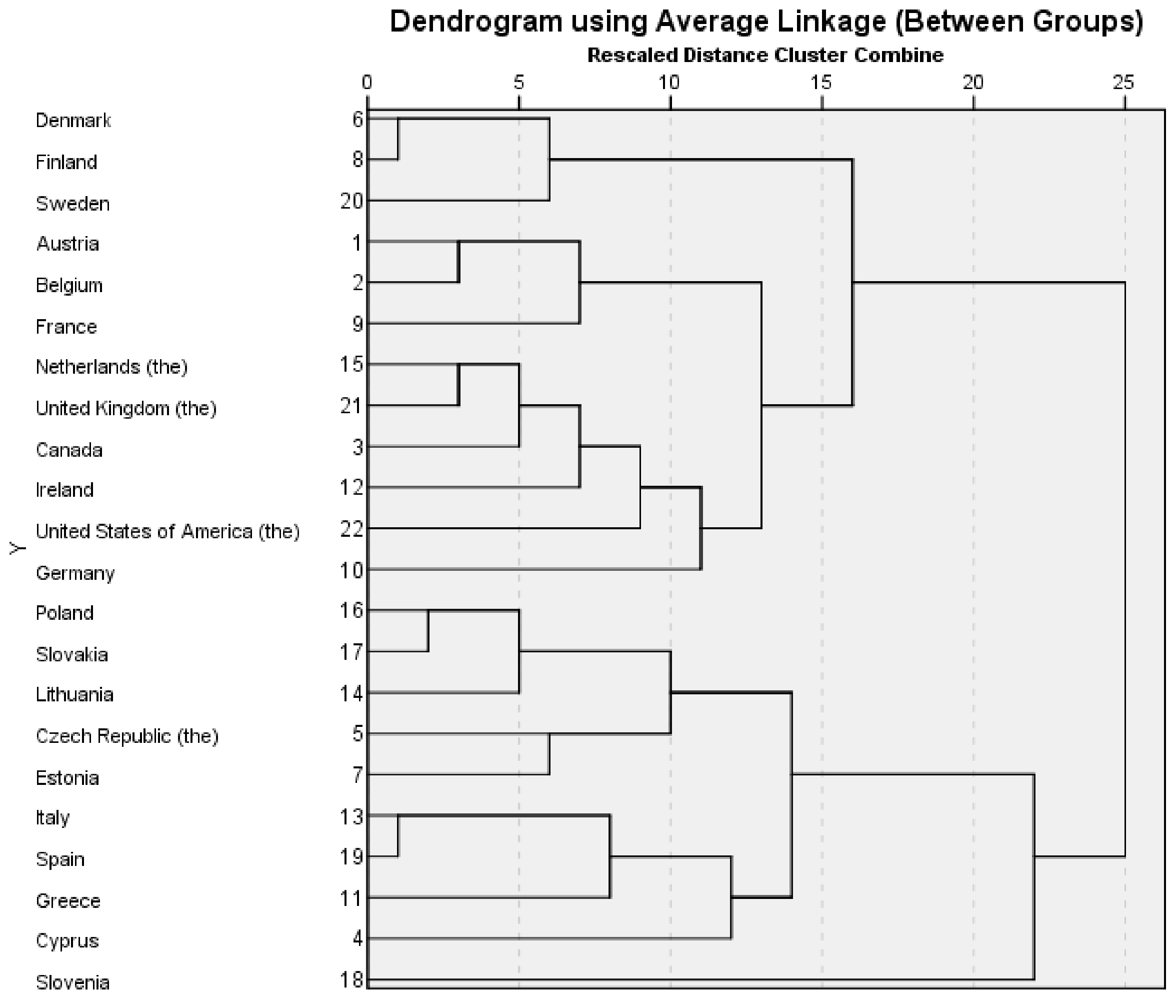


Figure 6.2 – Hierarchical Dendrogram Cluster Analysis
Source: Author's calculations using SPSS Version 26

The dendrogram in Figure 6.2 shows that there are two main Groups, which have been identified by this author as Groups A and B. Within the two groups, there are a total of six sub-groups which have been named continuously from Sub-group 1 to 6 in an attempt to limit potential confusion between groups and sub-groups.

Group A:
Sub-group 1: The Netherlands, the United Kingdom, Canada, Ireland, Germany and the United States.

Sub-group 2: Austria, Belgium, and France.

Sub-group 3: Denmark, Finland, and Sweden.

Group B:
Sub-group 4: Poland, Slovakia, Lithuania, the Czech Republic, and Estonia.

Sub-group 5: Italy, Spain, Greece, and Cyprus.

Sub-group 6: Slovenia.

Two issues emerge from this cluster analysis based upon Forms of Work Organization and Innovation indicators. Firstly, the groupings are not significantly different from the Sapir's Social Policy Model's (2005;5-7) groupings of countries into Anglo-Saxon, Continental, Nordic (including the Netherlands), and Southern, with the comment that countries not included in this research is due to data non-availability for those countries. The Central and Eastern European (CEE) countries were not included in Sapir's original work but refer to Makó and Mitchell (2013a;11-12) for integration of all EU countries into the groupings, effectively adding the Central and Eastern European countries as an independent grouping. Sapir's groupings are included in this research in Section 2.5.1. Work Forms in the EU and North American Context: A Comparative Examination. With very different discipline bases of grouping the countries, and the addition of Canada and the United States, relatively the same groupings appear. The differences are:

- Canada, Germany, the United States, and the Netherlands join the Sub-group 1 of the Anglo-Saxon (or North-western) countries: the United Kingdom and Ireland.
- in Sub-group 2, the Continental countries where France, Belgium, and Austria were in Sapir's original grouping.
- The Nordic grouping in Sub-group 3 loses The Netherlands to Sub-group 1.
- Sub-group 5 is not significantly different than Sapir's (2005;5-7) Southern grouping, adding Cyprus, which joined the EU in the fifth enlargement of the EU in 2004.
- The Central and Eastern European countries (Sub-groups 4 and 6) have perhaps one of the most intriguing findings with Slovenia as a one-country grouping. While Slovenia shares many of the characteristics that the Sub-groups 4 and 5 do, they also differ enough to have been found by the cluster analysis to be a separate entity.

Secondly, whilst this research does include innovation measures as part of the analysis, the relative grouping of countries is also similar to the European Innovation Scoreboard characteristics for the level of innovation for the countries. Section 4.3 of this paper delves into the various Innovation Indices, and while they may not a perfect tool to ascribe empirical findings, they do allow some support for the findings of the hierarchical cluster analysis, especially when using multi-disciplinary indicators.

Grouping	Countries	EIS 2019 Innovation Status Description
Sub-group 1	Netherlands	Innovation Leader
	Canada	Strong Innovator
	United Kingdom	Strong Innovator
	Ireland	Strong Innovator
	Germany	Strong Innovator
	United States	Strong Innovator
Sub-group 2	Austria	Strong Innovator
	Belgium	Strong Innovator
	France	Strong Innovator
Sub-group 3	Sweden	Innovation Leader
	Denmark	Innovation Leader
	Finland	Innovation Leader
Sub-group 4	Poland	Moderate Innovator
	Slovakia	Moderate Innovator
	Lithuania	Moderate Innovator
	Czech Republic	Moderate Innovator
	Estonia	Strong Innovator
Sub-group 5	Italy	Moderate Innovator
	Spain	Moderate Innovator
	Greece	Moderate Innovator
	Cyprus	Moderate Innovator
Sub-group 6	Slovenia	Moderate Innovator

Table 6.2 – Hierarchical Dendrogram Cluster Analysis
Source: Author's calculations EIS 2019 Country Results (EIS, 2019;32-70)

With two exceptions, the European Innovation Scoreboard (EIS,2019) descriptors match every country for every grouping. The exceptions are the Netherlands as an Innovation Leader where the other three countries in Sub-group 1 are Strong Innovators. The other exception is Estonia as a Strong Innovator in Sub-group 5 with Moderate Innovators as the rest of the group population.

6.3 Further Investigation of Similarities

To investigate what the actual similarities of the sub-group memberships are, the dataset was analyzed using the Min-Max Normalized data used in the Principal Component Analysis and the Cluster Analysis. By using this data in this form, the maximum distance between data points can be used to determine similarities and differences amongst the various countries. Table 6.3.1 shows the ranking of the average of the scores for each group for each indicator. Low or high scores may not mean that the result is positive or negative in the context of the indicator and the combined overall result, but only that groups combined results for each indicator are at a certain level compared to the other countries in the study. For instance, a low result for Taylorist work forms may actually be a positive situation for that group's national economies.

	Group A			Group B		
Indicator	**Sub-group 1**	**Sub-group 2**	**Sub-group 3**	**Sub-group 4**	**Sub-group 5**	**Sub-group 6**
Disretionary Learning	1	4	2	3	6	5
Constrained Learning	2	4	6	5	3	1
Independent	5	4	1	2	3	6
Taylorism	4	2	6	5	3	1
Simple	5	2	4	3	1	6
Expenditure on education	3	2	1	4	6	5
Researchers	3	2	1	5	6	4
ICTuse	2	3	1	5	4	6
Employment in knowledge intensive services	2	3	1	5	6	4
Staff training	2	5	1	6	4	3
Total computer software spending	1	2	3	5	4	6
Labour Productivity per person employed precentage change	3	5	4	1	6	2
Trademarks	5	2	6	4	3	1
Patents	3	2	1	4	5	6
Regulatory Quality	1	3	2	4	5	6
GERD By Business	4	2	1	5	6	3
Legend:						
1 or 2	High - Highest or Second highest score in category					
3 or 4	Medium - Third or fourth highest score in category					
5 or 6	Low - Lowest or second-lowest score in category					
Notes:	1. All calculations are the authors own using the normalized data from the Principal Component Analysis and Cluster Analysis dataset.					

Table 6.3.1 – Country Cluster Groupings with Indicator Rankings
Source: Author's calculations using SPSS Version 26

6.3.1 General Characteristics of Group A

Group A contains four groups that encompass the North American, Nordic, Continental, and North-Western (Anglo-Saxon) countries. While there are some contrasts between them, in general, they are similar. Group A holds the top three rankings for: Expenditure on Education, Researchers, ICT Use, KIBS Employment, Regulatory Quality, Total Computer Software Spending, Patents, and Regulatory Quality. The combined Sub-groups also hold three of the four top rankings in Discretionary Learning, Staff Training, and R&D Expenditure by Business. Sub-group 1 has no rankings lower than 5th, which, as stated previously, is not a positive or negative finding, only a finding that the sub-group membership has certain commonalities. Sub-group 2 has low Staff Training and low Labour Productivity per person employed percentage change rankings, the fourth-ranking for Discretionary Learning, but also have higher rankings in the incidence of Taylorist work forms than the other Group A countries. Sub-group 3 has low rankings in Constrained Learning, Taylorism, and Trademarks: this author posits those characteristics are due to the specific details of their national economies.

What are Group A countries presently doing poorly? The forms of work organization may be more entuned to national economy requirements, but Sub-groups 1 and 3 have the two lowest rankings for Trademarks applied for in their countries. This may appear surprising as those two Sub-groups also have the highest levels of Discretionary Learning work form and relatively low rankings for Taylorist work forms. Sub-group 2 has the second-highest ranking of Trademark Applications while having the second highest result for Taylorist work forms.

6.3.2 General Characteristics of Group B

The Sub-groups within Group B encompass the Southern and Central and Eastern European countries. With the exception of Estonia which is labelled a "Strong Innovator" by the EIS, all the other countries in this Group are "Moderate Innovators". Half of the total number of rankings (3 x 16 indicators = 48 rankings) are in the lowest two rankings, 5th and 6th. With the exception of the organizational forms of work, the Group B has the two highest Labour Productivity per Person Employed Percentage Change rankings. This may be connected to the "Catching Up" of the CEE countries as the Sub-groups 4 and 6 have these rankings, with the Sub-group 5 (Southern Countries) having the lowest ranking for the same indicator.

To state the obvious, where the Group A countries have the top three rankings for the indicators for Expenditure on Education, Researchers, KIBS Employment, Regulatory Quality, ICT Use, and Total Computer Software Spending, the Group B hold the three lowest rankings. Slovenia (Sub-group 6) differs from the other Group B countries having the highest ranking for Constrained Learning and Taylorist work forms, and Trademarks. Slovenia also had the second-highest ranking for Labour Productivity per Person Employed Percentage Change. Sub-group 5 has the lowest Labour Productivity per Person Employed Percentage Change, and Sub-groups 5 and 6 have the third and fourth rankings (respectively) for Trademarks. The reader may posit that the relatively high rankings for Trademarks is also part of the "Catching Up" of the Group B countries, although it would appear to be the exception for the Sub-group 6 compared to their other rankings. Sub-group 4 has a forms of work organization that somewhat reflect the Group A countries; low rankings in the Constrained Learning and Taylorist (both tend to restrict self-control of tasks and ability to problem solve), and rank fourth in Discretionary Learning.

6.3.3 Direct Comparisons between Sub-groups

Group B, Sub-groups 4, 5, and 6 review

Even within the two main groups (A & B), there are differences between the Sub-groups. Sub-groups 4, 5, and 6 (Central and Eastern Europe, Southern Europe, and Slovenia, respectively) are similar to each other, but there are differences that should be examined. This is especially prescient as the hierarchical clustering analysis found Slovenia to be substantively different from the other Southern and Central and Eastern European countries to be its own Sub-group. This examination of Group B countries use 'Similarities" and "differences" in the evaluation.

Similarities between Sub-groups 4, 5, and 6:

- Discretionary Learning: All three Sub-groups had medium to lowest results for Discretionary Learning. Sub-group 4, though, had two rankings in the second quartile and one in the third quartile. Slovenia (Sub-group 6) ranked in the lower third quartile, while Sub-group 5 had all fourth quartile rankings, including the lowest ranking of the 22 sample countries: Italy.
- Expenditure on Education: All three sub-groups had the three lowest group rankings of the sample countries. Sub-group 5 had the lowest ranking of all six Sub-groups, although Cyprus was the only country in the first quartile with a relative ranking of 5th out of 22 countries while the other Southern European countries ranked 22nd, 20th and 18th overall. Sub-group 4 had one country, the Czech Republic, in the second quartile, Estonia, Slovakia, and Poland were in the third

quartile, and Lithuania in the fourth quartile with a ranking of 19^{th}. Slovenia was in the mid-third quartile with a ranking of 14^{th} out of the total sample.

- Researchers: All three Sub-groups of Group B were at the bottom of the rankings for this indicator. The Southern countries were the lowest, with Slovenia the next lowest. No country was above the third quartile, although Slovenia was just below the boundary between the second and the third quartile.
- ICT Use: All three sub-groups had the three lowest group rankings of the sample countries. Slovenia had the lowest group ranking, but its result was a 20^{th} ranking with both Italy and Greece having lower individual country rankings. Sub-group 4 had only one country in the second quartile: Estonia. Sub-group 5 had two countries in the second quartile, but the very low rankings for Italy and Greece meant the relatively strong results of Spain and Cyprus were not able to attain a group ranking medium or above. As a Sub-group, the Central and Eastern European countries in Sub-group 4 were essentially statistically the same as Sub-group 5: 0.3030 versus 0.3032, respectively.
- Employment in Knowledge-Intensive Services: All three sub-groups had the three lowest group rankings of the sample countries. Sub-group 5 had the lowest individual ranking with Greece in the 22^{nd} position and only one country in the third quartile: Italy. Sub-group 4 had a less dense ranking of the countries: Slovakia had the 21^{st} ranking, but the Czech Republic and Poland were in the mid-third quartile, with Estonia and Lithuania in the second quartile, with Lithuania having a high-second quartile ranking of 8^{th} out of the 22 sample countries. Slovenia had a group ranking of 4^{th} on a mid-second quartile result.
- Staff Training: The three Sub-groups had three of the lowest four rankings in the sample countries, with Sub-group 2 of Austria, France, and Belgium having the fifth sub-group ranking position. That being stated, there are dissimilar results within the Sub-groups 4, 5, and 6 that make this indicator's results perhaps the most diverse of those reviewed to this point. In Sub-group 4, the Czech Republic had the third overall ranking of the sample countries, Slovakia and Estonia were mid-third quartile, and Lithuania and Poland were tied for the 20^{th} overall ranking of the 22 sample countries. Sub-group 5 also showed diversity with Spain having the 4^{th} overall ranking amongst sample countries. Greece had the lowest ranking of the sample countries, Cyprus was just inside the second quartile while Italy was mid-second quartile in ranking. Slovenia was at the second quartile boundary, which was very similar to the Sub-group 5, which was at the very top of the third quartile, essentially not statistically different from each other.
- Computer Software Spending: All three sub-groups had the three lowest group rankings of the sample countries. Slovenia and Sub-group 4 both had the lowest scores of the sample with Slovenia ranked last out of the sample countries. Sub-group 5 had the largest differential between highest and lowest ranking within-sub-group with Cyprus ranking 20^{th} overall and Italy, Spain, and Greece all in the lower-Second quartile for results.
- Trademarks: The Group B sub-groups showed relative strength of the number of Trademarks applied for with the Sub-groups ranking first, third and fourth out of the six Sub-groups. The Group had the three highest individual country results with Slovenia the highest, Cyprus second, and Estonia third. Both Cyprus' and Estonia's

results bolstered their Sub-group rankings. In Sub-group 4, Poland was in the lowest quartile and Slovakia, Lithuania, and the Czech Republic were in the third quartile. Similarly, in Sub-group 5, Cyprus's result bolstered the fourth quartile result of Italy and the mid-third quartile results of both Spain and Greece.

- Regulatory Quality: All three sub-groups had the three lowest group rankings of the sample countries. Sub-group 6 was in the lowest quartile of results, with Sub-group 5 having three countries in the third quartile and the other in the fourth quartile. Sub-group 4 had no countries in the lowest quartile, and two of the countries: Lithuania, and the Czech Republic were in the second quartile for rankings. This result compares somewhat favourably to Sub-group 2 from Group A.
- R&D Expenditure by Business: The three Sub-groups had three of the lowest four rankings in the sample countries, with Slovenia ranking above the Group A, Sub-group 1 (Netherlands, United Kingdom, Canada, Ireland, United States, and Germany). Sub-groups 4 and 5 both had third and fourth quartile scores for all countries, with only the Czech Republic in Sub-group 4 and Italy in Sub-group 5 ranking in the third quartile.

Country	Disretionary Learning	Constrained Learning	Independent	Taylorism	Simple	Expenditure on Education	Researchers	ICT use	Employment in Knowledge Intensive Services	OECD Staff Training	Total Computer Software Spending	Labour Productivity per Person Employed Percentage Change	trademarks	Patents	Regulatory Quality	GERD By Business
Sub-group 4																
Poland	0.4332	0.1852	0.6992	0.4053	0.3979	0.3150	0.2711	0.2463	0.3907	0.0430	0.2090	0.9777	0.0450	0.0208	0.3560	0.2107
Slovakia	0.1292	0.3647	0.5465	0.6008	0.3666	0.2697	0.2405	0.2201	0.0958	0.3480	0.2271	0.6807	0.3784	0.0042	0.3251	0.1232
Lithuania	0.0220	0.0787	0.8150	0.4460	1.0000	0.1480	0.2723	0.1716	0.5356	0.0430	0.0000	0.9096	0.3378	0.0083	0.5082	0.0518
Czech Republic (the)	0.5351	0.0211	0.6069	0.4182	0.4558	0.5895	0.3724	0.2537	0.3636	0.8910	0.2303	1.0000	0.4955	0.0573	0.5494	0.4179
Estonia	0.5405	0.0000	0.8298	0.0000	0.5053	0.4272	0.3553	0.6231	0.7002	0.3910	0.0672	0.8381	0.8649	0.0770	0.7757	0.1893
Average Score	0.3320	0.1299	0.6995	0.3741	0.5451	0.3499	0.3023	0.3030	0.4172	0.3432	0.1467	0.8812	0.4243	0.0335	0.5029	0.1986
Ranking	3	5	2	5	3	4	5	5	5	6	5	1	4	5	4	5
Sub-group 5																
Italy	0.0000	0.3695	0.8726	0.3965	0.9215	0.1098	0.1661	0.0784	0.2801	0.6520	0.5032	0.2177	0.2162	0.2458	0.2572	0.2857
Spain	0.2198	0.4904	0.5705	0.5350	0.7439	0.1647	0.2515	0.5224	0.1499	0.8040	0.5906	0.2043	0.3243	0.0510	0.3889	0.2071
Greece	0.0027	0.3321	0.5685	0.9321	0.9238	0.0000	0.2930	0.0000	0.0000	0.0000	0.5032	0.1560	0.3874	0.0000	0.0000	0.1607
Cyprus	0.2125	0.5403	0.5965	0.6008	0.5976	0.7518	0.0000	0.6119	0.2432	0.5040	0.1013	0.2146	0.9099	0.2115	0.4383	0.0000
Average Score		0.4331	0.6520	0.6161	0.7967	0.2566	0.1777	0.3032	0.1683	0.4900	0.4246	0.1982	0.4595	0.1271	0.2711	0.1634
Ranking	6	3	3	3	1	6	6	4	6	4	4	6	3	4	5	6
Sub-group 6																
Slovenia	0.2894	0.9040	0.1526	1.0000	0.0000	0.3437	0.4884	0.0933	0.5897	0.5000	0.0149	0.6435	1.0000	0.1156	0.1983	0.5339
Ranking	5	1	6	1	6	5	4	6	4	3	6	2	1	6	6	3
Legend:	Score	Highest Quartile, 0.75 - 1.00			Score	Second Quartile, 0.5 - 0.75			Score	Third Quartile, 0.25 - 0.5			Score	Fourth Quartile, 0 - 0.25		
Note:	Scores are normalized using the Min-Max Normalization method and are the variables used in the Principal Component Analysis and the Cluster Analysis, calculations by the author.															

Table 6.3.3.1 – Group B Country Cluster Groupings with Indicator Quartile Rankings
Source: Author's calculations using SPSS Version 26

Where the preceding section outlined the similarities between the Group B countries, they were mostly similarities for low rankings for the individual indicators. The following section shows the differences between the three Sub-groups and finds relative strengths of the Sub-groups versus the Group A countries. Differences between Sub-groups 4, 5, and 6:

- Constrained Learning: Sub-groups 5 and 6 had the 1st and 3rd highest rankings for Constrained Learning forms of work organization. Sub-group 4 had the 5th ranking of Sub-groups with only the Nordic countries exhibiting a lower ranking. Sub-group 5 showed that Cyprus' result of lower-second quartile was the highest result between Sub-groups 4 and 5, with the remainder of Sub-group 5 in the mid- to upper- third quartile. Of the Sub-group 4 countries, only Slovakia's ranking was in the third quartile, with Poland, Lithuania, the Czech Republic having fourth quartile results and Estonia having the lowest ranking of prevalence of this form or work organization.

- Independent forms of work organization: This indicator's results show Sub-group 4 has the 2nd group ranking for this type of work organization, with Sub-group 5 having the 3rd group ranking. Slovenia has a low ranking at 6th in the Sub-groups. Within their respective groups, Lithuania, Estonia, and Italy all have first quartile results. In Sub-group 4, the remaining countries range from low- to mid-second quartile results. In Sub-group 5, Spain, Greece, and Cyprus all have mid- to low second quartile results. In this indicator's results, both Sub-groups 4 and 5 are very similar.
- Taylorist forms of work organization: Sub-group 6 (Slovenia) has the highest ranking of all the countries in the sample, with Sub-group 6 having the third-highest ranking. Sub-group 4 is the third-lowest ranking for this form of work organization with only the Nordic countries of Sub-group 3 having a lower combined result. Slovakia has the highest ranking of this Sub-group in the mid-second quartile, and all of Poland, Lithuania, and the Czech Republic exhibiting lower- and mid-third quartile results. Greece has the second-highest ranking for this indicator, with its fellow Sub-group 5 countries Spain and Cyprus in the second quartile of results, and the lowest ranking of this Sub-group is Italy with a mid-third quartile ranking individually.
- Simple forms of work organization: Slovenia has the lowest ranking of the Sub-groups for this type of form of work organization. The other two groups have the highest and third-highest results for this indicator. Where second-ranked Sub-group 4 has Lithuania with the highest individual country ranking, all other countries are in the mid- to upper- third quartile for rankings. All four of the Sub-group 5 countries are in the first and second quartile for results with, highest to lowest results: Greece, Italy, Spain, and Cyprus.
- Labour Productivity per Person Employed Percentage Change: Sub-group 5 comprising of the Southern European countries have the lowest result in the Labour Productivity per Person Employed Percentage change with all four countries in the fourth quartile results. The Central and Eastern European countries have the highest Sub-group ranking with only Slovakia outside of the first quartile with a high-second quartile result. Slovenia has the second-highest Sub-group result with a mid-second individual country ranking.
- Patents: While all three Group B Sub-groups had higher rankings for Trademarks, the opposite is true for all Group B Sub-groups in Patents. All Sub-groups had results in the lowest quartile; comparatively, only the United Kingdom and Ireland had fourth-quartile results from all the other individual country rankings. Slovenia was ranked third for patents behind Sub-groups 4 (Germany and the United States) and the Nordic countries of Sub-group 3.

6.3.4 Group A Countries, Sub-groups 1, 2 and 3

This section examines the indicator rankings for Sub-group 1 (Netherlands, the United Kingdom, Canada, Ireland, Germany, and the United States), Sub-group 2 (Austria, France, and Belgium), and Sub-group 3 (Denmark, Finland, and Sweden). Similarities of the Group A Sub-groups:

- Discretionary Learning: The three Sub-groups held three of the top four rankings for Discretionary Learning. The highest was Sub-group 1, followed by Sub-group 3. Sub-group 4 (Austria, Belgium, and France) had the fourth ranking. Of the Sub-group 2 countries, France had the lowest ranking for Discretionary Learning with a 21st ranking, higher only than Italy. Austria also exhibited a low ranking in the third quartile while Belgium was in the low-third quartile. Sub-group 1 had three of the highest five rankings with the United Kingdom, the Netherlands, and the United States. Canada and Ireland had relatively high rankings with 6th and 7th rankings, respectively. Only Germany was below the second quartile for rankings. Of Group A countries, four of the twelve countries were on the lower two quartiles for rankings for this indicator.
- Expenditure on Education: All three Sub-groups held the highest three rankings for this indicator. The Nordic countries in Sub-group 3 had the three highest rankings of the entire sample countries. Belgium had the highest ranking in Sub-group 2, where France and Austria were just below the boundary of the second quartile rankings. Ireland was the only Group A country with a lowest quartile result, with a 21st ranking for government expenditure on education. The other Sub-group 1 countries had relatively low rankings with only the United Kingdom above the third quartile.
- Researchers: All three Sub-groups held the highest three rankings for this indicator. Again, the Nordic countries had the three highest results for Researchers. Sub-group 2 had the next highest ranking with somewhat similar results for each of the three countries; Austria and Belgium were in the low-second quartile with France just below the boundary between the second and third quartile. Of the Sub-group 1 countries, the Netherlands and Germany had the highest results with low-second quartile rankings, and the rest of the Sub-group 1 countries in the high-third quartile.
- ICT Use: All three Sub-groups held the highest three rankings for this indicator. The Nordic countries again lead the way as a group with two of the top three individual rankings, with Finland with a 7th place ranking. Sub-group 1 countries had the third-highest ranking, with the Netherlands with an individual 3rd place ranking. Only Canada was below the second quartile with a high-third quartile score, just below the boundary separating the second and third quartile. The United Kingdom had a high-second quartile score, whereas Ireland, Germany, and the United States all had low-second quartile scores.
- Employment in Knowledge-Intensive Services: All three Sub-groups held the highest three rankings for this indicator. The Nordic countries again led the rankings for Group A. Denmark was just below the boundary between the first and second quartile with a 7th place ranking, Sweden had the highest ranking of individual countries, and Finland had a 4th place individual ranking. Sub-group 1 had three first quartile rankings for the Netherlands, the United Kingdom, and the United States. Canada, Ireland, and Germany had the three second quartile rankings.
- Spending on Computer Software: All three Sub-groups held the highest three rankings for this indicator. The United States led all countries by a wide margin for this indicator and anchoring the Sub-group 1's highest ranking. Canada, Ireland, the Netherlands, and the United Kingdom all had second quartile scores with Germany having the lowest ranking of the Sub-group countries at 15th out of 22 countries. Sub-group 2 had three relatively similar rankings in the lower second quartile to have a Sub-group ranking of second. Sub-group 3 had low second-

quartile results for Denmark and Sweden, with Finland in the high-third quartile. Of all the Group A countries, only Finland and Germany were in the third quartile.

- Labour Productivity per Person Employed Percentage Change: The three Group A Sub-groups ranked 3rd, 4th, and 5th for this indicator. Sub-group 1 had the highest of the Group rankings with Ireland the highest individual country ranking at 5th out of the 22 sample countries. The remaining Sub-group 1 countries were mostly third quartile, although the United Kingdom was in the lowest quartile with an individual ranking of 17th. Sub-group 3 followed in the fourth-ranking with Sweden in the upper third quartile and Finland in the mid-third quartile. Denmark had the lowest ranking of all individual countries at 22nd. Sub-group 2 was 5th in the Sub-group rankings with France in the mid-third quartile and both Austria and Belgium in the lowest quartile.
- Patents: All three Sub-groups held the highest three rankings for this indicator. Here again, the Nordic countries had the highest sub-group ranking with Sweden and Finland having the two highest rankings and Denmark with a 5th place ranking. Sub-group 1 had the other two top-five rankings with the Netherlands and Germany, respectively. This Sub-group showed the most diversity of Group A countries with the United States and Canada with third quartile rankings and Germany and Ireland with fourth quartile rankings. In Sub-group 2, Austria had the highest individual ranking at 6th out of 22 countries, and France and Belgium being 6th and 8th, respectively. While there was a diversity of the rankings, all the Group B countries scored in the lowest quartile for this indicator.
- Regulatory Quality: All three Sub-groups held the highest three rankings for this indicator. Sub-group 1 had the highest-ranking and five of the top nine rankings. Only Ireland was outside of the first quartile with a very high-second quartile score. The Nordic countries of Sub-group 3 were next with three of the top nine rankings, and then Sub-group 2 with Austria having a mid-second quartile ranking and both Belgium and France with low-second quartile rankings.
- General Expenditure on R&D by Business: The Group A countries were ranked 1st, 2nd, and 4th in this category, with the difference between Sub-group 6 and Sub-group 1 (in 4th ranking) very small. The Nordic countries in Sub-group 3 again led all countries with Sweden having the highest individual country ranking and Denmark with the 5th highest individual ranking. Finland had a high-second quartile ranking at 6th overall individually. Sub-group 2 followed with Austria ranked 2nd for individual countries, and Belgium and France ranked 7th and 8th, respectively. In Sub-group 3, the United States and Germany were individually ranked 4th and 3rd, respectively. The Netherlands, the United Kingdom, and Canada all were ranked in the third quartile. Ireland was ranked in the high-fourth quartile, with the lowest of any A individual ranking at 15th overall, although this was ahead of all the Group B countries in the lowest quartile.

Country	Disretionary Learning	Constrained Learning	Independent	Taylorism	Simple	Expenditure on Education	Researchers	ICT use	Employment in Knowledge Intensive Services	OECD Staff Training	Total Computer Software Spending	Labour Productivity per Person Employed Percentage Change	trademarks	Patents	Regulatory Quality	GERD By Business
GROUP A COUNTRIES																
Sub-group 1																
Netherlands (the)	0.7572	0.1171	0.3256	0.4515	0.3697	0.4797	0.5678	0.8060	0.7568	0.5650	0.5384	0.3343	0.3423	0.8270	1.0000	0.4411
United Kingdom (the)	1.0000	0.3215	0.1378	0.3612	0.1120	0.5203	0.4750	0.7276	0.8403	0.4350	0.6130	0.2085	0.3874	0.2167	0.8169	0.4196
Canada	0.7126	0.7524	0.3108	0.2505	0.2226	0.4439	0.4591	0.4813	0.6192	0.9570	0.5917	0.2660	0.4324	0.2666	0.9115	0.2786
Ireland	0.7093	0.2639	0.1466	0.8174	0.2942	0.0239	0.4615	0.5485	0.5676	0.4780	0.7026	0.7424	0.2162	0.2167	0.7449	0.2411
Germany	0.3823	1.0000	0.0000	0.6544	0.2508	0.3150	0.5726	0.5224	0.6634	0.4130	0.4563	0.3789	0.5586	0.8125	0.8539	0.8607
United States of America (the)	0.8595	0.8273	0.0212	0.4698	0.1319	0.3652	0.4567	0.5224	0.7913	1.0000	1.0000	0.4176	0.0000	0.4323	0.7675	0.8357
Average Score	0.7368	0.5470	0.1570	0.5008	0.2302	0.3580	0.4988	0.6014	0.7064	0.6413	0.6503	0.3913	0.3228	0.4620	0.8491	0.5128
Ranking	1	2	5	4	5	3	3	2	2	2	1	3	5	3	1	4
Sub-group 2																
Austria	0.3077	0.0749	0.6260	0.8547	0.4070	0.4940	0.6325	0.4291	0.5233	0.5650	0.5000	0.1840	0.3333	0.6093	0.6226	0.9125
Belgium	0.5724	0.1958	0.4606	0.3517	0.5846	0.8019	0.5531	0.4627	0.7961	0.4780	0.5618	0.2287	0.1892	0.3697	0.5556	0.7071
France	0.0017	0.3829	0.7867	0.7352	0.6913	0.4964	0.4847	0.6381	0.6806	0.3910	0.5245	0.3192	0.9550	0.4708	0.5082	0.5518
Average Score	0.2939	0.2179	0.6244	0.6472	0.5610	0.5974	0.5568	0.5100	0.6667	0.4780	0.5288	0.2440	0.4925	0.4833	0.5621	0.7238
Ranking	4	4	4	2	2	2	2	3	3	5	2	5	2	2	3	2
Sub-group 3																
Denmark	0.8292	0.1209	0.6368	0.0387	0.0724	1.0000	1.0000	1.0000	0.7371	0.5870	0.5224	0.0000	0.1712	0.7890	0.7654	0.8143
Finland	0.8605	0.1852	0.4906	0.0305	0.2378	0.9523	0.8205	0.6157	0.7813	0.5650	0.4595	0.3853	0.1667	0.9020	0.8745	0.7232
Sweden	0.4462	0.0250	1.0000	0.4182	0.4558	0.9761	0.9035	0.8918	1.0000	0.7830	0.5245	0.4850	0.3784	1.0000	0.8621	1.0000
Average Score	0.7120	0.1104	0.7091	0.1625	0.2553	0.9761	0.9080	0.8358	0.8395	0.6450	0.5021	0.2901	0.2388	0.8970	0.8340	0.8458
Ranking	2	6	1	6	4	1	1	1	1	1	3	4	6	1	2	1
Legend:	Score	Highest Quartile, 0.75 - 1.00			Score	Second Quartile, 0.5 - 0.75			Score	Third Quartile, 0.25 - 0.5			Score	Fourth Quartile, 0 - 0.25		
Note:	Scores are normalized using the Min-Max Normalization method and are the variables used in the Principal Component Analysis and the Cluster Analysis, calculations by the author.															

Table 6.3.3.2 – Group A Country Cluster Groupings with Indicator Quartile Rankings
Source: Author's calculations using SPSS Version 26

Differences of the Group A Sub-groups:

- Constrained Learning Forms of Work Organization: This indicator and Taylorist forms of work organization shared the most dispersed results of the indicators for the Group A countries with Sub-groups ranking 2nd, 4th, and 6th. Sub-group 1 had the second-highest ranking for Constrained Learning, with the highest being Sub-group 6 (Slovenia). Within Sub-group 1, there were differences; the Netherlands were ranked 17th (6th lowest) for this indicator, both the United Kingdom and Ireland had third quartile scores, but Germany, the United States, and Canada were ranked 1st, 3rd, and 4th, respectively. Of all Sub-groups, Sub-group 1 exhibited the most diversity of rankings for this indicator. Sub-group 2 saw both Austria and Belgium with rankings in the lowest quartile, with France in the mid-third quartile. The Nordic countries of Sub-group 3 all had rankings in the lowest quartile.
- Independent Forms of Work Organization: The differences within the Group were that Sub-group 3 exhibited the highest ranking for this indicator, while the other two Sub-groups were 4th and 5th, respectively. In Sub-group 2, France had the 5th ranking, Austria was in the mid-second quartile, and Belgium in the high-third quartile. Sub-group 1's rankings were all third and fourth quartile, with Germany having the lowest ranking for Independent Forms of Work Organization.
- Taylorist Forms of Work Organization: This indicator and the Constrained Learning forms of work organization shared the most dispersed results of the indicators for the Group A countries with Sub-groups ranking 2nd, 4th, and 6th. Sub-group 3 in 6th place was the most homogeneous Denmark and Finland having very low rankings and Sweden with a third quartile ranking. Sub-group 1 was ranked 4th

and showed the widest dispersion of individual rankings between Ireland with an individual ranking of 4th, Germany in the mid-second quartile, and the remaining countries in the third quartile of results. Sub-group 2 had the highest ranking for Group A countries; 2nd overall. This group had one country in each of the upper three quartiles; Austria with a 3rd place ranking, France in the 5th ranking, and Belgium with a 19th place ranking.

- Simple Forms of Work Organization: Sub-group 2 was ranked 2nd overall with Austria having the 3rd highest-ranking and France having the 4th highest incidence of this form of work organization amongst all sample countries. Belgium was ranked in the mid-third quartile. Sub-group 5 had the highest overall ranking for all sub-groups. Sub-group 3 was ranked 4th with Sweden having the highest-ranking of this Sub-group just below the boundary between the second and third quartile. Finland and Denmark both had relatively low rankings with both countries in the lowest quartile. Sub-group 1 had the 5th ranked result for this indicator; The United Kingdom and the United States had the two lowest rankings for this group where the remaining four countries all had rankings in the low- to mid-third quartile.
- Staff Training: Sub-groups 3 and 2 were the two highest-ranked in the sample, respectively. A low-first quartile ranking for Sweden and combined with Finland and Denmark having second quartile results offset the fact that the two highest individual rankings [the United States and Canada] were in Sub-group 1. The third quartile results of the United Kingdom, Ireland, and Germany meant that the sub-group was ranked second. Sub-group 2 had the lowest ranking of Group A countries in 5th. Both Belgium and France had third quartile scores to mitigate Austria's second quartile result.
- Trademarks: In contrast to Patents where Group A held the top three spots, in this indicator they held the 2nd, 5th, and 6th ranking. Led by France, Sub-group 2 had the highest ranking of Group A countries. France was ranked 2nd overall, with both Austria and Belgium having relatively low rankings in the third and fourth quartile, respectively. Sub-group 1 was 5th overall with only Germany above the third quartile with a low second quartile ranking with both the United States and Ireland in the lowest quartile, the remaining countries ranking in the third quartile. The Nordic countries had the lowest combined ranking as a sub-group with both Denmark and Finland in the lowest quartile and Sweden in the third quartile.

6.4 Results Commentary

The Cluster Analysis groupings show that the classic groupings for EU countries based upon the historical academic literature (Sapir,2005;5-7) and geographical quantifications (Valeyre, Csizmadia, Gollac, Makó, et al.,2009;59) hold more or less steady through this investigative research. Different researchers using different indicators have reached more or less the same groupings under different circumstances. While this research did not seek to make an empirical connection with the prior research, it is of interest to this researcher that it has occurred, whether by coincidence or just happenstance. Whilst the cluster analysis has resulted in what one may consider traditional results, the fact that the characteristics of the previous quantifications of country groups remain with the Forms of Work Organization added to the analysis.

The variables in this analysis, due to the nature of the PIAAC data on forms of work organization are not available for more than one year in many cases makes this research a snapshot in time, albeit a snapshot that may allow for a better understanding of Innovation and what impacts national innovation results. The country groupings showed that there are some indicators that are communally shared with most or all members of the Sub-groups, but that there are other indicators that show much more diversity of results. That six of the sixteen indicator rankings of the Sub-groups that had the two group's results in ordinal groupings that reflected either the highest three or four rankings and the corresponding opposite group contained the lower four or three, respectively, shows some consistency of characteristics.

6.4.1 Forms of Work Organization

The Northern European and North American countries have a higher prevalence of Discretionary Learning compared to the Central and Eastern European and Southern European countries. That said, Estonia, the Czech Republic, and Poland, as shown Greenan et al.'s (2017, 11-15) work on the Programme for International Assessment on Adult Competencies (PIAAC), have the highest levels of Discretionary Learning of the CEE and Southern countries. Of those countries with high levels of Discretionary Learning, there is generally a second, and seemingly complementary form of work organization that their internal economies utilize. For example, the United Kingdom, Finland, Denmark, the Netherlands, Canada, Belgium, Estonia, and the Czech Republic all have the second-highest form of work organization in their economies as Independent. Other notes on forms of work organization, and as stated previously in this Chapter, there is variation presumed to be borne of the characteristics of each economy;

- Whereas Sweden has a relatively high level of Discretionary Learning, the highest form of work organization is actually Independent.
- Germany has the highest secondary form of work organization as Constrained Learning, and is the only country where this occurs. That Germany is considered to be an innovative country may be more based upon high results in the "Regulatory Quality" indicator.
- Poland's distribution of top-two forms of work are almost the same with Discretionary Learning and Independent within 1/10th of 1 percent.
- Independent form of work organization is the highest in Austria, Spain, Cyprus, Slovakia, Lithuania, Greece, France, and Italy. Of these countries, Slovakia and Greece's second-most prevalent work form is Taylorism.
- The only country that has Taylorism as their highest form of work organization is Slovenia, which may support the cluster analysis result of an individual Sub-group for the country.
- No country in the sample had Constrained Learning or Simple as the highest percentage of form of work organization in the PIAAC sample.

6.4.2 Innovation Variables

The Nordic countries lead Expenditure on Education with Belgium and Cyprus also in the upper quartile. From there, the results show that, with some notable exceptions, the continental European countries and the North American countries follow. The CEE and Southern countries then complete the rankings. The notable exceptions are Ireland with one of the lowest governmental expenditure of education and the Czech Republic with the highest expenditure of the CEE countries.

Information and Communication Technology (ICT) Use and Total Computer Software Spending is a somewhat mixed bag of results. Spain, Cyprus, and Estonia have the highest results for CEE and Southern countries for ICT Use, but only Spain has an above average result in Software Spending. The Nordic countries have high ICT Use but have lower spending on Software. The Americans have the highest spending on software, but only a medium result in overall ICT use, but as the indicator is based upon total economy [both business and personal] this may point to either the business spending which scope and scale would be different than personal software spending. Software investment in Canada is higher than average, but ICT use is below average. The United Kingdom and Ireland have higher than average results in both indicators. Slovenia has the lowest Software investment and relatively low ICT use. The CEE countries are second lowest in Software investment and relatively weak in ICT use.

Employment in Knowledge-Intensive Services are a strong point for the Group A countries, with Sweden, the United Kingdom, the United States and Finland having the highest prevalence amongst sample countries. The remaining Group A countries all have rankings in the upper two quartiles. Of the Southern and CEE countries, Estonia, Slovenia, and Lithuania, respectively, have second quartile results. Slovakia, Spain, Cyprus, and Greece have the lowest results of the sample.

The Americans and the Canadians lead the Staff Training prevalence. With the exception of Slovenia, the CEE countries are all weak in Staff Training. Greece has the lowest result of the sample countries, but for the Southern countries, Cyprus, Italy, and Spain have higher than average results for Staff Training. Of the Group A countries, The United Kingdom, Ireland, Belgium, France, and Germany have lower relative Staff Training than the others.

Labour Productivity per Person Employed Percentage Change had four of the six Sub-groups with rankings above the third quartile. All of these countries were Central and Eastern European countries. While the GDP growth stagnation in developed nations has been discussed in Chapter 3 which showed in section 3.2 that the CEE countries have been able to achieve higher Productivity growth than the EU-15 and North America.

Trademarks and Patents are also a mixed bag of results. The Oslo Manual considers Trademarks to part of marketing and brand equity activities and patents to be part of intellectual property-related activities (OECD/Eurostat,2018;58). The results of the hierarchical cluster analysis exhibit marked differences between the two in the sample group. There appears to be an inverse in the results of the two indicators in that the Group B countries ranked 1st, 3rd, and 4th for Trademarks, but they ranked as the three lowest for patents. While Group B countries had three of the four highest rankings in Trademarks, none of the countries ranked above the lowest quartile for Patents.

The Regulatory Quality levels of Group A, on the whole, is higher than the majority of Group B countries, yet Estonia ranked in the highest quartile with Lithuania and the Czech Republic in the second quartile. Only Greece and Slovenia exhibited very low rankings for this indicator. That the quartile scores were skewed to the upper quartile, and within that quartile were all the Group A countries, shows the strength of this indicator for those countries.

Total number of Researchers in each country and Expenditure of R&D by Business both have the highest results in the Nordic Countries and Sub-group 1, although the Nordic countries are stronger in the number of researchers in the population. The United States has the lowest result of all the Group A countries, with a score in the high third quartile. Austria, the Netherlands, and Belgium also have strong results in number of researchers, but of this group, only Austria has strong results in R&D Financed by Business. Slovenia has the most R&D Financed by

Business of the Southern and CEE countries, and those countries also have the lowest relative results for Researchers and R&D investment.

6.5 Chapter Summary

This chapter has shown that within all the relatively highly developed countries included in this small sample, there are differences between Groups and even Sub-groups, although there are similarities as well. The Continental, Nordic, North-western, and North American countries all have higher rankings than the Central and Eastern European and the Southern Countries. There are pockets of low rankings amongst the Group A countries that can only be posited to be connected to their national policies or economic environment, which is beyond the scope of this research. Only Canada did not have a single fourth quartile ranking across the entire group of indicators. Further to that line of enquiry, all the Group A countries were above the fourth [lowest] quartile for the indicators; Researchers, ICT Use, Employment in Knowledge-Intensive Services, Staff Training, and Total Computer Software Spending. Group B had at least one country ranking in the lowest quartile for any of the indicators. This is not meant to be pejorative against any of the countries, just the facts of the indicator results.

Although the groupings were very similar to the traditional groupings that have been quantified and examined in previous research (Sapir,2005), (Valeyre, Csizmadia, Gollac, Makó, et al., 2009;59), (Makó and Mitchell, 2013a), there is evidence that the Central and Eastern European countries have surpassed the Southern countries in many respects. Table 6.3.3.1 shows that the CEE countries in Sub-group 4 had higher rankings in al the indicators except Staff Training. Of this group, and with the exception of the Productivity indicator already discussed previously, both the Czech Republic and Estonia had rankings in the highest quartile. Estonia's upper quartile rankings included Staff Training [which was the opposite of the other sub-group countries low scores], Trademarks, and Regulatory Quality. Estonia also had upper second quartile results for the Discretionary Learning and Independent forms of work organization.

Whilst the traditional economic or innovation "order of nations" appears to be maintained in this research, there are slight indications that may be changing. That Slovenia has differentiated itself from other CEE countries to be a sub-group on its own and that Estonia and the Czech Republic are posting rankings in various indicators that are higher than their traditional peer nations provides hope to all other nations, whether within the scope of this research or not, that progress can occur. This reflects Makó, Mitchell, and Illessy's (2015;33) finding that the three nations were more innovative than their CEE counterparts.

7 Consolidation of Research Findings and Results

7.1 Chapter Introduction

Are innovative countries alike? What are the similarities and the differences? Does one Form of Work Organization lend itself better to innovation, and if so, is this shared with all countries that are more innovative than others? The preceding two chapters have examined the principal components of the dataset selected and the identified forms of work organization taken from the PIAAC (Greenan et al., 2017) and indicators that align with the Oslo Manual for Innovation (OECD, 2018). How all the inputs connect is nuanced and at times complex.

7.2 Results and Interpretations

Causality cannot be precisely determined from a principal components analysis, but from it, a glimpse into what has to be present for a country to potentially innovative can be made. That no single indicator was above the 0.850 level, but six of the indicators were above the 0.800 level, and two more were above the 0.700 level should signal to the reader that there has to be multiple contributors to support innovation at a country level, and it should also signal that there is no single "magic solution" that will induce a country to be suddenly innovative where it was not previously.

Principal Component 1 (PC1)		**Principal Component 2 (PC2)**	
Correlation	Indicator	Correlation	Indicator
0.848	Regulatory Quality	0.857	Independent Forms of Work Organization
0.836	Employment in Knowledge-Intensive Services	0.430	Expenditure on Education
0.843	Researchers	0.402	Simple Form of Work Organization
0.826	Patents	-0.849	Constrained Forms of Work Organization
0.816	ICT Use	-0.531	Taylorist Forms of Work Organization
0.801	Discretionary Learning		
0.775	General Expenditure on R&D by Business		
0.709	Expenditure on Education		
0.539	Total Computer Software Spending		
0.535	Staff Training		
-0.653	Simple Forms of Work Organization		
-0.477	Taylorist Forms of Work Organization		

Table 7.2.1 – Principal Component 1 and 2, Significant Correlations
Source: Author's calculations using SPSS Version 26

With also conducting a Hierarchical Analysis, the Principal Components can be reviewed in connection with which countries are similar to each other, as judged by SPSS Version 26. In Table 7.2.2, the descriptors [i.e.: strong, leaders, and moderate innovators] are taken from the European Innovation Scoreboard results (EIS,2018). Generally, the countries follow the EIS results with two exceptions. The Netherlands are grouped with "Strong Innovators" in Sub-group 1 of Group A whilst the EIS describes the Netherlands as being an 'Innovation Leader'. Estonia, described in the EIS as being a "Strong Innovator", is clustered with "Moderate Innovators" in Sub-group 3 of the Group B countries.

Country Groupings produced by Cluster Analysis					
Group A			**Group B**		
Sub-group 1 (Strong Innovators - EIS)	Sub-group 2 (Strong Innovators - EIS)	Sub-group 3 (Innovation Leaders - EIS)	Sub-group 4 (Moderate Innovators - EIS)	Sub-group 5 (Moderate Innovators – EIS)	Sub-group 6 (Moderate Innovators - EIS)
Netherlands (Innovation Leader – EIS)	Austria	Denmark	Estonia (Strong Innovator – EIS)	Italy	Slovenia
United Kingdom	Belgium	Sweden	Slovakia	Spain	
Canada	France	Finland	Lithuania	Greece	
Ireland			Czech Republic	Cyprus	
Germany			Poland		
United States					

Table 7.2.2 – Hierarchical Cluster Analysis Groupings
Source: Author's calculations using SPSS Version 26

7.2.1 Regulatory Quality

That "Regulatory Quality" was the indicator that had the highest correlation to PC1 was initially somewhat of a surprise to this researcher, but upon reflection and a little further research, it appeared logical. The World Bank (World Bank, 2018a) indicator was based upon sources that included, but were not limited to, the levels or amount of: unfair business practices, price controls, discriminatory tariffs, excessive protections, burden of government regulations, investment freedom, ease of starting a business, effectiveness of anti-monopoly policy, etc. (World Bank,2018b;1-2). Taken together, this indicator can be construed as "how fair and just" the country is to conduct business within. If a country provides a safe place to conduct business, less time has to be directed to either protecting assets, whether intellectual property or chattels, or worrying about reacting to changing political or legal conditions. To frame it in a psychological perspective, Regulatory Quality may fulfill Maslow's Physiological and Safety stages in his hierarchy of needs (Maslow,1943;371-379), thus allowing the climb to self-actualization for the firm, and perhaps even the country, to be possible.

Tebaldi and Elmslie (2013;899) found that innovation, as measured using patents as the proxy, show that institutional quality, control of corruption, business-friendly regulations and policies, intellectual property protection, and a fair and functioning legal system boost an economy's level of Innovation. These authors go further to say "…*Geography affects innovation, but only through institutions*." Coad, Pellegrino, and Savona (2016;327-328) found that "Regulatory Barriers", although negatively correlated to Innovation, only exerts "…*a barely significant effect at the 90% quartile only*." While van Ark et al argue (2003;11) that more restrictive regulations for labour, transportation, and customer access because of shopping hours limits may be some of the causes for lower European productivity, such restrictions do not totally explain why Europe lagged behind the United States. Sapir (2005;7) [Table 2.6.1.1 in this document] created his four European Social policy models with differing levels of Employment Protection Regulations and Unemployment Benefits levels, ranging from high to low. This social policy model, for all intents and purposes, shows that countries with high levels of Regulatory Authority may also have laws that are not the most generous in certain ways when examined in a localized manner, but compared to the rest of the world, may well be in the upper rankings.

In examining the growth of EU New Member States and potential convergence with the EU-15 countries, Grela et al. (2017:87) state that *"…Specifically, there is a significant relation between credit market and business regulations and growth in our sample: countries with good regulations tend to grow faster.*"

The Group A countries had the three highest rankings, but Group B countries had Estonia in the highest quartile and both the Czech Republic and Lithuania, ranking respectively, in the second quartile. This indicator, showing the highest positive correlation to Principal Component 1, casts a slightly different light upon the ways and means of supporting innovation from the institutional characteristics of a country.

7.2.2 Employment in Knowledge-Intensive Services, Expenditure on Education, and Staff Training

Employment in Knowledge-Intensive Services had the second-highest ranking in the principal components analysis PC1 and weakly correlated in PC2. This indicator from the International Labour Organization (ILO, 2019) is the percentage of the total population that are employed as Managers, Professionals, and Technicians and associated professionals for each country. The indicator shows the broad impact of the characteristics of the workforce for the country that is measured. The interconnection with other indicators shows the complexity of innovation and how there is no single indicator that will have an undue influence upon the innovation performance of a country. The higher the percentage of employed persons who are in the stated occupations translates into the higher the level of education required to fulfill such positions; even technicians and associated professionals will require a certain level of formal education and vocational training, and perhaps continuing education or re-certification, to be able to be employed in their chosen field of occupation. This author posits that the Expenditure on Education [moderately correlated to PC1 and PC2] and the extent of Staff Training will directly impact how many people are qualified to carry out duties as a Manager, Professional, and technician and associated professional in each country's labour market.

Peter Drucker coined the term "The Knowledge Economy" (1969;263), but Lundvall (2009;226) argues that the it is actually a "Learning Economy" because the new technology has to be first learned, then used, next understood, and finally exploited for innovation. Houghton and Sheenan (2000) wrote a high-level description of what the "Knowledge Economy" was and what should be done to meet the changing economic landscape. They state that the information revolution created the move towards codified knowledge, and from that, the share of that knowledge within individual economies globally, combined with the ability to transmit knowledge anywhere at low cost, effectively commoditizing knowledge (Houghton and Sheenan,2000;10). Makó and Mitchell (2013a;16-17) also examined organizational learning theories and created a model of the process by which tacit knowledge evolves to explicit knowledge. Makó et al. (2011;64) studied Organizational Innovation and Knowledge Use Practice in the Hungarian and Slovakian service business sector which, in part, examined the use of formal versus experiential learning by "Knowledge-Intensive Business Services" (KIBS) firms and found that "Skills development and formal training are important preconditions for innovation."

Group A countries had similar results for Employment in Knowledge-Intensive Services with no individual country below the second quartile. Group B countries also shared results similar to each other, but notably, Lithuania, Estonia, and Slovenia had rankings in the second quartile, with Estonia ranking higher than some Group A countries, but the other seven countries all had third or fourth quartile scores. Although Group A had higher results for Expenditure on Education, Cyprus ranked in the Highest quartile and the Czech Republic in the second quartile, and as a Group, the Group B countries all ranked in the bottom three for this indicator. There are some opportunities for the Group B countries for these indicators, though; Staff Training as a Group is higher than two of the Group A countries. For countries like the Czech Republic, which has a high ranking for Staff Training, a moderate level of Employment in Knowledge-Intensive Services and a moderate level of Expenditure on Education, supporting these indicators may be a way to increase innovation within that country.

7.2.3 Patents and R&D Financed by Business

The connection between Patents, Researchers, and GERD by Business is presumed to be a strong one; without researchers, patents may not occur without discoveries, but without funding the Research and Development, neither will occur. These three indicators are the third, fourth, and seventh-highest correlations, respectively, in the PC1 and are complementary to each other, although how they interact is not clear. One may posit true innovation comes from the lowest expenditure on R&D with the highest number of patents awarded, but that point is beyond the scope of this research.

Group A countries have the highest combined rankings for Patents, even with Ireland, the United Kingdom, Canada, the United States, Belgium, and France with rankings in the third quartile, as Group B has no countries with rankings above the Fourth [lowest] quartile. General Expenditure on R&D Financed by Business tend to follow the same distribution, but Slovenia has the highest ranking of Group B countries with a low second quartile result, and Group A countries the Netherlands, the United Kingdom, and Canada with third-quartile results, and Ireland in the lowest quartile.

Although Griliches (1989) says that Patents are not a "Constant-Yardstick" to measure productivity growth, they are a way to understand embedded knowledge and innovation creation at a national level. The results of the Cluster Analysis tend to support Raghupathi and Raghupathi (2017) that those countries with lower economic indicator results tend to rely upon

FDI for productivity support and less on either government or private sector R&D investment. Ketteni, Mamuneas, and Pashardes (2017;14-15), found that R&D and have a positive and statistically significant effect on growth of productivity, and that both ICT capital investment and human capital [enrollment in tertiary education], while Foreign Direct Investment (FDI) did not appear to have a significant effect upon growth of productivity. That assertion from Ketteni, Mamuneas, and Pashardes (2017;14-15) can be somewhat supported by the results of four of the indicators; importantly to this section both Patents and R&D Financed by Business, but also connecting into the indicators for Researchers, Expenditure on Education, and ICT Use, where Group A had generally higher rankings across all five indicators, with some notable exceptions such as Slovenia's Sub-group ranking of third for R&D Financed by Business.

7.2.4 ICT Use, Computer Software Spending, and Staff Training

Information and Communication Technology (ICT) Use signals the adoption and diffusion of technology by a population. This author posits that the more familiar a population is with technology, the further they are willing to experiment with uses for such technology. As with the other indicators in PC1 having inter-connections with each other, this may also be true with ICT Use and Total Computer Software Spending, with a connection to Staff Training. The division between commercial and personal software spending in the indicator is not elucidated, but one may surmise that commercial spending on software is higher than personal spending due to scope and scale of software required by business. Both Computer Software Spending and Staff Training are minor positive correlations, this may show how the "Complementaries" of staff training and systems upgrading support innovation and higher levels of Discretionary Learning (Arundel et al.,2007). The inclusion of these three indictors in PC1 may support the "Organizational Capital" theory (Brynjolfsson and Hitt,2002) that intangible assets increase productivity and produce higher market values for the firm. Lundvall (2009;223) argued that that the "Knowledge Economy" as Drucker coined it (Drucker,1969;263) is actually a "learning economy" because the new technology has to be learned, used, understood, and finally exploited for innovation. Lundvall (2009;226) found that Danish firms that did not combine the new technology with investments in employee training, change or training for management, and perhaps a change in the work organization had negative effects on productivity that could last several years. Brynjolfsson argues that the creation of knowledge encourages innovation, and ICT has "…a unique role in augmenting, if not automating, creativity and discovery." (Brynjolfsson,2011;74).

One may posit that the role of ICT investment allows the biggest spenders to create the most innovation and reap the rewards. One can logically accept the notion that those firms who spend the least on ICT investment in an industry where competitors spend more may not be able to compete. Brynjolfsson (2011;67-68) found that the interquartile [25th percentile to 75th percentile) gross profit margin grew from approximately 20% from the 1960s to the 1980s to approximately 35% from the mid-1990s to 2006. Brynjolfsson's results show that the 31 highest ICT intensive industries saw their gross profit margin roughly double, whereas the 31 lowest ICT intensive industries were almost unchanged. Arundel et al. (2007;25) also note that in countries where there is a high level of employer-supported training, the levels of discretionary learning tend to be higher, and also the levels of "endogenous innovation" (Arundel et al.,2007;29).

Makó et al (2009b;56) found that over half (52.7%) of the Knowledge-Intensive Business Services firm's employees had participated in a training course that was planned, provided, and paid for by the employer in the previous year versus only 23.3% of Manufacturing firms. Forms of Work Organization may also play into the equation of ICT Use. Logic would dictate that economies with large Taylorist or Constrained Learning percentages will likely not have large ICT usage when performing tasks just due to the nature of the work itself; even High-tech Manufacturing may include many relatively low-tech aspects. Makó et al. (2009b;51) also found that 44.5% of manufacturing companies use ICT for communication or information processing in the EU whereas 95.2% of Knowledge-Intensive Business Services firms do use ICT, and KIBS firms use ICT for developing activities approximately four times more than manufacturing firms [82.6% compared to 19.1%]. These two findings, taken with the preceding points by Brynjolfsson et al (Brynjolfsson and Hitt, (2002), Brynjolfsson (2011)), Arundel et al. (2007), and Lundvall (2009) may elucidate the ICT-induced innovation advantage that Discretionary Learning has versus the other Forms of Work Organization, but process or incremental innovation may occur at different rates, especially within the manufacturing sector; this was not part of the research agenda, but an observation by this author in reviewing the literature.

The United States led the sample countries with the highest result for Computer Software Spending with a result that was much higher percentage of GDP that there were no other countries in the highest quartile, it was only the United States. Staff Training for the United States was also the highest-ranking of the sample, even with a somewhat average ICT Use result. This situation may signal that even though there are less ICT Users proportionately in the United States, they have newer software tools and are better trained to use the software. The Nordic countries had relatively similar results to the rest of the Group A countries for Computer Software spending, but high results for Staff Training and the Highest for ICT Use. Three of the ten countries in Group B; Estonia, Spain, and Cyprus, had second quartile rankings for ICT Use, but six of the seven others were in the lowest quartile for ICT Use. Two Group B countries are in the highest quartile for Staff Training, the Czech Republic and Spain; and for Spain this was the only result in the highest quartile for the entire set of indicators in this study. The rest of the Group B have a fairly wide dispersion for Staff Training with Italy and Cyprus in the second quartile, Slovakia and Estonia in the third quartile, and the rest of the countries in the lowest quartile. While the Group B countries have reasonable Staff Training results, the very low Spending on Computer Software may have impacts on the way the training is delivered and keep the Group B countries at a disadvantage compared to the higher proportionate computer software spending Group A.

7.2.5 Forms of Work Organization

While there are many aspects of the Principle Component 1 [accounting for 42% of the results] that influence the results, only one Form of Work Organization is above the 0.800 level, and that is Discretionary Learning. The countries that make up the Sub-group that have the highest rankings in the sample are Sweden, Denmark, and Finland. Of the three countries, Finland and Denmark have Discretionary Learning shares of 47.23% and 46.29%, respectively, of their workers in a Discretionary Learning environment. In contrast, Sweden has 41.83% Independent forms of work organization, but has a very large percentage of Discretionary Learning forms of work organization at 34.79% (Greenen et al., 2017, 11-15), which is a higher percentage than 11 of the other countries in the sample on its own, let alone being the second-ranked form of work organization for a country. To put Sweden's results in context, with relatively high results in both Independent and Discretionary Learning, the results for the other three forms of work organization are: Constrained Learning 3.96% (20th of 22), Simple 7.38% (19th of 22), and Taylorist 12.03% (19th of 22). The other Forms of Work Organization are all negatively correlated to PC1: Constrained Learning [-0.055], Independent [-0.276], Taylorism [-0.477], and Simple [-0.653]. Having such a range of negative correlations with one positive was an expected result, although both Independent [PC2: 0.857] and Simple [PC2: 0.402] forms of work organization are positively correlated to PC 2, which accounts for 15% of the explanation of the total variance of the data set. Also within PC2, both Constrained Learning and Taylorist forms of work organization are negatively correlated at -0.849 and -0.531, respectively. None of the other three principal components (PC3, PC4,and PC5) have Forms of Work Organization that either positively or negatively correlated to them above the +/-0.400 level.

Lorenz (2015) compared different EU countries used 2010 EWCS data and 2005 EWCS work form results to correlate the frequencies of the four forms of work organization and the relation to innovation. Lorenz (2015;10-12) found that where there was a higher level of Discretionary Learning, the rate of innovation tends to be higher. Where Taylorist and Simple forms are the larger percentages of the forms of work, frequency of innovation is lower. Austria, France, and Ireland all have relatively high results for Taylorist forms of work organization, but they also have higher rankings in either Discretionary Learning or Independent forms of work organization. What these three countries also have are average to high results for the majority of indicators in Principal Component 1. Germany also has a high ranking for Taylorism, but has particularly high rankings for General Expenditure on R&D by Business, Regulatory Quality, Patents, and second-quartile results for Researchers, ICT Use, and Employment in Knowledge-Intensive Business Services.

The Nordic countries of Sub-group 3, labelled as the Innovation Leaders by the European Innovation Scoreboard (EIS, 2019), did not have the with the highest levels of Discretionary Learning, the Sub-group 1 had the highest Sub-group ranking, but the EIS described them as Strong Innovators. What Sub-group 3 did have, though, were strong results for Independent Forms of Work Organization, which was the highest correlation of Principal Component 2 (PC2). Sub-group 3 also had very low rankings for the Constrained Learning, Taylorist, and Simple Forms of Work Organization, which were all either negatively or weakly correlated with both PC1 and PC2.

Arundel, Lorenz, Lundvall, and Valeyre (2007) examined the differences in the organization of work and innovation within the EU-15. Using European Working Conditions Survey data, they attributed the four different types of work forms; Discretionary Learning, Lean Production, Taylorism, and Simple/Traditional and their respective frequency in each of the countries. They found that the type of learning, at a national level, can be correlated with the type of innovations that the country will be able to produce. For example, countries that have high discretionary learning and lean production work forms tend to have high strategic and intermittent innovation modes where innovations are created "in-house" and are new-to-the-market innovations (Arundel et al., 2007;20-24). Arundel et al. (2007;25) also note that in countries where there is a high level of employer-supported training, the levels of discretionary learning tend to be higher, and also the levels of "endogenous innovation" (Arundel et al.,2007;29). This is supported by the results of the Cluster Analysis in Chapter 6 where, for the large part, those countries with high levels of Discretionary Learning tend to have higher levels of innovation. Further to this assertion, Estonia is recognized as being a "Strong

Innovator" by the European Innovation Scoreboard (EIS,2018) with the highest ranking for Discretionary Learning in the Sub-group 4, and also the highest ranking in the Sub-group for Independent form of work organization, somewhat similar to Sweden [The reader should recall that the Principal Component 2 had the highest correlation to the Independent form of work organization indictor]. The Czech Republic also had a lower second-quartile ranking for both Discretionary Learning and Independent form of work organization, but lower rankings in the PC1 indicators with the exception of Regulatory Quality [low second-quartile] and Staff Training [third highest of the entire sample countries].

At the other end of the scale, The Sub-group 5 had the lowest rankings for Discretionary Learning, but moderate to high levels of Independent Learning, yet even with that result had the lowest results for 5 of the 11 non-Forms of Work Organization indicators. This echoes Makó et al.'s (2013b;10) finding that between the Central and Eastern European countries and the Southern European countries, generally the CEE countries have a higher level of cognitive dimensions in their jobs. Sub-group 6 [Slovenia] is the exception to the aforementioned results as it has low Discretionary Learning, Independent Learning, and Simple Learning, but high levels of Taylorist and Constrained Learning forms of work organization. Whilst the EIS (EIS, 2018) label them as a "Modest Innovator", Slovenia has the third-highest ranking in Expenditure on Education, the highest ranking in Group B for Researchers, second-highest ranking for Employment in Knowledge-Intensive Services, an average result for Staff Training, and the highest General Expenditure on R&D by Business, these may be part of the reason they are unique enough to warrant their own Sub-group, and should this same analysis be conducted in the future, perhaps Slovenia may be in a different Sub-group, or even group should the potential lag between investment and implementation and when the country can see their return on investment (Brynjolfsson et al.,2017;9-16).

7.2.6 Labour Productivity per Person Employed Percentage Change.

This single indicator, or any variation that quantifies Gross Domestic Product growth, in many ways should be a telling proxy metric for innovation of countries (Acs et al.,2002;1), but in this research, the results were somewhat counterintuitive. Why, with the amount of innovation we have experienced in the last thirty years, is productivity of the "innovative" countries at such a low level compared to the pre-1974 time period? ICT has become a mature General-Purpose Technology [GPT], with those who argue that it does not have the type of impacts that previous GPTs allowed, yet the way we live our daily lives has changed markedly.

Summarizing Gordon (2018), the productivity slowdown in the United States and the EU-15 has been caused by non-economic or public policy matters, and can be connected to population decline through lower birth rates and the aging workforce with retirements creating a lower employment participation rate which has not been replaced through increased immigration, manufacturing employment losses to factor economies by globalization, a decrease in tertiary education due to high cost, and through high levels of student debt, the decline of young entrepreneurs starting businesses and later household formation.

Gros (2018;2) stated that new Member States, whether they are part of the Eurozone or not, are moving toward convergence with the EU-15, although the economic and currency crisis of the recent past have caused some slowdown in it. Gros (2018;6-7) also points out that the new Member States have averaged 6% growth from 1999 to 2016 compared to a 2% average for richer member states. While Gros (2018;8-9) also points out that there appears to be an increasing East-West convergence, there is also growing North-South convergence with the "peripheral" southern countries [Spain, Malta, Cyprus], and the remaining southern countries are continuing their low growth with half of the New Member States overtaking Portugal and Greece in GDP per capita. Within the same section, though, Gros notes that in the past, NMS countries appear to stall once approximately 82% of the EU average, convergence stops.

Grela et al. (2017;87) found a significant positive relation between productivity growth and innovation. The CEE countries that had higher levels of Patents applied for, high-technology employment, and employment in Knowledge-Intensive Business Services tended to grow more than countries that had lower levels in the three respective indicators. This connects very well with the literature from Lundvall (2009;226) concerning the "Learning Economy".

One other note to consider with the Principal Component Analysis is that which indicators are considered to be important for innovation may be somewhat impacted by economic conditions in North America and the EU-15 as Labour Productivity per Person Employed Percentage Change was positively correlated to PC2, and negatively correlated with all the other Principal Components.

7.3 Hypotheses Results

H1: Innovative countries share more characteristics with each other than with less innovative countries.

Idea: *The hypothesis is that innovative countries share traits that make them innovative; whether it is education, government support, or social characteristics, common threads will enable countries to be innovative.*

H1 has been proven. The Hierarchical Cluster Analysis and subsequent review and comparisons of the grouped countries in the dataset showed that the most innovative countries were grouped together based upon their characteristics and that countries generally were grouped with those others that shared like characteristics. The results generally followed the European Innovation Survey (EIS,2018) and other Innovation indices results for relative rankings in an "order of magnitude" manner, but not exactly. For the most part, these results also reflected the traditional economic or geographic groupings that have been applied in various academic and governmental research. The novelty in this research was the addition of Forms of Work Organization with the Innovation indicators. Combining the two reinforced the results and groupings in many ways, such as the similarities of the Nordic countries to each other and the Southern countries to each other.

H2: Productivity and Innovation are connected, but are not proportional.

Idea: *Although Innovation and Productivity are inter-connected, the same levels of each in different countries may not achieve the same results.*

H2 has not been proven. The discussion concerning the Labour Productivity per Person Employed in section 7.2.6. and relative levels of innovation is a difficult question that this research has not come to a definitive answer. The high productivity rankings, as proxied by Labour Productivity per Person Employed Percentage Change, shows the

Eastern European Countries in Sub-group 4 having the highest rankings in the sample, yet the other indicators show relatively lower scores and due to that, put Sub-group 4 and 6 countries into the lower country grouping for level of innovation. Part of this may be due to the "snap-shot" characteristic of this study not being able to adequately compare results as the act of economic convergence or lags between implementation and benefits is still underway for the New Member States. An alternate reason may also be that whatever issue or related issues that have caused the productivity slowdown in the economies has not affected the CEE countries as yet. For this reason, this hypothesis cannot be completely proven through this research.

H3: ICT use supports organizational or process innovation, but outside influences may limit the actual increases to productivity.

Idea: *Information and Communication Technologies have allowed productivity to increase, but some countries can harness the innovation better.*

H3 has been proven. This hypothesis can be proven through the results of the as proxied by Labour Productivity per Person Employed Percentage Change versus the relative level of innovation as determined through the Principal Component Analysis and the Hierarchical Cluster Analysis which grouped countries into "like" groupings based upon their characteristics. The countries with higher innovation rankings exhibited lower levels of productivity growth versus the less innovative countries. This is where the literature from Gordon (2018) proves to be very important to consider, but perhaps not the entire story, as to why highly innovative countries are experiencing low growth. All things held equally, ICT and the spin-off effects of complementaries such as training and organizational design innovations, should result in productivity growth. Issues such as market and economic factors such as trade agreements or sanctions, general economic climate, and interest rates may have more of an impact than the potential performance of national economies.

8 Conclusion

8.1 Introduction

Multi-disciplinary research can be challenging. It can also be rewarding, perplexing, and confusing, but if one is fortunate, it can also be enlightening. This author leaves it to the reader to decide which outcome is most fitting for their own mind. This research had two novel approaches:

1. The inclusion of Forms of Work Organization when examining Innovation.
2. The inclusion of the United States and Canada when examining Forms of Work Organization.

While there have been some researchers such as Bloom et al. (2012) who have examined management practices across the globe, they only examined Manufacturing, Schools, and Hospitals. This researcher was unable to find any research that connected the Forms of Work Organization that included Canada and the United States with the European Union, nor also including Forms of Work Organization in relation to Innovation.

8.2 Summary of the Research

Innovative countries do share more characteristics with each other than they share with less innovative countries. The traditional geographic groupings also appear to hold generally for this research, and although there are positive signs that the Central and Eastern European economies are catching up to the Continental, Northwestern, and Nordic countries, there is room for improvement as yet. The Southern European countries are still at a deep disadvantage compared to the rest of the European Union and North America.

Within the innovation indicators selected for inclusion in this exploratory research following the Oslo Manual, there was not one that stood out as being the “magic wand” to be able to grant any country instant increases in innovation through both scientific analyzes. With six clustered indicators highly correlated to Principal Component 1 (PC1) and all within 0.047 of each other, including the Discretionary Learning form of work organization, this researcher posits that the collection of adequate levels of all of these together is very important for a country to be innovative. The six highly correlated indicators were: Regulatory Quality, Employment in Knowledge-Intensive Business Services, Researchers, Patents, ICT Use, and Discretionary Learning. Expenditure by Business in R&D, general national Spending on Education, Computer Software Spending, and Staff Training were also moderate correlations, which would support the notion that innovation is complex and depends upon the right recipe to deliver dividends.

The addition of the Forms of Work Organization and the resultant findings that economies “work” more innovatively when workers are provided with higher levels of control over their time, their methods, and decision-making authority. Discretionary Learning was highly correlated to Principal Component 1 and the Independent form of work organization was the highest correlation to Principal Component 2. Taken together, they share many characteristics and show that having independence in planning one’s own time, ability to solve complex problems, collaboration, sharing work information, and persuading or influencing people are valuable job characteristics to develop and support to enhance innovation.

8.3 Key Findings

Innovation is complex, and no single determinant will individually allow non-innovative countries to become innovative in a short period of time. This research should assist both Governments and Industry in examining where policy changes, changes to the national educational systems, and financial or tax-credit support for Innovation should be placed, and perhaps even be able to create a roadmap for allowing countries to become much more innovative in the future. While the antecedents of innovation appear to be understood to be many and complicated (Brynjolfsson and Hitt,1998;11, Brynjolfsson and Hitt,2002;175-176). There are many important characteristics that countries have to have for Innovation to be able to be realized.

- That Regulatory Quality was the highest correlation in PC1 was a surprise to the author, yet this supports the recent findings of Grela et al (2017;87) that countries with good business and credit regulations tend to grow faster, perhaps the same type of conditions allows countries to innovate better or faster. Once considered critically, living and working in a safe environment with a high quality of regulatory sophistication where the basic human and societal needs are satisfied shows great potential for those citizens to be able to focus on issues that are on a higher plane of thought than day-to-day survival requirements. In many developing countries that are active global supply chain participants, these “safe” conditions may not totally exist.
- Forms of Work Organization really do matter when it comes to Innovation. This exploratory research showed that two Forms of Work Organization are correlated to countries that are considered to be innovative; Discretionary Learning and Independent. Discretionary Learning was one of five indicators that had a correlation above the 0.800 level in the first Principal Component, and Independent was the highest correlation of Principal Component 2 at an 0.857 level.
- This research showed that high levels of Regulatory Quality, Researchers, Employment in Knowledge-Intensive Business Services, Patents, ICT Use, and investment in Research and Development by Business all need to be present for a country to be innovative.
- Training and Total Computer Software Spending are less important than the clustered six indicators, but both still need to be present in a sufficient manner to support innovation.
- Productivity growth is generally used as a proxy for innovation; it may be that the measures need to be examined in relation to innovation due to the negative correlation to four of the five Principal Components in this research, perhaps due to the stagnation of Productivity in the advanced economies.
- This research showed that the generally accepted academic view of Europe being “left behind” by the United States in productivity should be revisited in view of the Conference Board’s 2018 adjustment to the productivity statistics and by incorporating the entire EU-28 results into the assessment.

8.4 Future Research

I have greatly enjoyed this research and all the ways that the results created questions as to how all these indicators interact touching forms of work organization, productivity, and innovation. While I examined many different subjects and streams of literature, there were research directions that I could not undertake. Avenues for future research or application of this subject are:

- Further research should focus on the links between productivity and innovation to find the causes of the lingering low productivity of mature nations in the face of accelerating technological innovation. The situation, to this author's mind, is counter-intuitive as we are at the boundaries of technology presently, but seemingly cannot make even small leaps in productivity in the advanced economies.
- Building partnerships with other trading nations, specifically those innovative countries in Asia that are, or could potentially become, significant trading partners for nations in the European Union. This approach could also be used to identify those nations that offer complimentary economic or commercial situations that do not exist in one's own country, thus creating opportunities for co-operation or symbiotic trade/investment that may benefit both nations.
- Extend the research to include a detailed inclusion of Artificial Intelligence (AI) development indicators to provide preliminary research on how the existing innovation indicators are impacting the ability of individual countries to develop AI technologies. This future research would be in the same vein as this present research: exploratory.
- A more detailed examination of the European Union and other OECD countries in relation to Forms of Work Organization and Innovation will be able to be conducted once the Programme for International Assessment on Adult Competencies (PIAAC) third round of the first cycle and the second cycle are complete in the early 2020s. Having a yearly, or at least time-phased panel data from the PIAAC would be able to create a way to understand which indicators, over time, are the most impactful.
- Act as a direction for the EU countries to be able to support the development of conditions to increase innovation within their countries, and specifically, the Central and Eastern European countries that are still engaged in the "Catch-up" phase with the other EU countries. The Southern Countries Greece, Italy, and Portugal should also consider in which of the indicators they need to support to draw themselves from their current economic situation.
- Act as a blueprint for future social and societal development for those EU Candidate nations (North Macedonia, Montenegro, Serbia, and Albania).
- Introducing the economic and industrial sector profiles for each country may also be able to create a better understanding of why certain forms of work organization are more prevalent in some economies compared to others, and how they interact at a national and supra-national level.

8.5 Chapter Summary

This chapter summarizes the findings of this exploratory research and addresses the three hypotheses. While only two of the three hypotheses were proven, that provides an avenue for potential future research to examine the issue of persistent low productivity in highly developed economies.

The fundamental aim of my research was satisfied: Examining the characteristics of the countries of the European Union, Canada, and United States proved that Forms of Work Organization do impact innovation, either positively in the case of Discretionary Learning and Independent, or negatively in the case of Taylorist, Simple, and Constrained Learning. This research also elucidated that innovation is complex and requires many inputs to occur.

Finally, avenues of future research have been identified that may, through investigation and iteration, provide knowledge and understanding to be able to advance the cause of innovation and the proliferation of forms of work organization that support it.

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10 Appendix A – Correspondence with U.S. Bureau of Labor Statistics

[ors] ORS and NCS Cognitive data

MB

Mitchell, Brian

Sun 6/30/2019 7:14 PM

(No message text)

You forwarded this message on Sun 6/30/2019 7:14 PM

You forwarded this message on Sun 6/30/2019 7:14 PM

LB

Forward

Lavrenyuk, Nikolay - BLS <Lavrenyuk.Nikolay@bls.gov>

Tue 5/28/2019 9:45 AM

- Mitchell, Brian;
- NCSinfo <NCSinfo@BLS.GOV>

Good day Mr. Mitchel,

Thank you for your interest in the Occupational Requirements Survey (ORS).
Data for cognitive and mental requirements are currently being collected and will be published for the 2019 reference period. We did not collect or publish cognitive and mental requirements of jobs for the 2018 reference period in order to align the collection questions to the requirements we are attempting to understand.

Kind regards,

Nikolay Lavrenyuk, Economist, U.S. Bureau of Labor Statistics

National Compensation Survey | Better Decisions Begin with Better Data

202.691.6199 | ncsinfo@bls.gov | www.bls.gov/ncs | Get the facts on the BLS

From: Request for Occupational Requirements Survey Information [mailto:labstat@bls.gov]
Sent: Sunday, May 26, 2019 1:01 PM
To: NCSinfo <NCSinfo@BLS.GOV>
Subject: FW: [ors] ORS and NCS Cognitive data

View the frequently asked questions

To receive an answer to your ORS inquiry, enter the following:

*** Required Field**

* Email address:	mitb01@uqo.ca	
* Full name:	Brian Mitchell	
Telephone number:	8193148610	Ext:
	(For example, 1234567890)	
* Subject:	ORS and NCS Cognitive data	

*** Enter your question in the box:**

Good Afternoon:

I am a Ph.D. student at St. Stephen's University in Hungary (although living in Canada). I am researching working conditions and forms of work. The Occupational Requirements Survey (ORS) and the National Compensation Survey (NCS) information I found on the BLS website both refer to the collection of "Cognitive" factors that workers experience carrying out their jobs. Is there somewhere I can find this data as it is the core data that I need to be able to align US organizational work forms with the existing EU data for comparison purposes.

Thanks,
Brian

11 Appendix B – Correspondence with Mr. Teshin Mehdi of Statistics Canada

Assessing Job Quality in Canada: A Multidimensional Approach

Back to list

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Tahsin Mehdi to you Apr 23, 2019

Hi Brian,

Unfortunately, Canadian data on job quality or firm innovation/productivity is virtually non-existent (in terms of what's available publicly). Europe and the U.S. are definitely ahead of us in terms of that kind of data. At Statistics Canada (where I work), we typically use administrative data from tax forms and business registers to measure such things. There's not really an "off-the-shelf" dataset for such things so it takes months of work to link and clean the data first. If you're not an employee of Statistics Canada, it would be very difficult to get permission to use such data.

Brian Mitchell Apr 30, 2019

Hi Tashin:

Thanks - that's what I figured as I've not been able to find it...

Cheers,
Brian

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12 Appendix C – Correspondence with Ms. Sabrina Leonarduzzi of OECD

Sabrina.LEONARDUZZI@oecd.org
Tue 7/2/2019 4:52 AM

- Mitchell, Brian;
- Vanessa.DENIS@oecd.org

Dear Brian,

We thank you for your interest in the PIAAC data. The results and data files of the 3rd Round of the 1st Cycle in which Hungary participated will be released on 5 November 2019.

Best regards,

Ms. Sabrina Leonarduzzi
Assistant
Directorate for Education and Skills, PIAAC

2, rue André Pascal - 75775 Paris Cedex 16
Tel: +33 1 45 24 92 77
sabrina.leonarduzzi@oecd.org || www.oecd.org

Follow us on:

From: Mitchell, Brian[SMTP:MITB01@UQO.CA]
Sent: Monday, July 01, 2019 11:07:04 PM
To: EDU PIAAC Archives
Subject: PIAAC 3rd Cycle question
Auto forwarded by a Rule

Good Afternoon:

My name is Brian Mitchell and I am a Ph.D. candidate at Szent Istvan University in Godollo, Hungary. I am using the PIAAC data from the first two cycles of the survey for part of my dissertation. I have not been able to find any information on the release of the third cycle. Hungary is part of that cycle, and I'd love to include that data in my research. Can you tell me if the third cycle has been released, or when it is anticipated to be released?

Thanks,
Brian

Brian Mitchell, MPM, PMP, LEE

13 Acknowledgements

This particular academic journey has been a long one and has had many twists and turns along the way. I have to thank Dr. Csaba Makó for his wisdom, insight, his ability to let me explore various academic streams, and his (at times) biblical patience. Dr. Makó introduced me to the world of forms of work organization which took me along an exciting path of inquiry and away from the organizational trust and organizational design research I'd completed in my Masters degree at the Université du Québec en Outaouais.

This Ph.D. journey would not have been possible without the support and encouragement of Dr. Tamas Koplyay at the Université du Québec en Outaouais. I continue to learn from Tamas through co-authoring and discussions about not only corporate lifecycle but also life in general.

Finally, I thank my family for their love and support through the difficult times. Being a father and husband while working full time and completing a Doctorate is no easy task, and while it has brought a number of challenges amongst competing duties and responsibilities, I would change nothing about the journey.