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Effect of innovation and research activities on regional development

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Innovation and research activity of the region is an important determinant of regional development. The aim of the thesis is to evaluate the impact of innovation and research activities on the regional development. On the basis of this analysis the suggestion will be propose for current practice.

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GRUPP, H. Foundations of the Economics of Innovation. Edward Elgar: Cheltenham, 1998. ISBN 1-85898-716-4.
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TOMLINSON, P. R. Co-operative ties and Innovation: Some new evidence for UK Manufacturing. In Research Policy, 39 (6). School of Management, University of Bath, United Kingdom, 2010. ISSN 0048-7333.
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AUTHOR'S DECLARATION

I hereby declare:

This thesis was prepared separately. All the literary sources and the information I used in the thesis are listed in the bibliography.

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ABSTRACT

Innovation and research activity of the region is an important determinant of regional development. Innovation and research have been billed to play an active part in product development, process development and extensively regional economic development. The aim of this research thereof, is to identify the impact of innovation and research activities in NUTS 2 regions in the European Union for European Union policy making and knowledge of regions with better innovation performance on regional development. First research hypothesis constructed supposes that “there is a positive and significant relationship between R & D inputs and regional innovation. Second hypothesis constructed was also established that “there is a positive and direct impact between regional innovation and regional development”. Linear regression was used to assess the measure of innovation, that is patent with regional development indicators- Real GDP per capita, employment rate and Disposable income. The entire 274 NUTS 2 regions were the sample assessed in this research with particular focus on regional policy structuring in the European Union.

However, the regions were classified into Northern, Western, Eastern and Southern EU NUTS 2 regions. It was discovered Eastern EU NUTS 2 regions had relatively almost the same impact on Real GDP/capita as Northern and Western and Southern regions in 2007. However, although disposable income of Northern and Eastern EU NUTS 2 regions recorded experienced quite higher impact by patents in both 2007 and 2012, it could not be concluded to be better than Western and Southern regions due to unforeseen impact of non-monetary Research and Development processes in the regions. Employment rate rather, had almost no impact from patents for all classified regions in both 2007 and 2012.

KEY WORDS

Innovation, Patents, Research and Development, Gross Domestic Product per capita, Research and Development Expenditure, Regional Development.

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LIST OF THE ABBREVIATIONS

GERD/c	Total (gross) intramural R & D expenditure per capita
PFTE	Percentage of full time equivalent in employment
RGDP	Real Gross Domestic Product
RGDP/C	Real Gross Domestic Product per capita
EPO	European Patents Office
R & D	Research and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
OECD	Organisation of Economic cooperation and Development
ESA	European System of Accounts
EPO	European Patents Office
PPM	Patents per million inhabitants
NUTS (2)	Classification of Territorial Units for Statistics (II)
WPA	United Nations' Work Projects Administration
SNA	United Nations' System of National Accounts
NSF	National Science Foundation
EU	European Union
PCT	Patents Cooperation Treaty

Introduction

Innovation and research activity of the region is an important determinant of regional development. Innovation and research have been billed to play an active part in product development, process development and extensively regional economic development (OECD 2015). It is adjudged that various micro regions undertake projects and investments that support the research activities of the large multinational entities as well as Small and Medium sized firms in their regions to propel these firms to implement various improvements to their administrative activities, processes and products. In this vein, research will be conducted into discovering the exact impact of innovation and research activities on regional development. The aim of the thesis is the therefore to evaluate the impact of innovation and research activities on the regional development with focus on NUTS 2 regional classification system of European Union member states.

Oslo Manual explained innovation as "implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations. The tri-partite definition of innovation classifies innovation as any commercial activity which exhibits the simultaneous characteristics of newness, improvement, and uncertainty, provides the basis of our subsequent empirical analysis of innovation which we undertake in this paper.

Other research in this field such as a study conducted by Gulogly and Teklen (2012) using a bivariate panel causality test results confirmed this premise such that R & D expenditures were found to have caused innovation when measured using triadic patents (patents from European Patent office) and technological change subsequently caused economic growth. Buesa et al. (2010) also conducted research on determinants of regional innovation in Europe and concluded that determinants of regional innovation in the European Union are mainly (innovative) firms and the environment in which the latter are situated (both the Regional productive innovation environment and the National environment). In this process, the firms are supported—though generally in an indirect way—by the other agents of the R & D system. However, there has not specifically been any research assessing innovation on regional development in NUTS 2 regions in the European Union. Thus, objectives will be to:

- Identify the specific inputs of innovation process,
- Identify the relationship of these inputs with output of innovation,

- Identify and discover the impact of outputs of innovation on the outputs of the economy of NUTS 2 regions.

To achieve these objective answers will be sought on questions relating to innovation and regional development. The research questions are;

- How does research support innovation?
- Does innovation have an impact on regional development?
- How does innovation affect development in regions?

In virtue of this, research hypothesis will also be constructed between the variables of innovation and regional development.

H1- Regional research and development inputs have a positive and significant relationship with regional innovation which is measured by number of patents per inhabitants.

H2- Regional innovation measured by number of patents per inhabitants has an impact on regional development indicators.

The research will be divided into four parts. First will be the theoretical section which will enlighten us on the theoretical background, researchers' ideology and different opinions and research results regarding the research object and the variables to be considered. Second will be the research methodology which will detail the research strategy to be used, the sample size and the population considered and the approach to the research that will be considered. It will also detail the research tool used for the analysis of the research variables to be used in the analysis.

Third will be the results section will consist of the analysis of the variables analysed and assessed to achieving the stated research hypothesis. It will mainly consist of the usage of linear regression between the variables of input and innovation, which was patents in this research, chi square test to determine the significance of the relationship of the research variables and the measuring variable of innovation, that is patents. Patents will finally be assessed against regional development variables that is, real gross domestic product per capita, employment rate and disposable income. Findings and recommendations will be the next chapter outlining the discoveries of the research and ways to improve further research and current situation and lastly conclusion will be the closing chapter to sum up all the recordings and research question and hypothesis outlined in the research as well as future research directions.

1 Theoretical concepts: Research, Innovation and Regional Development

In this section, we will discuss the concept of Research and development, delving into the structure and the determinants of it. The chapter will also display various theoretical ideologies of the concept and perceived connection of Research activities on the selected measure for innovation. Models, theories and forms of innovation will also be actively explained and examined to understand the impact it may have on the development of a region or county.

1.1 Interpretation of Research and Development

The concept of innovation and research has been, for a while, has been mis-used and mis applied in lots of ways. In theory actually, there is not so much of a thin line between the terms, research and development and their inputs as well. Notwithstanding their stark similarities, this section seeks to explain the true and progressive meaning of the term research and development up to the most current literature.

1.1.1 Concepts and definitions

The concept of Research and Development has had its definition updated and tweaked from the early ages to accommodate the new processes and technological upheavals that accompanies this modern age. To comprehend the fundamental and body-wide concept of Research and Development, we will assess various definitions of the concept from renowned institutions and authors.

Oxford dictionary reveals that the term “research” has French Origins as far back as the 16th century. It explained the term “search” as the act of “examining thoroughly” a concept or an activity (Godin, 2001). Research was hence established as the act of “searching closely and carefully” (Godin 2001) and was extensively applied in scientific enquiries. However, interpretation of research in this context faded added quickly in the years preceding the end of the 19th century to pave way for the element of systematisation.

Due to the lack of “systematisation” US Work Projects Administration (WPA), decried the lack of similar standards used by different institutions and Government bodies which made it difficult for International institutional and Governmental comparisons. This and many movements by industrialists in the 1930’s pushed for establishment of a United Nations System of National Accounts (SNA) in 1993 defined R & D as “"an activity undertaken for the purpose of discovering or developing new products, including improved versions of qualities of existing products, or discovering new or more efficient processes of production”.

It went on to add that R & D was undertaken with the underlying objective of "improving efficiency or productivity or deriving other future benefits ". As broad as his definition was to even include efforts expended in initial product design, product and marketing cost as well, it however, was accused of being too close to innovation itself and for also excluding research conducted for non-commercial purposes or with no immediately intended productive use. This also resulted in countries excluding R & D assets remain national accounts' statistics. Babbie (1998) came out with the perception of the interpretation of research as "a systematic inquiry to describe, explain, predict and control the observed phenomenon. Research involves inductive and deductive methods "few years before official. Similarly, Webster dictionary added a simplified explanation of research as "a diligent inquiry or examination in seeking facts or principles". Grupp (1998) also concurred to this trend of explaining R & D as a "systematic, creative work that advances the state of our knowledge, whether about man, culture or society and uses this knowledge to identify new potential applications". Following the Frascati Manual, the convention in the literature is to measure R & D by the Gross Domestic Expenditures on R & D (GERD) that is calculated as the ratio of R & D expenditures to GDP by Falk (2006). GERD provides an internationally comparable measure that accounts for innovative activity in each region, regardless of differences in the source of financing or sectors (Falk, 2006).

European System of Accounts, (ESA 2010, para 3.82) gave the widely-accepted definition of Research and Development as a "creative work undertaken on a systematic basis to increase the stock of knowledge, and use of this stock of knowledge for the purpose of discovering or developing new products, including improved versions or qualities of existing products, or discovering or developing new or more efficient processes of production.". OECD (2007) adopted this definition in explaining its statistical terms. Upon the recommendation of the Canberra Group on the Measurement of Non-Financial Assets, United Nations' SNA (2008) changed the treatment of R & D from an expense to a capital investment resulting in a capital stock of knowledge generated from R & D. (EC et al., 2009). They subsequently adopted definition of R & D from the Frascati Manual and used from there on in its further publications.

R & D therefore, agreeably, can be conveniently understood as a systematic productive process which uses inputs of labour, goods, services, and capital to produce and apply 'knowledge (Ker 2014). This definition has internationally been adopted and consistently used among all European Union member states for the purpose of consistency, comparability and reliability of economic statistics (Ker 2014).

According to Ker (2014), UNESCO, in the documents of OECD explicitly explained the concept “systematic” in R & D as: “an activity to be considered at the international level of science statistics must be properly structured, i.e. it must meet the minimum requirements of a systematic activity such as: the person (s) exercising this activity must work during a significant activities, i.e. activities carried out sporadically, or from time to time, within the various services of an institution, thus not meeting the above-mentioned minimum requirements of a systematic activity, should not be taken into account. There follows, therefore, that non-institutionalized, individual and/or discontinued, diffused or scattered activities are to be excluded for the presentation of international statistics.”

It could be seen from the similarities and advancement in definitions opined by authors, dictionaries and International bodies that R & D possesses a systematic feature and an objective to discover information about the relationship between known variables or to incrementally assist in the improvement or advancement of a given ideology or reality.

1.1.2 Types of research and development

OECD in the sixth edition of the Frascati Manual, adopted the understanding of R & D as a term spanning three related but practically different activities: basic research, applied research, and experimental development.

Grupp (1998) concurred Frascati manual on explaining the dichotomy of R & D activities. The Frascati Manual (2015, 45 p.) as well as the previous editions supposes that R & D activities can be subdivided into three coherent activities. Notwithstanding the coherence, there doesn’t necessarily have to be an intention of one stage wilfully graduating unto the next stage as each stage has its own intended results and exceptional use to the world innovation. R & D were deemed to consist of activities of Basic Research, Applied Research and Experimental Development.

Basic research

This involves any experimental or theoretical studies conducted to generate knowledge of a set of observable facts and pre-set foundations (Frascati Manual 2015, 44 p.). It is a conducted to widen the theoretical concepts and increase the knowledge base on a particular phenomenon without any pre-established future intention or use of the knowledge acquired. It is characterised by analysis of structures, shapes and relationships of variables, law and/or theories. Basic research has its roots firmly entrenched in the scientific methods (Grupp 1998, Bickman and

Rog, 2008). This shows an affinity to positivistic approach propounded by August Comte. Results of this experiment are specifically published in websites housing scientific journals and to other interested bodies. However, basic research could be "pure" where research conducted is not expectant of socio-economic or cultural problem but merely to add up to the knowledge base or it could be "oriented" where research is conducted with the intention of adding up to the knowledge base to solve a future or expected societal hurdle. Bickman and Rog (2008) further classified this form of experiment as being conducted in controlled laboratories as well as possessing entirely different purpose and context from the other form as is usually performed in High education sectors and sometimes Governmental institutions. Examples are Research concerning some natural phenomenon or relating to pure mathematics (Kothari 2004).

Applied research

This form of R & D features a more direct and objective focused kind of research. When basic research is conducted to target a specific or certain area of interest (Bickman and Rog 2008, Grupp 1998). Practically, it also uses scientific methodology to address a current and nibbling societal canker that besets an area. Environmentally, applied research is not conducted in a controlled setting unlike basic research which is traditionally and "primarily" meant to acquire knowledge. It is conducted in a lot more chaotic, complex and erratic environment with much higher expectation and desire for quick and feasibly applicable results to societal upheavals. Thus, the principal aim of applied research is to reveal a solution for a prevailing practical problem.

An example is a research to identify social, economic or political trends that may affect an institution or a marketing research conducted to identify changing consumer needs. (Kothari, 2004).

Experimental development

Synonymously termed as development, Grupp (1998) and Frascatti Manual (2015, 45 p.) both similarly explained that this referred to the systematic work that hinges on the previous fountains of knowledge acquired by basic research and information generated from applied research. Such revelations are resorted to in improving or producing new products, equipment, plant, processes and systems.

However, as differentiated these systems have been operationally explained, research at the experimental development level can feature both results acquired at the basic level and utilised at the “applied” stage or may rather react based on knowledge generated from pure basic research to create new systems, services or improve products. Frascati Manual (2015) however explains that, such linear application (in the latter) could be barracked by feedback that is generated when specifically used to solve a pending problem.

Although some private organisations undertake these three dichotomised activities as a single whole, efforts are made by some institutions to structurally classify them by their features. According to the Frascati Manual (2015), whether it is basic or applied, it must be assessed against these three criteria which are:

1. What are the expected uses of the results (of the research)?
2. How far ahead in time is the project likely to lead to results that can be applied?
3. How broad is the range of potential fields of application for the results of R & D project? (if is billed to have a wider area of application, then it is a deeply “pure” basic research)

Criteria of R & D

Research and Development activities, per the Frascati Manual (2015) should be organized and conform to a joint set of criteria before it could be confidently recognized as R & D activity. Even though R & D activities can jointly be connected as a single project, it still does not take away the essence and objective of each R & D activity. The criteria proposed are described below.

Novelty

This concept emphasized the intention and ability of research to generate knowledge already unknown in its area of research or generate a solution to a known problem. Understandably, researches are in different contexts and hence this concept must be explained in those lights as well. Entities that pursue research with no pre-set or initial objective (pure basic research) such as Research institutes and Universities undertake it with new advancements in the knowledge pool.

Applied research used in businesses and social sciences which are traditionally intended to solve a known problem should ensure the findings generated are entirely anew to the knowledge already dwelling within the industry or results of the findings should in no way bear too much striking similarity with already existing knowledge

In experimental research however, maintenance activities to uphold a flailing or quickly depreciating resource is duly credited as being of a novel feature and hence can be classified as R & D. Frascati Manual (2015) adds that any form of systematic testing to provide documentation of other possibly alternative use of a chemical reaction that has already been adopted in production processes (an existing technology) to achieve a new molecule, which earlier, may have been deemed an improbable outcome by the scientific literature , can be termed as possessing the feature of novelty.

Creativity

For a research activity to be concluded as being R & D oriented it must be conducted to produce objective and new concepts or ideas that very much improves on current knowledge holdings. This feature operates to effectively exclude research conducted on repetitive change to processes or products ensuring it could only be satisfied by human input or researchers interference. However, although routine processes are excluded "new" methods discovered to perform some quite usual tasks in an operation could equally be considered as and R & D. Hence any routine activity could not be classified as an R & D but if is undertaken with the objective of developing new processes or methods to improve a process or a product, then it could be classified as so.

Uncertainty

In basic research, it is expected that research is conducted with no ulterior motive, objective or intention but only to merely add to existing collection of literary research. It is believed that R & D in general, has a subtle uncertainty about the costs, or time, needed to achieve the expected results, as well as the question of whether its objectives, be it to add to research collection or to solve a societal problem or improve a product can be achieved to any extent at all.

Systematic

Grupp (1998), Godin (2001) Jain, Triandis and Weick (2010) and Frascati Manual (2015), all agree to the need for research to be systematic in its structure and process. In this context, R &

D is expected to be conducted and organized such that the exact purpose and source of financial capital is noted and recorded. The availability of such records is very much in line with an R & D project that is aimed at settling specific needs with its own human and financial capital. This criterion tries to fulfil the need for mission and a budget to fund the cause of the research.

Transferability

Ethically, an R & D project completed should possess the potential or result in a transfer of the discovery or knowledge to other researchers for reproduction and subsequent usage notwithstanding the results of the research. It is deemed ethically unacceptable and a defeat to science to retain and not record knowledge or research results or otherwise solely reserved in the minds of the researcher. Such demeaning act could not be deemed to be research. Even as businesses seek protection over their research results in the form of patents (which are subsequently published for public use), other businesses could have access to it at a price. Codification of knowledge from basic research by tertiary institutions and other research institutes is meant for future and current perusal and possible usage for further advancement in applied research duly satisfying the desire for transferability.

1.1.3 Science, technology and research and development

Science and technology is usually, wrongly, used to refer to activities of research and development. Little insight into these practically different terms seduce most people to inconclusively term them as same or similar. Some scholars however, view science and technology as generally different from research and development by institutional demarcations. Information below will throw light on the activities and purpose of the three arguably related terms.

Table 1: Comparison of concepts of science, research and technology

	Science	**Technology**	**Research**
Manner of activity	Is a college instruction and is basically concerned with preservation and transmission of knowledge (Grupp 1998)	Technology consists of 1) Physical components such as products, tooling, equipment, techniques and processes; 2) Informational component consisting of management, marketing, production, functional areas and quality control. (Kumar et al 1999)	Pure Research is that part of research conducted outside the company and available for public use (Grupp 1998)
Purpose of activity	Science generates understanding of fundamental mechanisms and new knowledge and the innovation process focuses on commercial and societal use of knowledge. (Jain et al 2010)	Associated with the knowledge or information of it use, application and the process of developing the product. (Lovell 1998 and Bozeman 2000)	To solve a social problem or to provide add up to the collection of knowledge. (Frascati manual 2015)

Source: (Grupp 1998, Lovell 1998, Kumar et al 1999, Bozeman 2000, Jain et.al 2010, Frascati manual 2015)

Despite their practical and fundamental differences, it could be concluded that science, technology and research are mutually supportive and interactive with each other as it could be seen that science promotes research and research hugely supports the creation and continuous development of technologies. Their interactive impact cannot however be overestimated.

1.1.4 R & D as an input to Innovation?

Peter Drucker (1985) in his book "Innovation and Entrepreneurship" defined innovation as "the specific tool of entrepreneurs, how they exploit change as an opportunity for a different business or service. It is capable of being presented as a discipline, capable of being learned, capable of being practiced". Roy Rothwell and Paul Gardiner (1985) also opined in their book "Invention, Innovation, Re-innovation and the role of the user" that innovation does not necessarily imply the commercialization of only a major advance in the technological state of the art (a radical innovation) but it includes also the utilization of even small-scale changes in technological know-how (an improvement or incremental innovation). Chris Freeman (1982) also contributed to this perception by adding that "Industrial innovation includes the technical, design, manufacturing, management and commercial activities involved in the marketing of a new (or improved) product or the first commercial use of a new (or improved) process or equipment"

This study actually resorts to the interpretation given by Chris Freeman as well as the interpretation of innovation by the Oslo Manual which stated it as "implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations. The tri-partite definition of innovation classifies innovation as any commercial activity which exhibits the simultaneous characteristics of newness, improvement, and uncertainty, provides the basis of our subsequent empirical analysis of innovation which we undertake in this paper. The minimum threshold expected of an innovation is the product, process or marketing method must be new or significantly improved version.

However, most studies recognize R & D activities as the basis for achievement of what may be referred to as innovation. The most prominent of them is R & D intensity, which is measured as the amount of investment invested in Research and development expressed as a percentage of Gross Domestic Product and the number of personnel employed in R & D areas. (R & D personnel).

According to the technological push (linear model) of innovation, investment in R & D activities results in a deserved technological change and is subsequently diffused to meet consumer demands and satisfy their needs. In this context, R & D activities are realized as "inputs" and innovation rather realized as an output of the R & D process. As more people are employed to meet the increased demand, income will be paid off as compensation. As new nominal income is acquired, all other things being equal the employee would be relatively better off (standard of living) than before whilst the firm also gets to meet increased demand, growth and expansion of operations as supported by Say's law.

Study conducted by Gulogly and Teklen (2012) using a bivariate panel causality test results confirmed this premise such that R & D expenditures were found to have caused innovation when measured using triadic patents (patents filed at European Patent office (EPO), United States Patents and Trademark Office and Japanese Patent Office) and technological change subsequently caused economic growth as well. Additionally, it was also concluded that the inverse also generated technological innovation such that an increase in national or regional output increased investment in R & D activities which subsequently had a positive impact on the technological change.

As important as R & D is to innovation, in R & D investment is not the only factor that affects the rate of and ability of regions to innovate. Other factors such as fiscal policies, public policies, monetary policies, regulatory policies, standards, procurement capacities, presence of a highly skilled technical workforce, and market entry difficulties are also important in crafting an environment that incites innovation (NSF 2012)

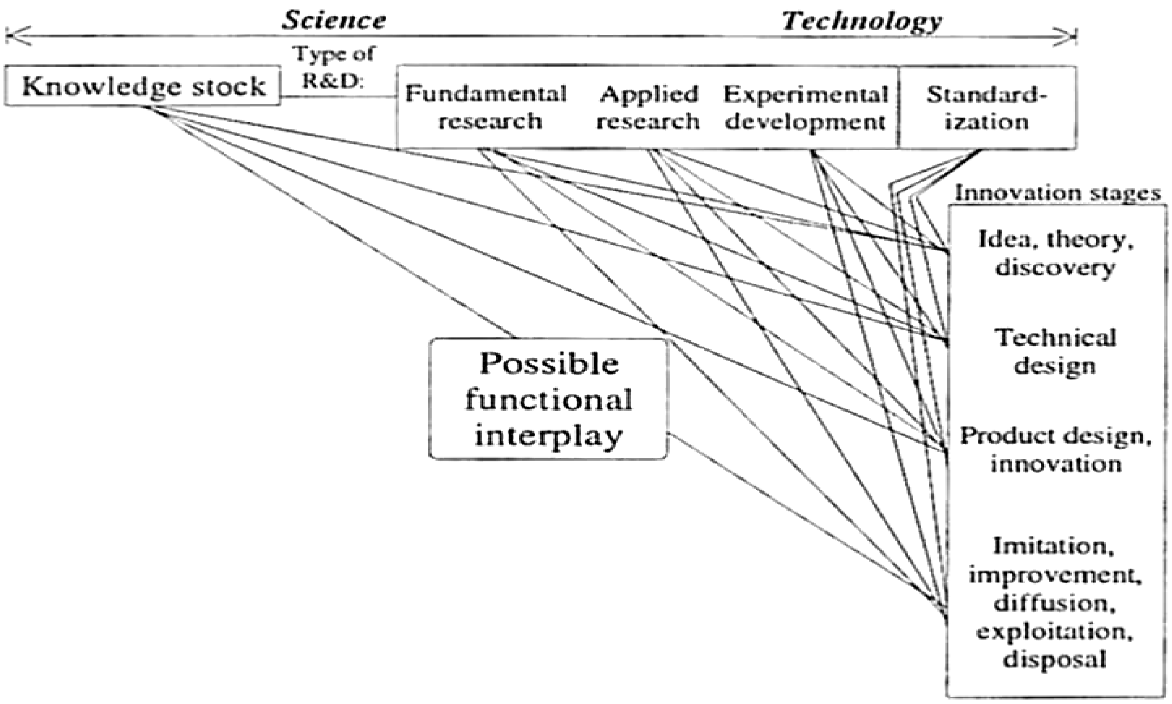
1.1.5 Functional reference of R & D and Innovation

Investment in R & D activities cannot justifiably be said to be synonymous with innovation (Bowen 2012). R & D activities should not be seen as a necessary pre-condition for innovation but rather should be viewed as an adjunct to the achievement of innovation as many firms can introduce new products without reasonably conducting R & D activities argues Grupp (1998). He explained that the design of reasonable and econometrically valid indicators of innovation processes comes in fourfold. He believed that upon various analysis of literatures,

- Innovation stages were characterized by feedback
- Research and development is not a unified whole on its own, however, it can rather be segregated in diverse and specifically identifiable processes.
- Research and Development's interaction with innovation should be regarded as functional
- Time dimension is a key to comprehending progress used to describe various stages using terms such as paradigms, cycle, phases.

With the use of a heuristic, two-dimensional and orthogonal structure below, Grupp (1998) used the diagram to explain the key stages of innovation, the connection and contribution of the types of R & D with the various stages of innovation thereby strongly displaying the functional connection of R & D with their innovation.

Figure 1: Functional connection between R & D and Innovation



Source: Grupp 1998

R & D processes, as mentioned earlier, adds up to the stock of knowledge and the various forms of it and shows a complex and interconnected back and forth impact on the stages of innovation due to the element of feedback.

However, there is the premise that the interfaces between them are not always direct and clear-cut and any assumption that the stages of innovation follows up on each other should be erased (Grupp 1998).

Innovation stages

Innovation is defined as the introduction of new or significantly improved products (goods or services), processes, organizational methods, and marketing methods in internal business practices or in the open marketplace (OECD/Eurostat 2005).

Idea, theory and discovery

An already mentioned function of R & D, basic research specifically, is the ability to add up to knowledge base, generate new-found ideas and improve already known theories which may result in new models for abstraction of realities. Even as other authors such as David (1992) argued relevance of basic research on technology development, the existence of knowledge base technology makes it difficult to ignore the impact of the quantity of fundamental research in the innovation system.

Technical design

R & D also assisted in the production of technical designs. Even though usually some products are phased out even before they are released or even projects cancelled because better prototypes are discovered. Grupp (1998) explained that while much technical design never reaches commercial levels to be eventually diffused, other designs may subsequently be built on to lead to industrial product design and innovation.

Product design and innovation

Activities beyond the stages above, in any industry falls under the real of product design-embodies the term that R & D activities usually takes place in within companies which via technical functionality, consider questions of cost and pricing, production processes, guarantees and compliance with standards (Grupp, 1998). Compliance with standards, be it compatibility standard, minimum quality standard or a variety standard can be classified as innovation in this respect.

However, there is always the tendency to reverse engineer products or quite frankly imitate already existing products which could be tempted to be termed as innovation as well. Most prominent among this are rival innovations which may require as much R & D investment and functional support as the already existing product.

Diffusion and dissemination of technologies are recognised by most authors as the means through which innovation and knowledge revealed extends to impact the quality of life of users and citizens. Practically, it is quite different from basic research the system theory proposes the opposite.

1.2 Concept of innovation

Variety of schools of thought have given rise to the different scientific views regarding innovation from various authors and researchers. Most prominent among them is the Schumpeterian view of innovation which arose in the 1950's. This posits that the changes in the methods of production and transportation, production of a new product, change in the industrial organization, opening-up of a new market is what he perceived as innovation which he directly accused as being the reason for rise in investments productivity and business fluctuations. Different researchers with diverse views have arose with time giving contrasting and similar sources and impact of innovation since the 1950's. The variety of source, impact and essence of innovation is what has been crafted as models of innovation and will be explained below in order of their development. However, studies of researchers recently tend to reveal a borrowed belief in two or more of these models.

1.2.1 Models of innovation

Perception of innovation has evolved for years and various researchers hold singular ideologies and perception of how innovation is created and diffused in the spatial economy. However even though perceptions have progressed revealing advancements in models used, different researchers resort to different models to explain a cause-effect or possibly the impact on economic growth and desired mode of prolongation of innovation. First to be revealed was the black box model.

Black box model

Unveiled in the early 1950's, the black box model represents the earliest attempt to describe the conundrum of the component of economic growth that was generated as a result of investment in science and technology that were unexplained by changes of factors of production like capital and labour. The theory, borrowed from Cybernetics, explained that about 90% of these unexplained changes were caused by technological growth and further controversially stated that, innovation process itself is not important, however, the essential components to be studied were the components of inputs (research and development investments-GERD or R & D personnel) and outputs, which it referred to as technological products (Marinova and Phillimore 2003). This model exclusively barred the need for research world of nonentities inevitably attracting criticisms from authors such as Rosenberg and Frischtak (1983) who criticised the self-imposed ordinance of economists not to inquire into operation they were fully aware was very reactive and sensitive. Although the approach made its way in blocking any knowledge about innovation processes, it however, affected public policies on innovation due to the limited understanding of it. Subsequent models were researched to comprehend the interactions.

Linear model

As a response to the black box model and to satisfy the curiosity around what lies in the "black box", this model was developed. This model strongly criticised and nicknamed as the pipeline model believed in a sequential approach to innovation such that more science leads to more innovation thereby effectively prioritising scientific research as a precondition and the basis for innovation. This model literally establishes a linear relationship among the nature of the sources of innovation, of the innovative process, and the effect of innovation itself.

Figure 2: Technological model of Linear innovation model

Source: Marinova and Phillimore (2003)

This was described as the "technological push" model alluding to its imposition and assumption that basic research conducted led to innovative products manufactured and successfully sold out as well.

However, as this notion of linearity ignored the possibility feedback and loops between innovation processes and falls very much in line in line with Says's law -supply creates its own demand. Grupp (1998) was rather contrasting and asserted that R & D was rather an adjunct to innovation and not necessarily a precondition.

The other side of this sequential model rather rested on the condition that demand rather was the catalyst of innovation contrary to Say's law. Developed in recognition of the essence of the marketplace and potential requisitions of demands of consumers the "demand pull" or "need pull" side of the linear model was created.

Figure 3: Demand pull linear innovation model

Source: Marinova and Phillimore (2003)

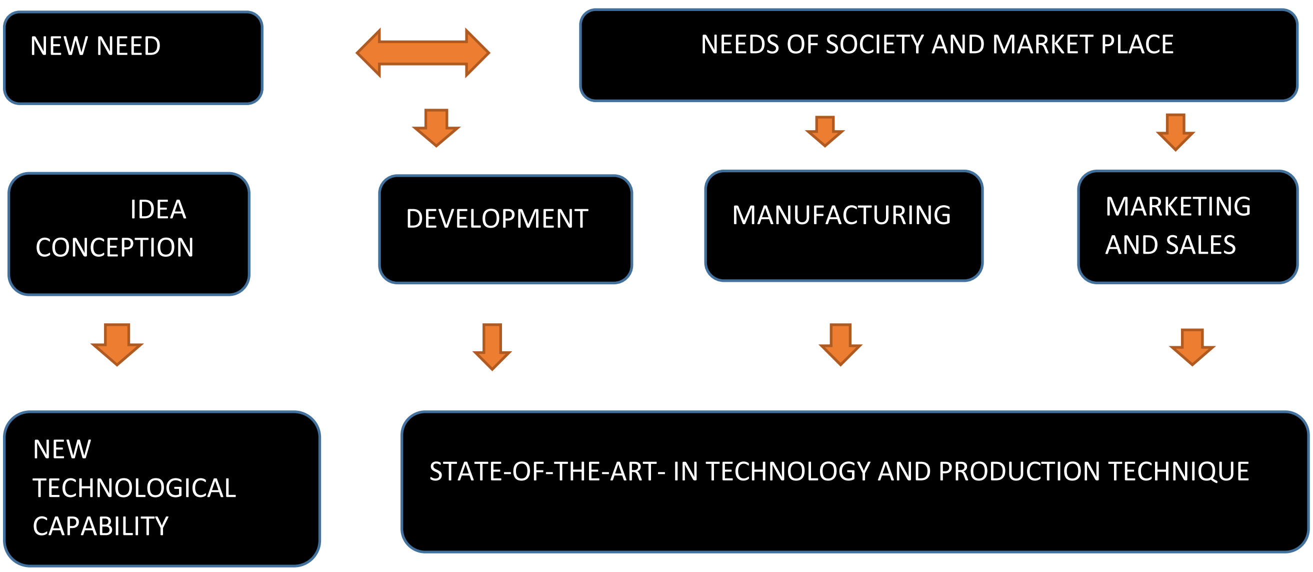
This approach rather displayed a linear relationship with consumer need as a catalyst for need for innovation and diffusion effectively operating from the demand side rather than supply. Policy implementers widely adopted this approach widely for its simplistic approach and a clear ideology that market failure justified public investment in R & D. This linear model is not without its critics such as Schmidt- Tiedemann who cheekily named it "pipeline model" and Grupp (1998) who alluded the life of this model was only held by need for economic policy implementers to justify the need for sponsorship in artificially protected areas. However, ideas for innovation may emerge from various sources or at any stage of research, development, marketing and diffusion. (OECD 1997). Innovation can take many forms, including adaptations of products and incremental improvements to processes Mothe and Paquet (2012). Mensch (1979) further showed, using the example of computers in the UK during the sixties, that the lifecycle of products can create a foundation for subsequent technological change. This showed the sensitivity and presence of feedback in innovation process that the linear model fails to capture.

Interactive model

To demystify the overly simplified linear model of innovation this model evolved to give a thorough comprehension of the factors and actors of the innovation processes. This model perceives innovation as a complex and communicative intra-organisational and extra-organisational interactions including internal functions that connected firms to larger scientific and technological communities.

In the writings of Marinova and Phillimore (2003), the model has revealed and explained the variety of interactions required for the success of innovation as well as the previously unknown players and organizations. It also drew the attention of researchers of researchers to the lag between technological ideas and economic outcomes revealing the distance of innovation cycles (whether long or short). However, it was criticized as having fallen short of revealing the specific drive of innovation and why some regions performed better than others, how they learnt and the specific role of firms in the innovation network.

Figure 4: Structure of interactive model of innovation

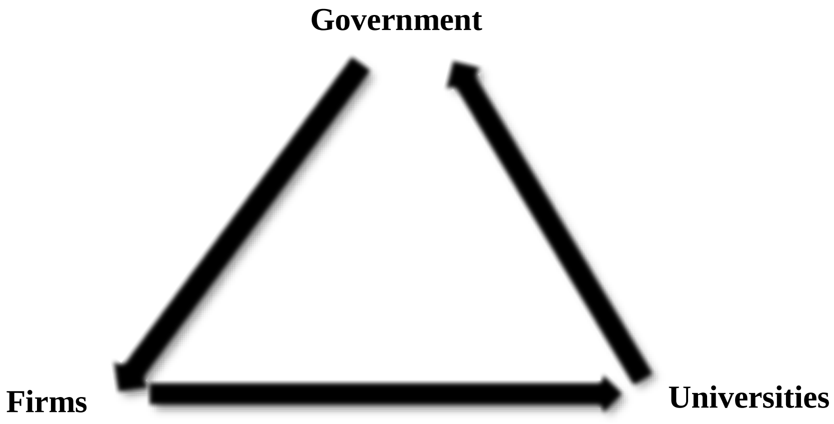


Source: Marinova and Phillimore (2003)

Systemic models

This model presupposes that the quest for innovation requires a cooperation from among firms as well as an array of agents within firms. It beliefs that the traditionally established hierarchical mechanisms fail and hence there is the need for new entities to occupy the sensitive position between organizational boundaries and market entities to facilitate what Marceau (1992) termed as "permeability" of firms. This approach focuses on innovation as a system featuring complex interactions, synergies and interconnectedness. It strongly argues that firms can substantially benefit from creating networks of relationships with other similar firms and organizations and hence there is no need for firms to create any form of in-house innovative structures. Most practical and well-known product of the system model is the "National system of innovation" used for local and regional assessment and assimilation of innovation. Innovation and technology development are believed to be the result of a complex set of relationships among actors in the system, which includes enterprises, universities and government research institutes. The triple Helix model that features interaction firms, corporations and Government to generate innovation was also borne from this model. Innovation chains that connects suppliers with, strategic networks and alliances and regional networks are all concepts of this systemic model.

Figure 5: Triple Helix structure portraying the systemic model of innovation



Source: Marinova and Phillimore (2003)

Designed above is a triple helix structure depicting the desired active relationship and interaction among the factors of corporations, academic institutions and the ruling government as a strong factor in the creation and diffusion of innovation.

Evolutionary model

This model arose to oppose the fundamental economic theory alluded to hinge on market equilibrium and perfectly informed spatial market with no information gaps. In line with Schumpeterian belief that posits that innovation embodies change and hence ideas of innovation are not dependent on the price placed on it but rather they are spurred by social conventions, personal relationships with people or between persons and businesses (Marinova and Phillimore 2003). This model placed emphasis on innovation being an outcome of an imperfect economy in a market economy. This approach is best summed in the OECD report (1996) which recommended Governments to increase the number of innovative firms rather than correct marketing imperfections.

This approach believes that outcome of innovation is largely due to the result of subtle interactions of the innovative players of people and firms and hence Governments should be urged to creating fertile innovative conditions such as encouraging learning, supporting stronger business to person bonds and creating a balance between the need to ensuring competition and cooperation. Authors such as Leydesdorff (2000) perceives the triple helix model as being an evolutionary model however, Marinova and Philimoore (2003) perceives it otherwise.

Innovative millieu

This model evolved in the early 1970's and explicitly relies on the knowledge creation and territorial organization as strong factor of innovation. It presupposes innovation as an intrinsic geographic activity of firms locked in productive inter relationships backed by active territorial learning activities. Camagni and Capello (2000) added that such interactions creating the innovative milieu do not necessarily hinge on market interactions but also an exchange of goods and services, ideas and information among people in a locally created network.

This model hinges on the high ease of contact and genuinely undoubtful level of trust among players to reduce uncertainly and facilitate sharing. This model seeks to explain the success of firms in concentrated areas of firms sharing the same inputs and possibly same output. It also assists Government services in comprehending how small and medium scale enterprises with little recognized technologies can thrive in a strongly interactive environment and why certain localities are more of a hub for some firms than others. This model in a nutshell, reflects economic globalization that is featured by increasingly unhindered mobility of goods and services but only limited by factors of knowledge and innovation capital. (Jeannerat and Crevoisier 2014).

1.2.2 Forms of innovation

The diversity in orientations of research in innovation has resulted in various authors crafting and perceiving innovation in fairly different forms. Differences in characteristics of innovation and their different response to environmental and organizational factors deeply impacted in the works of Jansel, Frans, Bosch and Volberda (2006) when innovation was classified as being explorative and exploitative. Other researches also revealed that process generation of diverse types of innovation at the industrial level was in stark contrast with their adoption at the organizational level (Tornatzky and Fleischer 1978, Daft 1978, Abernathy and Utterback, 1978).

The works of Zaltman et al (1973, 31 p.) identified close to twenty (20) types of innovation which were grouped by state of the organization their focus and outcome of innovations. The works of Kimberly and Evanisko, (1981) Lam (2005) and Birkinshaw, Hamel and Mol (2008) rather distinguished innovation as either technological (or technical) and administrative (organization or management) innovations. However, despite all the diverse segregations of the term innovation the most widely studied and known classification of innovation lies in the distinction of innovation as either a process innovation or a product innovation. (Kotabe and Murray 1990)

Damanpour, Walker and Avellaneda (2009) also focused on innovation types based on its applicability in the service sector : service innovations, technological process innovations, and administrative process innovations whilst Edquist et al. (2001) and Meeus and Edquiat (2006) rather merged the two strongly established typologies of innovation by drawing a line within product innovations to reveal "product" and "service" innovations and process innovations into "technological" and "organizational".

Hamel (2006), in the same vein, focused on the distinct types of process innovation dividing them into two sections such that process innovations were divided into innovation in operational process (logistics and customer services) and innovation in management processes (effective project management and strategic planning).

As our research will rely on the usage of data from the European Patent office (EPO) as a measure of innovation we will be focusing on product and process innovations as the main forms of innovation as recognised by EPO and applied by Kotabe and Murray (1990) and Light (1998).

Product innovations

This explains the form of innovation that possesses characteristics, features or in-built applications that differs from that which is offered on the market already. Alegre et al. (2006) stated that product innovation involved various activities such as technical design, research and development, management, production as well as means of commercializing products in the market. Product innovations according to Guloglu and Tekken (2012) play a significant role in the formation of new markets; the supply of modern technologies and is more important than adaptation to existing patterns of market demand.

Process innovation

This encompasses a new way or method of production that has not been used before or rather a new way of commercially handling a commodity to result in efficiency of productions, improved products and or increased production. Process innovations, contrary to product innovations, have an exclusive internal focus of boosting the efficiency and effectiveness of firm processes as well as delivery services ensuring end users receives the best services or product there is. The new processes created can be related to the 'technological core' or the 'technical system' of the firm (also known as technological process innovations) or rather the 'administrative core' or the 'social system' of the firm (also known as administrative process innovations) (Damanpour et al.,2009).

1.2.3 Patents as a measure of Innovation

As referred from previous studies (Buesa et al. 2010, Kleinknecht, Van Montfort and Brouwer 2002) patent was resorted to as the dependent variable for the measurement of the variable, innovation. Data for patents will be extracted from the European Patent Office (EPO) on the EUROSTAT REGIO database. Contrary to registering of patents with the respective national offices, registration of patents at EPO is believed to overcome the problem of "Headquarters effect"; rightfully so because they are allocated to the inventor's place of residence (Buesa et al. 2010).

Previous studies have expressed doubts on whether patents are exactly right enough to be used as an indicator for the number of product and process innovations in a spatially defined economy. It could be said, agreeably, a strong limitation of patents as a usage is the occasional unavailability of data as data collected refers to the income due to such innovations. As a rule, patents acquired takes eighteen (18) months before they are made public, effectively making it difficult to get a very updated patent database on EUROSTAT website. Now-casting method, however, has been recommended to overcome this lag. Schmoch (1999) also raised a concern that introduction of a product only came at the final phase of the innovation which is usually far off from when the supply took place whilst OECD (2004, 139 p.) also added that R & D relationship with patents almost has no time lags and is essentially contemporaneous.

This begged the question of the relationship between patents per inhabitants and innovation and the probability of the former transforming into the latter generated the use of patents as a measure of innovation resulting from investment in the R & D sector.

Agreeably, use of patents has some limitations such that, not all innovations are finalized as patents as it is expensive to register patents for innovations. Alternatively, some firms resort to other types of protection such as low pricing to deter any interest in false application, a quick market launch or in some cases resort to secrecy of the new knowledge.

Acs and Audretsch (1988) undertook a research which revealed that the ratio between patents and innovation could vary significantly based on the industrial sector, ranging from an average of 49 % to 0.6 %. Arundel and Kabla researched in response to a claim by the EPO (OEP 1994, 25 p.) that an estimated 50% of innovations were patented. He validly refuted this with the discovery that an average 33% of patents were produced in case of product innovations and 20.1% in the case of services (Arundel and Kabla, 1998, 133.p). This showed stark differences in industrial different sectors. In the pharmaceutical sector, 79.2% of product innovations were found to have been patented whereas in the case of textiles this percentage does not go beyond 8.1%.

However, use of patents assure a minimum level of originality whilst also maintaining a close link to inventions (Buesa et al. 2010). Although very few empirical studies have been conducted on patent and innovations, none of them have detected any significant difference in results of output indicators affirming the significance of patent as a good measure of innovation yet. Igami and Subrahmanyam (2015) also conducted a research on the validity of patents as a measure of innovation in the Hard Drive Industry and found that patents predict innovations better than a random guess, but a simple refinement would even make them more useful. Acs et al. (2002) in effect concluded, empirically, there is evidence that patent provides a reasonable measure of innovation.

1.3 Innovation on regional development

This section seeks to add to the literature on the concept on innovation and its assessed impact on regional development. Its adds up practical applications by the European Union, explains the cooperative impact of innovative firms on regional growth, the measure of growth of regions and also unveils the innovation policies implemented to push the EU to the fore of the world's most innovative economies.

1.3.1 Knowledge spill-overs and cluster effects

Neoclassical economics effectively ignored the essence of investment in R & D and innovation acquisition as having any weight on the extent of regional development. However, with the introduction of the systemic model that recognises the subtle and obvious interactions of regional players and institutions and the swathe of research that concurs to research having a positive impact on regional growth (Rodríguez-Pose and Crescenzi 2006, Buesa et al. 2010, Jean et al. 2012, Guloglu and Tekken 2012) have made it quite difficult to ignore the knowledge diffusion and assimilation by region(s) as a vital source of generation of innovation and regional development. Knowledge spill-overs occurs when regions not only resort to internal abilities to produce innovation but attract and assimilate basic knowledge or innovation already produced in nearby regions or possibly distant regions in a virtual network. The differences in economic strengths of regions sharpens their ability to create new-technologies, to assimilate current ones from outlying regions, to effectively crumble vested interests aimed at holding off existing technologies, to establish institutions that ensures adequate protections of property rights acquired and to strategically create fertile environmental factors for innovation growth (De Groot, Nijkamp and Acs, 2001).

Owing to the almost non-existent barriers to knowledge transfers and the much quicker information flow in the 21st century among micro units such as firms, research organisations and academic institutions, regions can interact with each other in at various levels. Such interactions are highly strengthened by the creation of networks of inter and intra-regional players and are very sensitive in formulating strategies for fertile ground for generation or acquisition and assimilation of products and process innovation.

Geographically concentrated networks or "clusters" have also incited various inquests and propositions to creating a regional policy to ensure the growth of such. Porter defined it as

"*Geographic interconnection of interconnected companies, specialised suppliers, service providers, firms in related industries and associated institutions*"

Owing to the success factors of most clusters in specific spatial locations such as Silicon Valley of the Southern California, the Baden Wurttemburg region of Germany and Boston's Route 128, various researchers (Bröcker, Dohse and Soltwedel 2012) have alluded this success story to the wilful exploitation of the network of these institutions. These clusters are observed to be composed of substantial number of small to medium sized firms, providing an array of new products with comparatively short product life-cycles. Membership in clusters and inter-firm networks is believed to foster innovation and growth, by promoting indigenous concentrations of small member firms, encouraged to engage in mutual exchange of both informal and formal information and develop a potential for very flexible kinds of inter-firm alliance. It also improves productivity, incites competitiveness, inter-firm efficiency and further innovations to better serve consumers and stay ahead of competition.

Surge in resurgence of interest in ideas from evolutionary and institutional economics has been credited for the digression from the neoclassical view of innovation creation and regional development to the impact of social institutions and organizational connections in creating innovation and regional growth although Gordon and McCann (2005) disagrees with this.

From the point of view of innovation theory, there is no inherent reason why the relationship between geography and industrial organization should be put a step above other alternative arrangements. Rather, (Gordon and McCann 2005) believed that theory has suggested that quite different forms of institutional and spatial arrangements could be better placed for innovation in various kinds of business and that any attempts to focus on discovering a single 'ideal' model of firm and industry geography organization to maximize innovation would be a gross misunderstanding of the concept of innovation and growth of essential features of the innovation process.

Knowledge Networks

Knowledge networks and markets are recognized as having a primary role in the functioning of the innovation system as promotion of knowledge is considered as potential instruments for achieving structured policy targets (OECD 2013) and hence the Public sector should be wary of the threats and incentives it poses to the markets within which they operate.

Huggins and Johnston (2010) distinguish two forms of knowledge network: (1) touch networks, through which firms acquire understanding; and (2) alliance networks, through which companies collaborate to innovate. Networks of alliances usually involves formalized collaboration and joint ventures, and different 'contracted' relationships eventually resulting in common and repeated interaction. Companies then gain extensive benefits from these alliances by using accessing and utilizing the expertise of its partners. This goes to endorse the notion that the ability of a firm to profitably benefit from knowledge sharing is dependent upon the aid profiles of their partners (Ireland et al. 2002, Stuart 2000). An overriding feature of most of the literature on alliances is the focus on 'repeated' and 'enduring' or 'sustained' interactions or relationships (Huggins 2001). Yli-Renko et al. (2001) established that information exploitation for information-primarily based companies depends on repeated and extreme interaction, as well as the willingness of companies to proportion records. As Gulati (1999) argues 'maximum alliances involve prolonged contact among partners, and corporations actively rely on such networks as conduits of valuable information'. Contrary to the term alliances, contact networks include non-formalised interplay and relationships between corporations and different actors. The structure of those networks is regularly extra dynamic, as corporations continually replace and trade their contacts (Huggins 2000; 2001, Mcevily and Marcus 2005, Grabher and Ibert 2006). For both alliances and call networks, the point of interest of the network is on having access to knowledge. This is consistent with the Knowledge-based view of firm, which considers inter-company networks as basically a means of making use of the knowledge of others, as opposed to necessarily in search of to internalize such information inside the company (furnish and Baden-Fuller 2004). Despite the fact that corporations, additionally, are searching to acquire understanding through inter-firm networks, it's far much more likely that the internalization of knowledge might be performed through different modes related to hierarchical integration, including firm mergers and acquisitions (Grant and Baden-Fuller 2004).

It is crucial to highlight the potential of negative influences of a cluster of networks. For instance, without powerful network management expertise may also drift off freely out of a company than productively into it (Teece 1998, Fleming et al. 2007). Additionally, as corporations come to be increasingly more acquainted with one another's knowledge, poor network outcomes may initially or consistently emerge, plunging companies into low price and unproductive networks which could potentially cripple the introduction of latest understanding and innovation (Arthur 1989, Adler and Kwon 2002, Labianca and Brass 2006). To preserve to their market position in the innovation technique, networks are frequently required to conform to involve new individuals and configurations to fulfil changing needs (Hite and Hesterly 2001, Lechner and Dowling 2003). The steadiness or dynamism of networks is dependent upon whether community actors are seeking to shape additional relationships with actors within the current network or new relationships with actors that are external to a network (Beckman et al. 2004). However, the stability of networks is threatened when participants seeks to explore new relationships with new actors, rather than in addition take advantage of the resources of their existing community (March 1991, Beckman et al. 2004). Therefore, in a knowledge-based environment, there is the life-threatening need to consistently be dynamic and evolve to ensure a consistent development of networks. (Gargiulo and Benassi 2000, Mcfadyen and Cannella 2004). As Gulati (1999) opined, networks are dynamic and trade through the years, which indicates that networks require diversity in the varieties of investments made. If diversity is not sustained, in the long-run, networks will observe fading heterogeneity through the articulation of shared norms, standards, and policies of conduct among firms (Oliver 1997, Monge and Contractor 2003). Westlund and Bolton (2003) presented a persuasive case concerning some of the negative aspects of networks, arguing that the strong trust embedded in interpersonal relations can derail actor-level development although stable networks reduce the cost of knowledge transfer, it is able to also be the case that knowledge may become more and more homogenous and much less useful across community actors (Maurer and Ebers 2006). The occurrence of stable and strong ties may additionally result in companies operating in inefficient networks (Lechner and Dowling 2003) increasingly fluid and temporary networks.

Resources of Networks

The resource-based view of the firm recognizes that a firm's assets, which include their software and transferability, are essential elements in developing and sustaining intensive benefit (Wernerfelt 1984, Barney 1991, Rangone 1999). Such assets encompass both the tangible and intangible property owned or managed via firms considered a sensitive source of price creation. Those resources are frequently taken into consideration with respect to each the size of firms and their capability to undertake innovation (Wiklund and Shepherd 2003, Thorpe et al. 2005). However, as Zaheer and Bell (2005) noted, scholars with a useful resource-based view of the company generally tend to focus most effective on the internal capabilities of firms. As a way of addressing this hole, current studies have proposed an extension of the useful resource-based view of the company to account for outside network talents further to internal skills (Lavie 2006). Gulati and Gargiulo (1999) and Gulati, Nohria and Zaheer (2000) introduced the concept of community assets to apprehend the blessings bestowed by means of such networks in permitting companies to leverage valuable statistics and/or assets possessed by their inter-company community partners.

In an increasingly innovative financial network, knowledge has ended up as a key aspect in competitiveness at each the country wide and regional scale. (Dunning 2000, Tödtling et al. 2006). In regional research, the talk about know-how and its impact on nearby improvement has concentrated on the difference among codified (specific) and tacit (implicit) expertise (Polanyi 1967, Maskell and Malmberg 1999a). While codified knowledge (within the shape of manuals, blueprints, and so forth) can be without difficulty transferred and delivered into a region from outside (provided there is the correct absorptive capability), tacit know-how is a customized kind of know-how (primarily based on someone's 'sensible' experience and particular 'understanding') whose transfer depends on face-to-face contacts. However, tacit understanding also can be a concern to a system of externalization with the aid of which it is converted into codified knowledge.

Nonaka and Takeuchi (1995) explained that information is created in a continuous technique of transformation between tacit and codified expertise. The talk about the role of understanding in regional development centred on the assumed ‘stickiness’ of tacit knowledge and its functioning as a locally particular development useful resource that fosters processes of nearby cluster formation (Maskell and Malmberg 1999). With regards to the interrelationship of dynamics of tacit and codified information (Ernst and Kim, 2002, Bastian, 2006), a narrow recognition on tacit know-how does no longer seem to offer the suitable method for information the effect of understanding in nearby improvement. Moreover, the geographies of information networks might range appreciably due to sectoral characteristics (Asheim and Coenen 2005). The theoretical debate has birthed a difference between ‘artificial’ and ‘analytical’ information bases (Coenen et al. 2004, Asheim and Coenen 2005). An artificial understanding base is every day in as an alternative conventional industry consisting of mechanical engineering, which draws inside the innovation system as the utility or novel mixture of present know-how, i.e. On mastering with the aid of doing and interacting, in order that tacit know-how is fairly essential. Through contrast, industries with an analytical knowledge base, which include statistics era or biotechnology are characterized through a relatively more potent reliance on scientific inputs and codified understanding, even though tacit expertise can also be applicable (Tödtling et al. 2006).

Innovative potential is the potential to generate new understanding and remodel it into new merchandise, processes and kinds of corporation. This ability also includes the potential to utilize understanding from external assets (outside to the innovating company or external to the innovating company’s region). Innovation research has highlighted the reality that a fundamental share of improvements arises from the interaction between corporations as well as between corporations and research establishments (Lundvall, 1992, Lo and Schamp 2003). However, the inter-linking of expertise resources occurs at specific spatial levels on the same time: on one hand, geographical clustering and inter-firm networking inside a location can sell interorganizational understanding flows; on the other hand, supra-regional and international connections might be equally vital so that you can get access to outside knowledge sources (Bathelt et al. 2004). Innovative fulfilment might for that reason rely on the appropriate mixture of information inputs from local and local as well as country wide and international assets of know-how. The debate on countrywide and regional innovation systems (Lundvall 1992, Cooke et al. 2004, Asheim and Gertler 2005) has emphasized the range of geographical scales of interactive information technology inside the innovation manner as well as the form of concerned actors. A local innovation device (in phrases of a locally interacting information generation and exploitation gadget that is hooked up to external structures) might be conceptualized as being built on three pillars:

(a) the local corporations' inner innovation potential,

(b) the local innovation infrastructure, which Includes a location's public studies establishments, Innovation-related public promoting corporations, and so forth and

(c) the regional expertise network, which interlinks actors via formal and informal relations that comprise and channel interorganizational expertise flows each at the regional level and to actors situated in different areas on the country wide or global level.

These three components constitute the best part of all relevant sources of innovation, due to the fact that local actors can also draw on innovation infrastructures on the national scale and on expertise links that increase to partners outside the location at the national, supra-countrywide and international scale (see above). But, besides the regional innovation infrastructure, the local expertise community constitutes a supply of modern ability that is open to a place's strategic political tasks for strengthening competitiveness in the context of a more innovation-driven economy. In regions which might be properly endowed with public studies establishments, instructional institutions, innovation centres, and so on., knowledge generation and diffusion can be actively inspired, provided 'that those businesses broaden dense links to the companies of the vicinity' (Tödtling et al. 2006). This underlines the relevance of research on regional understanding networks.

Licenses and patents, or participation in conferences and galas are also applicable (Tödtling et al. 2006). Nonetheless, the networking kinds of information sourcing are of specific importance, due to the fact 'they represent intentional and selective family members to unique companions inside the innovation procedure and they are greater interactive and durable than marketplace hyperlinks' (Tödtling et al. 2006). The nature and mechanisms of interorganizational expertise flows are nonetheless uncertain. In the literature on regional clusters and innovation networks, it is regularly assumed that interactions based inter-organizational linkages contribute to the diffusion of understanding and the spread of innovation impulses some of the ensemble of interconnected corporations and different cluster-associated groups. From this angle, formal (contractual) network relations provide strategic blessings to the complete ensemble of interconnected actors in terms of information spill-overs but, geographical clustering may additionally result in a dense internet of informal community relations, which characteristic as a similarly vital mechanism of inter-organizational know-how diffusion. According to Owen-Smith and Powell (2004), there are two approaches wherein formal networks is probably understood to transmit understanding among groups: these network 'linkages can represent either "open" channels or extra proprietary, "closed" conduits' (Owen-Smith and Powell, 2004, 5 p.). The primary theory translates linkages as channels that direct information flows between community nodes in a rather diffuse way and facilitate expertise spill-overs to the collective gain of both loosely linked and centrally located agencies. His second concept, however, sees community links as surprisingly closed conduits ('pipelines') characterized through criminal arrangements. But eventually the question how much of these networks is recognized, regulated or facilitated by the Public sector to prevent undue exploitation of these networks.

1.3.2 Regional development indicators: Gross domestic product (GDP)

A successfully introduced innovation is expected to be diffused to reach of the mass populace with the fundamental purpose of affording the consumer a better product or service than before effectively enabling them to enjoy a better standard of living than previously. Standard of living can be perceived with social indicators like Human Development Index and Multi-dimensional poverty index or even more. However, to measure the economic improvements in the lives of the populace a much better indicator could be GDP per capita. According the Word Bank, in their document (WDI 2014), Gross domestic product was defined as the sum of gross value added by all resident producers in the economy plus any product taxes (less subsidies) not included in the valuation of output. However, to discover the real impact of innovation on economic growth barring inflation and exchange rate differences, the Real Gross Domestic Product per capita (RGDP/C) would be preferred as concurred by Barro (1996).

Employment rate

As people employed in institutions work for wages and salary to fulfil their transactional and precautionary needs for money and improve their standard of living. This variable was also used as a measure of regional development in the analysis ahead. Based on the EU Labour Force Survey, this variable represented Regional (NUTS level 2) employment rate of persons of the age group 15-64 as a percentage of the population of the same age group. The survey spanned the entire population dwelling in private households but, however, it did not consider those in collective households such as halls of residence, boarding houses and hospitals. Specifically, the employed persons must be aged 15-64, who during the reference week did any work for compensation, profit or family gain for at least one hour, or absent at work but had a job or business from which they were temporarily absent.

Disposable Income

Real household net disposable income is defined as the sum of household final consumption expenditure and savings, minus the change in net equity of households in pension funds. This indicator also corresponds to the sum of wages and salaries, mixed income, net property income, net current transfers and social benefits other than social transfers in kind, less taxes on income and wealth and social security contributions paid by employees, the self-employed and the unemployed. Household gross adjusted disposable income additionally reallocates "income" from government and non-profit institutions serving households (NPISHs) to households to reflect social transfers in kind OECD (2015).

The indicator includes the disposable income of non-profit institutions serving households. Disposable income, as a concept, is closer to the idea of income as generally understood in economics, than is either national income or gross domestic product (GDP).

1.3.3 Policies of European Union

In today's fast-paced societies where products depreciate much quicker than before, updates provided on software almost weekly, firms eagerly craving for productive ideas to get ahead of competition and governments finding ways out of budget constraints, there is the implicit need for speed, prudence and efficiency and productivity in every aspect of the economy. With the EU bloc boasting the largest market in the world (almost 500million) but with a quickly ageing labour force and quickly developing markets like the Chinese market (European Commission 2015), it is imperative to act quickly and strengthen its innovation grounds its counter-effect on society.

Innovation Union was established as part Europe 2020 plans to give a comprehensive and ground-touching impact of innovative activities by collectively ensuring a strategic and all-inclusive business-focused policy on research and innovation, to incite competitiveness and create new job opportunities and handle nibbling societal problems. This initiative was run simultaneously with other flagship initiatives such as Industrial policy for Globalisation-which is centred on creating a strongly competitive and highly diversified manufacturing value chain in small and Medium scale enterprises, Digital agenda and Agenda for new skills.

In line with the linear model of innovation and the systemic model, EU seeks to place high priority on investments in knowledge to create an European market that rewards innovation. This can be evidenced by the Europe 2020 objective of spending 3% of EU's GDP on research and innovation and the ground-breaking Horizon 2020 worth over 80billion euros of funding for research and innovation from 2014 to 2020. European Innovation Partnerships, also run in tandem with "Innovation Union" policy to ensure a healthy ageing of European working force solve societal problems and create competitive advantage in sensitive markets in the Union. The initiative when taken in light of the diminishing EU labour force rate, quickly-catching up Chinese innovative market who have moved from mere imitation to strong innovation contenders and the potential of other regions to poach excellent researchers to other lucrative grounds, the achievement of innovation moves from just being an objective but rather a necessity if EU wants to be the hub of economic growth and beacon of development in the world. It was all summed up in the European Commission's document dubbed "Europe 2020 Flagship initiative Innovation Union" with the statement:

"…our capacity to create millions of new jobs to replace those lost in the crisis and, overall, our future standard of living depends on our ability to drive innovation in products, services, business and social processes and models".

It would be noteworthy to point out a precedent by Ewers and Wettmann who, in 1980, devoted a portion of their research to "Determining factors of regional innovative potential". The authors conclusively established that two factors were significant to influencing regional performance: the potential for action of regional economic units—which will depend on their internal characteristics—and the interaction of these units with their environment and among themselves.

2 Methodology

This chapter will introduce the methodology of the research. The methods resorted to for data collection will be discussed and explained in the first section which will be then followed up by the various methods of interpreting and analysis of the data.

2.1 Data collection

The research is focused on analysing the impact on innovation and research on regional development in NUTS 2 regions in the time of 2007 and 2012. These time periods were selected in light of the economic depression that happened in the years of 2008 to 2010 (Verrick and Islam 2010). Considering the research of Verrick and Islam (2010), the year 2011 was deemed as the year of recovery for most nations, hence to acquire information devoid of extensive external impact, the years of 2007 and 2012 was selected. NUTS 2 (Nomenclature of territorial units of Statistics) regions represent classification of regions according to the population sizes. By the NUTS regulation, NUTS 2 regions must have a minimum of 800,000 and a maximum 3million inhabitants (Eurostat 2015). This regional classification system was instituted to facilitate an objective allocation of cohesion funds for the achievement of Europe 2020 targets from the period of 2014 to 2020 (Committee of Regions 2009) and, also, permit collection, development and harmonisation of European regional statistics. NUTS 2 was selected as the unit of analysis to allow the researcher to observe the ground-level impact of innovation in the standard of living of inhabitants in these regions and to also make the research more feasible and useful for regional analysis.

As the data required for this research had to be region centric and specifically for NUTS 2 regions, European Commission's website, Eurostat Regio database, was resorted to for information on these regions. This classification covers 276 regions in the European Union in the EU28 member states namely Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK. However, countries like Republic of Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta under the NUTS 2 system are classified as a single NUTS 2 region whilst some regions also had no information for the period selected. Therefore, the issue of inadequacy of data for some regions and the treatment of some countries as regions made it quite difficult for correlation and regression analysis hence the sample size of 276 was trickled down to 234 regions for some of the analysis.

Content analysis was the technique used in quantitative research and most especially for exploratory studies. It is used to draw inferences on the content of recorded text (Miller and Whicker 1999,68 p.). In this vein, printed articles, text and already recorded information of research and development, innovation and regional growth were extracted from the Eurostat Regio Database. Although this method of data collection is difficult to interpret and can be highly interpretive at times. This was deemed comfortable for the research because it is useful in examining large volumes of data and it allows a study and of social interactions without giving any space for researcher's bias or interferences.

Examined sample

The sampling system used here was the total population sampling system which is a form of purposive sampling method under the non-probability sampling method. Purposive sampling method is very convenient for exploratory research such that it offers a cost effective and time-consuming method. It is also appropriate to use this method when there are few primary data sources of information for analysis and, given the spread and features of the population, it is very convenient for an exploratory study.

However as useful as it can be to exploratory research, it is believed to be susceptible to manipulation by the researcher because the sample frame selected may be motivated by known or unknown bias from the researcher. It was also criticized to be highly vulnerable to errors and difficult to use in generalizing findings.

To acquire reliable and credible data for the research of these regions, the author resorted to the database that had pre-grouped information specifically relevant to NUTS 2 regions. Data was therein extracted from Eurostat Regio database for the 276 regions worked on.

In line with the linear model of innovation, the researcher believed that innovation had inputs that worked together to create the output of innovation in each economy. Therefore, as part of the studies, there was an intended analysis of the inputs of innovation on themselves to find out the correlation between these input variables (GERD/C and R & D personnel as a percentage of regional employment per full-time equivalent)).

These inputs of research and development will also be mapped against patents, the measure of innovation in this research to discover the relationship and impact using regression and chi square tests respectively. Patents will then be assessed with real gross domestic product per capita (RGDP/c) which in this research, is the measure of the regional development per every inhabitant.

The data for variables for research and development was first focused on as it is deemed the inputs of innovation although, agreeably, feedback can occur between the output (innovation) and input of research as stated in the literature by Grupp, 1998. GERD/c was downloaded from the EUROSTAT website as a measure of the total expenditure of research and development in both private and public sectors of a spatial economy per each inhabitant of the population of the region. This was to acquire an accurate and individual measure of the input to innovation when narrowed down to the value invested and calculated per individual.

The data for Real Gross Domestic product per capita and Gross Domestic Product per capita (PPP) were also subsequently extracted for each NUTS 2 region from EUROSTAT. We had data for RGDP/C euro per inhabitant, purchasing power standard per inhabitant, purchasing power standard per inhabitant as a percentage of EU average and million euro or GDP in monetary terms. However, after careful consideration purchasing power standard per inhabitant was selected when assessing inputs of R & D to easily measure the underlying monetary value of each populate of the region to ensure the purchasing power across all regions remains the same for all participants. Real Gross Domestic Product per capita was also used later in the analysis when assessing the efficiency of regions. The figure for GERD/c was calculated as a percentage of the Gross Domestic Product per capita in purchasing power parity terms to know the exact percentage regional wealth invested in R & D for every individual.

Researchers employed in research and development as a percentage of full time employment was subsequently endorsed as another input of the research and development process. R & D personnel include all persons employed directly on R & D, as well as those providing direct services such as R & D managers, administrators, and clerical staff. Those providing an indirect service, such as canteen and security staff, should be excluded." (§ 294 - 295, Frascati Manual, OECD 2002).

Here, we had data for intramural research and development expenditures as well as the number of Research and Development personnel as a percentage of full time employment. The latter was chosen to allow us to acquire a measure of the variety of inputs of both monetary and social value. Hence this variable was mirrored against the GERD/c as a percentage of RGDP/c find the relationship between these inputs. In assessing impact of research and Development on regional development, however, GERD/c was used as the main input of regional development to assess the corresponding impact on regional development indicator, RGDP/c because in line with the linear innovation theory, outputs of Research and Development were re- invested as inputs to subsequently generate output once again. Hence

According to European Commission -Eurostat-, patents application to the European Patent Office (per million inhabitants) data referred to applications filed directly under the European Patent Convention or to applications filed under the Patent Co-operation Treaty and designated to the EPO (Euro-PCT). All the patent statistics from Eurostat arranged and shown by priority date, i.e. the date on which the patent application was first filed anywhere in the world. This was the earliest date and it was chosen to be the closest to the date of the invention providing more accurate data on the real inventive activity of a country/region. (Eurostat 2017).

In line with the studies of Buesa et al. (2010), patents were used as the basis of measurement of innovative capability of a region. Hence, the data extracted was the patents per million inhabitants such that if a country had a total patent application of 20 for a given year with a population of ten million, their patent per million would be two (2) patents per million for the given year.

However, since by law figures for patents are released 18 months prior to application, the lags involved made it even more difficult to have data that was ahead of the year 2012. Hence, after careful consideration data for the years of 2007 and 2012 were used as the focus of analysis to evade the occurrence and recovery period of the global crisis that happened from 2008-2010.

Research philosophy

The research follows the positivistic approach propounded by August Comte. This philosophy presupposes belief in observed and measured data specifically for the purposes of collection of data and subsequent interpretation to produce findings of research that are equally observable and quantifiable.

This philosophy effectively excludes any researcher’s bias since the researcher is independent of the study and manifestation of human interest is eliminated resulting in purely objective and factual results. Deductively, results from the findings of the research will be used to make conclusion.

2.2 Research approach

To fulfil the aims of the research and to effectively test the hypothesis of interest research will be conducted to support our conclusions. The research design of this study will be exploratory and quantitative at all levels. Cross sections of data will be used and conclusions will be deduced from the findings of the research.

The aim of the research is to evaluate the impact of innovation and research activities on the regional development in the NUTS 2 regions within the European Union. To achieve this result, the following hypothesis will be tested to discover the truth in this pre-set conclusion.

H1- Regional research and development inputs have a positive and significant relationship with regional innovation which is measured by number of patents per inhabitants.

H2- Regional innovation measured by number of patents per inhabitants has a positive and significant impact on regional development indicators.

Research Strategy

According to Saunders (2003), research strategy is a general plan that helps researcher in discovering answers to research questions in a systematic way. This section explains the structured tool used for the study and the type of study conducted during the analysis**.**

Cross sectional study

This is an observational form of study that analyses data extracted about a population or a subset of the population. Here the cross section of the variables General expenditure on research and Development per inhabitants, Research and Development as a percentage of full time employment will be researched on for the years of 2007 and 2012. In line with the linear model, the study recognizes these variables as inputs of innovation and are treated as variables of research and development. These inputs will be individually mapped against patents, which is used as a measure of innovation for 2007 and 2012 and patents against Real Gross Domestic Product per capita (RGDP/C) for 2007.

For the purpose of this study, cross sectional study was chosen because it captures data of a specific point in time which is especially relevant since this study focuses on specific years to be researched, that is 2007 and 2012. Although it cannot be used to analyse behaviour overtime cross sectional study is not costly to perform and even though it reveals multiples variables at the time of the data acquisition, research on it does not take lots of time.

2.3 Data analysis

This section adequately reveals the explains the various statistical methods used in analysing and assessing the impact of the input variables of the research on the output variables on the research. The tools used to analyse the various data will be extensively explained below.

Least square regression:

Least square method of regression analysis was initially discovered by Legendre (1805) but Gauss (1809) was credited with establishing the basis of the least squares method when he used it to predict the location of asteroids. Regression analysis facilitates estimation and prediction and to discover relationships among a series of values. Linear and multiple regression was mostly used in empirical analysis to discover the direct impact of independent variables of R & D on dependent variable of innovation classified as patent as used by Buesa et al. (2010). Consequently, patent submitted to the EPO office would be made the independent variable against Real Gross Domestic Product per capita, (RGDP/C), a measure of regional development per inhabitant of a region.

Mathematically linear regression can be defined as:

$y\ i = a + \beta x + \varepsilon\ i$

where

“y” - represents the dependent variable, or output

“a” - represents the intercept (the constant sum of dependable variable “y” when independent variable “x” is zero.

“β" - represents the slope (that is the rate of change in one unit of dependable variable of “y” for each unit of independent variable of “x”)

“x” - represents the value of the independent variable or the input variable

“ε” - represents the error variable

Multiple regression in this study is further used to assess efficiency of regional Research and Development. Independent variables of persons with tertiary education, tertiary persons employed in science and technology and persons with tertiary education and/or employed in science and technology. As seen below, multiple regression, mathematically, shows subtle difference from linear regression as shown below;

$y_i = a + \beta x1 + \beta x2 + \beta x3 + \beta x4 \ldots\ldots\ldots\ldots\ldots + \varepsilon_i$

y(i) - represents the dependent variable, or output

"a" - represents the intercept (the constant sum of dependable variable "y" when independent variable "x" is zero.

$\beta x1$ - represents the slope (that is the rate of change in one unit of dependable variable of "y" for each unit of independent variable of "x1")

$\beta x2$ - represents the slope (that is the rate of change in one unit of dependable variable of "y" for each unit of independent variable of "x2")

$\beta x3$ - represents the slope (that is the rate of change in one unit of dependable variable of "y" for each unit of independent variable of "x3")

"x"- represents the value of the independent variable or the input variable

"ε "- represents the error variable

The core of regression analysis involves mapping a dependent variable with a corresponding independent variable to discover the degree of reliance of the independent variable on the dependent variable, the consistency of impact of the dependent variable on the independent variable and in some cases, the causation of which has been criticised to be highly deceptive (Crespi, Maffioli, Mohnen,and Vázquez 2011). In relation to this study, following other authors such as Buesa et al. 2010)

Why choose regression analysis

Regression was chosen as the main tool of analysis solely because the study is oriented to exploring the impact of a one (independent) variable, innovation, on another supposedly dependent variable, regional development. Modelling and regression analysis as used by Buesa et.al (2010), shows and explains the connection of a dependent variable on an independent variable revealing the direct impact of a specifically considered variable.

Generally, application of regression may be appropriate when the researcher has an accurate description of the selection process and has access to a valid and relevant set of information on the selected variables impacting participation. Crespi et al. (2011) expressed concern that an unclear selection process, especially when participation is affected by factors unobserved, matching and regression will not provide accurate results reflective of the data given.

Reliability

Predictions are nearly always subject to some uncertainty. This uncertainty arises because not all the variation in the response can be explained by the fitted model. By making some assumptions about the unexplained variation, we can quantify the uncertainty and calculate a confidence interval, or range of plausible values for a prediction.

Descriptions of variables used

This section will explain the variables used in assessing the explaining the term research and Development, innovation and regional development. A combination of other variables that were used to gain a specific interpretation and results of the research will also be added and explained below.

Gross Domestic Product on Research and Development (GERD)

According to the Frascati manual 2015, Gross Domestic Expenditure on Research and Development (GERD) consists of expenditures spanning areas of local business, Government, Universities, higher education sectors, private non-profit sectors and the rest of the world. Generally, it consists of total domestic performance financed by the business sectors of a region, total local performance financed by the Government sector, total domestic performance funded by higher education sectors, total domestic performance that is financed by private non-profit sector and finally the total indigenous performance funded by all other parts of the world. This figure is used to interpret the total financial expenditure expended on Research and Development in a region.

Real Gross Domestic Product per Capita (RGDP/C)

This represents the total Gross Domestic Product of a region adjusted for inflation and divided by the average population. It is calculated as the ratio of real GDP to the average population of a specific year. In most cases, it is used as an indicator of the standard of living of a region, since it is a measure of average real income in that country. However, it is not a complete measure of economic welfare. For example, GDP does not include most unpaid household work. Neither does GDP take account of negative effects of economic activity, like environmental degradation. Real GDP per capita is based on rounded figures.

GERD per capital as a percentage of Gross Domestic product per capita (GERD/c as a PGDP/c PPP)

In this study, this variable was used to represent the portion of Income attributable to citizens that was invested in R & D activities. This figure represents the amount of money per head of a population of a region invested in R & D in the region. This is to assist in assessing the monetary value per citizen involved in improving R & D activities and consequently, their standard of living. Usually, most researchers such as Buesa et al. (2010) prefer to use R & D expenditure as a percentage of GDP most commonly known as R & D intensity. However, the need for this study to discover the real impact per individual in each region uniformly across all EU NUTS 2 regions assessed highly influenced the need to use this variable, GERD/In as and RGDP/c.

Number of R & D personnel as a percentage of Full Time Equivalent (R & D as a PFTE)

R & D personnel include all persons that are directly employed in R & D, as well as persons supplying direct services such as administrators, R & D managers and clerical staff. However, persons providing indirect service, such as floor workers and building security, should be rather excluded." (§ 294 - 295, Frascati Manual, OECD 2002). This figure is used as an indicator of inputs to R & D to represent the number of personnel R & D personnel engaged in full time employment in R & D activities. This sum as well as GERD as a PGDP/c for the purpose of this study were classified as inputs to R & D process that generates output (innovation) in line with the linear model of innovation.

Patents Per Million Inhabitants

In line with Buesa et.al. (2010), Acs et al. 2002, this variable was used as measure of regional innovation by assessing the number of patents submitted to the European Patents Office (EPO).

GERD/In as % RGDP/C and R & D % FTE were used as used as inputs factors and matched against the output factor patent to assess the level of dependence of innovation on these inputs of R & D.

Chi square test of Independence

This is a test conducted to assess the level of significance of a category of data to reject or accept a stated hypothesis. Specifically, the approach is much more appropriate for simple random sampling, the variables under study are categorical. As used by Hung, Yien, Yang and Kuo (2011) in their innovation analysis, it was used to accept or reject the alternative hypothesis stated that "Regional Innovation has an impact on research and Development indicators ". In this test, GERD/c as a PGDP/c (PPP) and R & D personnel as a PFTE will be compared individually with Patents per inhabitants for 2007 and 2012 to discover the *p- value*. The significance level of this test will be set to "0.05". Hence, *p- value* results of the test will be used to reject the stated hypothesis if it is below the significance level and vice versa.

3 Results

This section comprises of the practical research conducted with reference to the NUTS 2 regional classification system by the Committee of Regions in European Union. Here, we will attempt to discover the relationship between the inputs of R & D among the available NUTS 2 regions. We will also subsequently conduct a test to discover the significance of the relations between these inputs and their connection with the measure of innovation, patents per inhabitants. Patents per inhabitants will also be mapped with RGDP/c for three different years using linear regression analysis to know the differing impact of different years selected and eventually, GERD/c selected as the main input of Research and Development will also be assessed to detect the direct impact of research activities on RGDP/c. For ease of interpretation, these analyses will be classified by their location such as North, West, East and South of Europe aside their traditional NUTS 2 classification.

Connection between inputs research and development

The table below will show the results of the linear regression conducted between the Research and Development inputs namely, GERD/c and R & D personnel as a PFTE. This was conducted for the years of 2007 and 2012 exclusively using data available from 276 NUTS 2 regions.

Data on regions assessed were available on Eurostat using regression analysis and correlational values. However, some regions were excluded due to eligibility reasons and data unavailability.

Member states that had two NUTS 2 regions like Ireland and states that were recognised as single NUTS 2 regions, such as Republic of Cyprus, Lithuania, Luxembourg, Estonia, Malta, were excluded from this analysis of inputs and some further analysis too. This was because it made it difficult to run linear regression of these individual states for further analysis. However, they featured in the latter part of the analysis where patents had to be assessed and efficiency of patents of regions were also calculated.

To determine the strength of the relationship between the two variables, in Table 2 below, we will closely observe from the table below the correlation coefficient between the two input variables. In 2007, it could be observed that all Eastern European countries (except Poland), Northern European member states had very strong relationship between the two input variables, such that excluding Poland who although recorded a correlation value showing 87% connection between the two inputs, all other member states had recorded above 90% connection between both variables. This implies that more than 90% of the values of R & D personnel as a PRGDP/c is explained by GERD/c as a PFTE. This trend was very reminiscent of the strength of relationship among the same inputs in the Western European and Southern European member states such that aside

Table 2 : **Relationship between GERD/c and R & D personnel as a PFTE**

Member states	Area	R2		Correlation		Outliers	
		2007	2012	2007	2012	2007	2012
Finland	N	0.99	0.99	0.98	0.51	-	-
Sweden*	N	0.86	0.93	0.93	0.97	-	-
Austria*	W	0.93	0.85	0.97	0.93	Wien	Wien
Belgium	W	0.93	0.89	0.96	0.95	Brussels	Brussels
Denmark	W	0.55	0.96	0.95	0.99	Hovedstaden	Hovedstaden
Germany*	W	0.85	0.88	0.93	0.94	Braunschweig	Braunschweig
France	W	0.91	0.88	0.96	0.94	Ile de France	Ile de France
Netherland	W	0.8	0.63	0.89	0.79	-	-
United Kingdom	W	0.50	0.51	0.80	0.76	Inner London	Inner London
Bulgaria	E	0.94	0.93	0.97	0.97	-	-
Czech Republic	E	0.85	0.88	0.92	0.93	Praha	Praha
Hungary	E	0	0.23	0.89	0.93	-	-
Poland	E	0.76	0.65	0.87	0.8	Norte	
Romania	E	0.89	0.61	0.94	0.78	-	-
Slovakia	E	0.94	0.94	0.97	0.97	-	-
Spain	S	0.89	0.93	0.95	0.97	-	-
Italy	S	0.73	0.85	0.86	0.93	-	-
Portugal	S	0.96	0.9	0.98	0.95	-	-

Source: Eurostat

NOTE: *Countries with "***" *had their data for 2011 used in 2012.*

N- Northern Europe

E-Eastern Europe

W-Western Europe

S- Southern Europe

United Kingdom and Italy which recorded 80% and 86% connection respectively, all other member states had a connection strength of more than 90% between both variables under using the correlation coefficient.

Similarly, in 2012, data analysed showed an equally strong connection between the input variables almost all the states. However, in Eastern Europe, Poland recorded a reduced connection from 87% in 2007 to 80% in 2012 just as Romania did from 94% to 80%. Netherland in the Western region of Europe also recorded a relatively low figure of 79% for 2012 whilst United Kingdom also ended up recording a 76% connection between inputs (a 4% reduction from 2007). Although these values can be termed as, statistically significant, Finland rather dropped down from a 98% connection to a 51 connection between the inputs. Although, this slump looks deep, it could be alluded to data unavailability of some regions considered in 2007 as compared to 2012. Be that as it may, the results of the test of relationship of the input variables of GERD/c as a GDP/c (PPP) and R & D personnel as a PFTE can be termed as significant for all regions excluding Finland.

Hence, from the data above which shows the results of linear regression between the input variables of innovation namely, Gross Expenditure on Research and Development and Research and Development personnel as a percentage of full time equivalent of employed personnel in Research, it could be seen that the fitness of data of the regions , as measured by "R^2"- co efficient of determination and the correlation coefficient between the variables, was discovered to be significant for all the regions of the 19 member states considered in both years except for Finland in 2012.

Hypothesis 1: Research and Development inputs have a positive and significant relationship with Regional Innovation measured with patents per inhabitants.

As our research is fundamentally based on the linear model of innovation, these discussed variables, R & D personnel as a PFTE and GERD/c as a PRGDP/c, were treated as inputs to the innovation process that subsequently produces output in the form of technology, development and findings that are eventually patented with the European Patent Office among the EU member states. In line with our first hypothesis which posits that "research and development indicators have a positive and significant relationship with Regional innovation", we will assess and discuss the chi square test results of GERD/c as a PRGDP/c and Patents for 2007 and 2012 and R & D personnel as a PFTE and Patents for 2007 and 2012 as presented in the table below.

Table 3: Chi square test of independence between GERD/c as a PRGDP/c and Patents per Inhabitants.

Variables	**Classification**	**Number of regions**	
		2007	**2012**
GERD/in as a percentage of RGDP per capita.	Low GERD/in and low patent regions.	95	84

	Low GERD/in and high patent regions	22	8
	High GERD/in and high patent regions	94	62
	High GERD/in and low patent regions	23	30
Total		234	184
R & D personnel employed as a percentage of full time equivalent in employment.	Low R & D personnel and low patent regions	90	74
	Low R & D personnel and high patent regions	60	16
	High R & D personnel and high patent regions	56	54
	High R & D personnel and low patent regions	28	40
Total		234	184

Notes: *Figures for Germany, Sweden and Austria in 2012 were rather figures for 2011.*

This test assesses the level of independence of Patent on these input variables. Regions assessed were also classified into those with low and high input variables in relation to Patents per inhabitant. It was observed that out of 234 regions 95 of these regions that had low GERD/c as a PRGDP/c transformed into low Patent per inhabitants in 2007 making up about 40.5%. In the same vein 94 regions out of 234 that also had a high GERD/c as a PRGDP/c also transformed this into a high patent per inhabitant figure for the region making up 40.1% of the assessed regions. A sum of approximately 81% of regions operating in support of the first hypothesis.

In 2012, 84 regions had transformed a low GERD/c as a PRGDP/c into a low patent per inhabitant making up 45.6% and a corresponding 62 regions transformed high GERD/c as a PRGDP/c into high patents per inhabitants forming 33.7% of the lot. Could be conveniently concluded that 79.3% of regions in 2012 showed a direct relationship between GERD/c as a PRGDP/c and Patents per inhabitants as similarly shown by 80% of regions in 2007.

On the other hand, regions that operated to against the first hypothesis were regions that had transformed low GERD/c as a PRGDP/c into High Patent per inhabitants and vice versa. In 2007, 22 regions had a low GERD/c as a PRGDP/c but managed to notch up a High patent per capita per inhabitant and a corresponding 23 regions had a high GERD/c as a PRGDP/c but a low patent per inhabitants. Mathematically, these regions together formed 9.4% and 9.8% respectively of the regions considered totalling up to 19.2%.

Figure 7: GERD/in as a PGDP/C (PPP) vs Patent per Inhabitant 2012

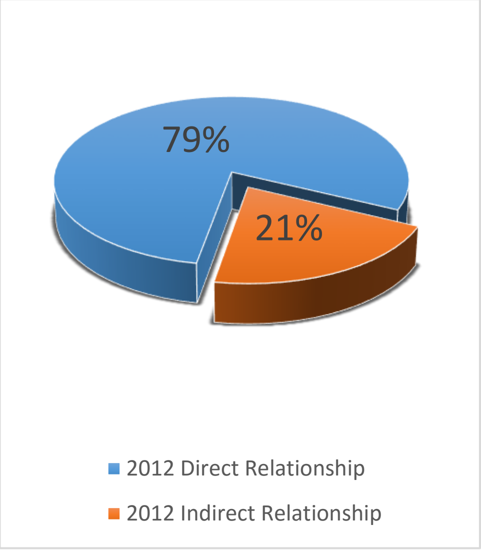
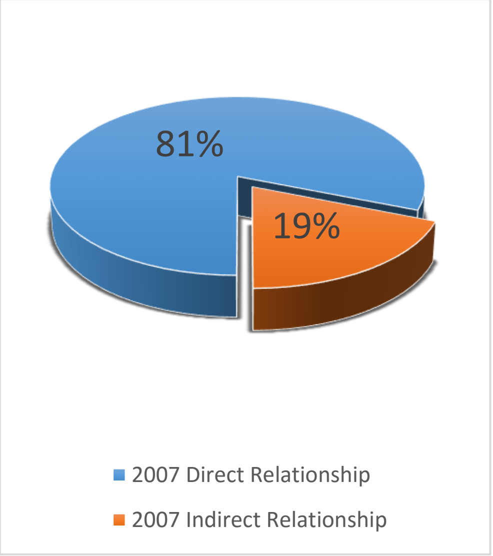


Figure 7: GERD/in as a PGDP/c (PPP) vs Patent per Inhabitant, 2007



Note: *Direct relationship: shows the percentage of regions that recorded a high GERD/c and Patents per inhabitants and a low GERD/c with a low patent per inhabitants.*

Negative relationship: Shows the percentage of regions that recorded a low GERD/c but high patents per inhabitants and a high GERD/c with low patents per inhabitants

In 2012, 8 regions which had a low GERD/c as a PRGDP/c contrastingly recorded a high patent per capita whilst 30 regions also recorded a high GERD/c as a PRGDP/c but a low patent per capita, a percentage point of 4.3% and 16.3% respectively summing up to 20.6%. This inadvertently represents an inefficient and unproductive usage of financial resources in producing innovated and subsequently patented products

Considering the variable, R & D personnel as a PFTE, in 2007, 90 out of 234 regions which had low R & D personnel as a PFTE had a corresponding low patent per inhabitants making up 38.5% whereas 56 regions that had high R & D personnel as a PFTE transformed it into a high patent per inhabitant forming 24% of the data all forming up a percentage point of 62.5%.

In 2012, 74 regions showed a direct relationship between low R & D personnel as a PFTE and low patent per inhabitant whilst 54 regions also reported high R & D personnel as a PFTE with a high patent forming a percentage point of 40% and 29% respectively making a total of 69%.

Contrastingly, 60 regions in 2007 recorded low R & D personnel as a PFTE and high patents per capita, a percentage point of 25.6 whereas 28 regions also had High R & D personnel as a PFTE but reported a low patent per inhabitants making up 11.9% of the regions considered. A sum of 37.5% of regions showing an indirect relationship between R & D personnel as a PFTE and patents per inhabitants. In the same vein, in 2012, 56 regions also showed an inverse relationship between R & D personnel as a PFTE and patents per inhabitant such that 16 of them recorded low R & D personnel as a PFTE and a high patent per inhabitants and 40 of them vice versa. A percentage of 8.7% and 21.7% respectively and a combined of 30.4%.

Figure 9: R&D Personnel as PFTE vs Patents per Inhabitant, 2007

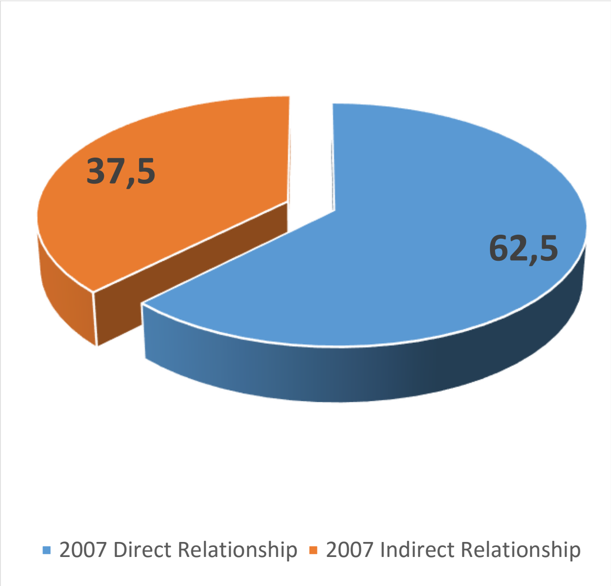
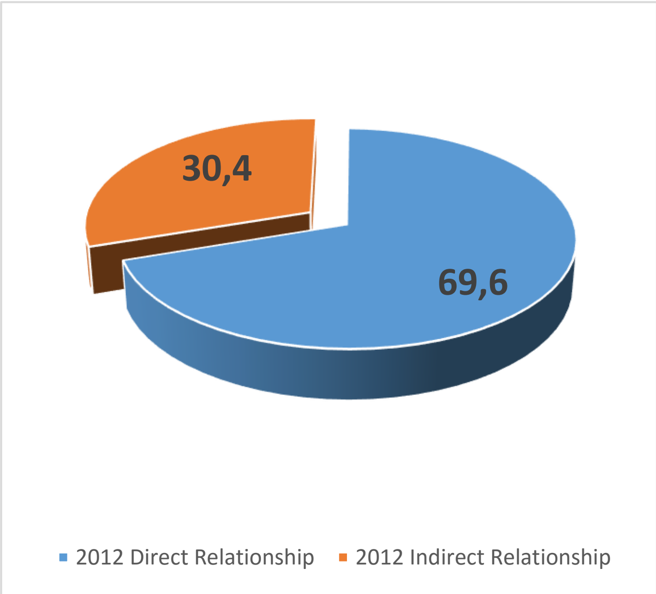


Figure 8: R&D Personnel as PFTE vs Patents per Inhabitant, 2012



Considering the significant "*p*" values of the data, the data can be considered mathematically significant to reject or maintain the stated first hypothesis. From the analysis above, the regions that have a significant relationship between GERD/c as a PGDP/c (PPP) and patents per inhabitant were 81% in 2007 and 79.4% in 2012. Regions that also showed displayed similar significance between R & D personnel as a PFTE and patents per inhabitants were 63% for 2007 and 69% for 2012. This shows a clear majority of regions showing a positive relationship and impact of variables of Research and Development as significant inputs to regional innovation as measured by patent. Hence, the first hypothesis, in virtue of the significance of the data and majority of regions acting in support, can be conveniently accepted as true.

Hypothesis 2: Regional Innovation has a positive and significant impact on Regional Development indicators.

As emphasised earlier, patent per million inhabitants of EU member states submitted to the European Patent Office was used as a measure of the innovation level of regions. As we seek to fulfil or reject the hypothesis stated as "Regional innovation has a significant effect on regional development as measured by Real Gross domestic product per capita". With that in mind, we sought to determine the time value of patents on regional development to know the feasibility of mapping patents of one year with RGDP/c of the same year. This was because of the assumption that patents acquired in one year may take quite a while for it to be extensively distributed, purchased and used up to eventually contribute to the regional development indicator, RGDP/c. The table below shows the impact of patents of the years 2001, 2004 and 2007 on the year 2007 comparing the slope of the various years to see any significant changes among the years.

To test the significance of the data, mathematically "p" must be <0.05 ". From the "p" values, the data was found to be significant with "p" values for Patents vs RGDP/c for all years considered. As the significance of the data was endorsed, we went ahead to consider the values of exchange Patents per million inhabitants and Real Gross Domestic Product per capita for the years assessed. It could be observed that there were no significant differences in slope of the patents per inhabitants and RGDP/c. Patents per inhabitants compared RGDP/c after a 7-year period, 3-year period and within the current year had slopes of "47", "49" and "48" respectively. We eventually decided to continue the analysis of regional innovation and regional development with concurrent values of both variables.

Table 4: Comparison of Patents per inhabitants and RGDP/c for 3 differ. delays (6, 3 and 0 years)

Variables	Delay	Years used	Coefficient	Adjusted R^2	*p-value*	No of Observations
Intercept	6 years	2001 vs 2007	21947.5	0.12	<0.01	232
Slope(x)			**46.68**		<0.01	
Intercept	3 years	2004 vs 2007	21331.23	0.12	<0.01	
Slope(x)			**49.05**		<0.01	
Intercept	Same year	2007 vs 2007	21087.37	0.1273	<0.01	
Slope(x)			**48.2788**		<0.01	

Source: Eurostat

In assessing the impact of innovation on regional development, the research took two fronts, assessment with outliers involved and assessment excluding outliers to enable a uniform assessment of all regions.

Table 5: Results of Linear Regression between Patents Per Inhabitants (x) and RGDP/c (Outliers included)

	Region	**Abb**	**Loc**	**Slope**	**Intercept**	**R^2**
1.	Bulgaria	BG	E	1160	2158	0.83
2.	**Czech Republic**	**CZ**	**E**	**33.19**	**10871**	**0.04**
3.	**Hungary**	**HU**	**E**	**-456**	**12335**	**0.4**
4.	**Poland**	**PL**	**E**	**-45.9**	**8268**	**0.00**
5.	Romania	RO	E	1748	3560	0.88
6.	Slovenia	SL	E	322.48	-1782	1
7.	Slovakia	SK	E	1025	2563.6	1
8.	**Finland**	**FI**	**N**	**30.57**	**29918**	**0.32**
9.	Sweden	SE	N	32.44	28872	0.48
10.	**Spain**	**ES**	**S**	**75.9**	**23139**	**0.31**
11.	Italy	IT	S	81.4	21312	0.5
12.	**Portugal**	**PO**	**S**	**501**	**11860**	**0.5**
13.	Austria	AT	W	103	14062	0.69
14.	Belgium	BE	W	48.27	20751	0.5
15.	Germany	DE	W	24.44	22735	0.44

16.	Denmark	DK	W	59.15	26885	0.77
17.	France	FR	W	58.7	21165	0.64
18.	**Netherlands**	**NL**	**W**	**54.6**	**27628**	**0.15**
19.	United Kingdom	UK	W	70.35	24727	0.72

Source: Eurostat

NOTES: *Regions in bold were those that had statistically insignificant "p" values*

Abb: Abbreviation

Loc: Location of Region by cardinal points

From Table 5, the significance of the data was assessed with the "p" values. Significance of the data was assessed on the standard that:

If P <0.05, data was termed as statistically significant. If p >0.05, data was termed statistically insignificant.

Member states namely, Spain, Finland, Hungary, Netherland, Poland and Portugal, statistically, had insignificant "p" values, hence their analysis of impact patents per inhabitants on RGDP/c could not be considered as valid.

An assessment based on locations revealed that Eastern European member states had the highest R^2 for Eastern European member states. This variable explains the percentage of the independent variable that is explained by the dependent variable. This explains that in Romania, 88% of real gross domestic product per capita is determine by the patents produced. This was closely followed by Bulgaria with 83%. However, Slovenia and Slovakia although has perfect scores for this measurement only had just two points on the graph. Other Eastern European member states had statistically insignificant p- values, hence could not be statistically accepted. This could lead to the conclusion that Eastern regions are a lot more dependent on patents per inhabitants for real gross domestic product per capita as a measure of regional development

Among the Western regions of Europe, Denmark recorded the highest determinant of real gdp per capita with a figure of 77% of RGDP/c being determined by patents. This was closely followed by United Kingdom with 72%, Austria with 69% as could be seen from the table. From this perspective, it could be concluded that patents per inhabitants do not have such a strong role in improving real gross domestic product per capita as it is in the Eastern EU member states.

Northern regions of Europe consisting of Sweden and Finland recorded 32% and 44% respectively as the percentage real gross domestic product per capita that is determined by patents. Southern regions of Europe had statistically insignificant "p" values, hence, the values could not be validly accepted and analysed.

Table 6: Linear Regression between Patents Per Inhabitants (x) and RGDP/c, 2007 (Outliers excluded)

	Country	Abb	Loc	Slope	Intercept	"R" squared	P-value	Name of Outliers
1.	Bulgaria	BG	E	1160	2158	0.83	0.03	-
2.	Czech Republic	CZ	E	57	10437	0.21	0.3	Praha
3.	Hungary	HU	E	-456	12335	0.4	0.18	-
4.	Poland	PL	E	329	5593	0.37	0.03	Mazowieckie
5.	Romania	RO	E	1748	3560	0.88	0.02	-
6.	Slovenia	SL	E	322	-1782	1	-	-
7.	Slovakia	SK	E	887	5135	0.98	0.1	-
8.	Finland	FI	N	61	20492	0.96	0.02	Alan
9.	Sweden	SE	N	7.9	32832	0.4	0.13	Stockholm
10.	Italy	IT	S	81	21311	0.5	0	-
11.	Portugal	PO	S	501	11860	0.5	0.18	-
12.	Spain	ES	S	123	19871	0.65	0	-
13.	Austria	AT	W	103	14062	0.7	0.01	Vorarlberg
14.	Belgium	BE	W	48	20751	0.5	0.02	Brussels
15.	Germany	DE	W	24	22735	0.44	0.	Hamburg
16.	Denmark	DK	W	59	26885	0.77	0.05	-
17.	France	FR	W	36	22587	0.61	0	Ille de France
18.	Netherlands	NL	W	54	27628	0.14	0.25	Noord Brabant
19	United Kingdom	UK	W	70	24728	0.7314	0	Inner and outer London

Source: Eurostat

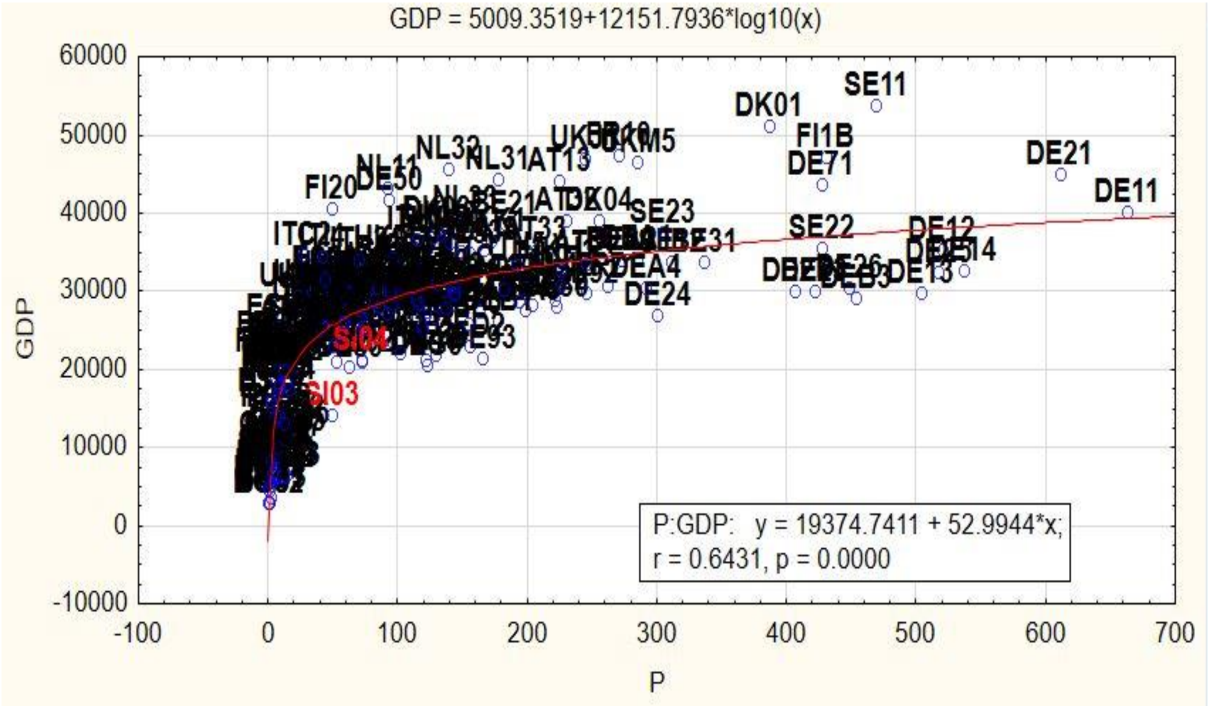
NOTES: *Member states in Bold had "p" values that were statistically insignificant, that is, p>0.05.*

Among Northern European member states, Finland recorded 96% of RGDP/C being determined by patents whilst Sweden on the other hand had 34%. In the western European union member states, Denmark recorded the highest of 72% followed by 73% of United Kingdom and lowest of all, 44% for Germany. This goes to show a very low reliance on patents produced and a reliance on other factors, like foreign direct investment, consumption, international trading in improving the standard of living of inhabitants.

Eastern European Union member states recorded very high co efficient of determination of the output variable, real gross domestic product per capita. Highest of them all was Slovakia showing 98% of the real gross domestic product per capita being determined by patents produced. Next in line was 88% for Romania, 83% for Belgium and the lowest being Czech Republic with 21%.

For Southern European member states, aside Portugal which recorded 18% of RGDP/c being determined by patents, Spain and Italy both had almost zero figures in this respect.

Figure 10: Patents per Inhabitants (x) vs RGDP/c (y) for all NUTS 2 Regions, 2007.



Given the logarithmic shape, the diagram visually implies that not all regions have the same impact of patents per inhabitants on their RGDP/c. From the diagram above, it could be observed that Eastern and Southern European member states dominated the section between 0 and 20 patents per inhabitants and just over 20, 000 euros for RGDP/c. This section represents the vertical section, where increases in patents per inhabitants do not generate significant increase in RGDP/c.

However, the area representing the curve and the section after was mostly dominated by the Western and northern European member states. At that point, any point increase in patents per inhabitants generated a correspondingly significant increase in RGDP/c as observed from the diagram. This goes to show that in as much as Eastern and Southern European member states producing. more and more patents, their impact on regional development is not as efficient and effective as compared to Western and Northern European member states who has a lower rate of change of patents per inhabitants for RGDP/c but has a higher RGDP/c with even a low dependence on patents.

Table 7: Adjusted coefficient of determination results of Patents vs GDP/c, 2007 and 2012

AREA	OUTLIERS INCLUDED		OUTLIERS EXCLUDED	
	R^2	ADJ R^2	R^2	ADJ R^2
REGIONS IN EASTERN EU MEMBER STATES	0.43	0.31	0.67	0.6
REGIONS IN NORTHERN EU MEMBER STATES	0.4	0.00	0.68	0.68
REGIONS IN SOUTHERN EU MEMBER STATES	0.43	-0.14	0.55	0.1
REGIONS IN WESTERN EU MEMBER STATES	0.65	0.58	0.53	0.41

Source: Eurostat

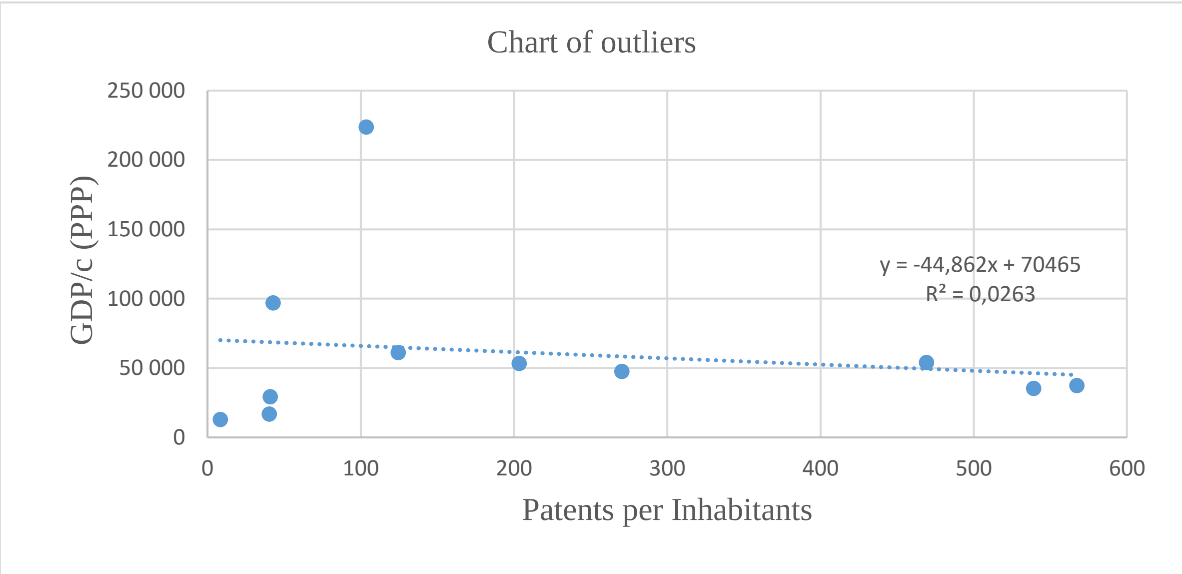
However, since R^2 is adjudged not to work well with an entire population used as samples, adjusted R^2 was also calculated in Table 7 for the data to reduce the impact of samples that does not contribute any impact on the dependent variable, that is GDP/c (PPP). Using the adjusted coefficient of determination, it could be rather concluded that regions in Western EU member states had the best impact of patents in GDP/c (PPP) such that 58% of GDP/c (PPP) were explained by patents, followed by 31% for Eastern NUTS 2 EU regions. Southern member states rather recorded a negative impact of patents on GDP/c (PPP) whilst Northern member states had no definite value attached in 2007.

When outliers were excluded, Northern EU NUTS 2 regions performed best with 68% of GDP/c (PPP) being explained by patents, followed by 60% for Eastern NUTS 2 regions, 41% for Western EU NUTS 2 regions and the lowest being 10% of GDP/c directly determined by patents for Southern NUTS 2 regions.

Outliers: Patents per Inhabitants vs RGDP/c

For further analysis, data for regions that were discovered as having an exceptional trend to the pattern of the NUTS 2 regions within their member states were also analysed to discover any pattern of trend within the regions. Consisting of eleven NUTS 2 regions, namely, Stockholm, Brussels, Hamburg, Noord Brabrant, Vorarlberg, Inner London, outer London, Praha, Közép-Magyarország, Mazowieckie and Ille de France linear regression was conducted for the input variable of patents per inhabitants and output variable of RGDP/c.

Figure 11: Relationship of Patents per Inhabitants and RGDP/c of Outliers of NUTS 2 regions in European Union Member states.



Source: Eurostat

As could be observed from the data, there was no definite relationship among the regions considered evidenced from the negative relationship and the almost unrelated relationship between the variables. These outlying regions were those observed to have the least and highest patents that were unusual among fellow NUTS 2 region in their member states, however, they were ironically observed to produce an unreasonable an unusual figure given the investment in patent in their regions. This was explained by NSF (2012) as being due to fiscal policies, public policies, monetary policies, regulatory policies, standards, procurement capacities, presence of a highly skilled technical workforce, and market entry difficulties that incited competition within those areas and increased regional growth within the regions other than other regions. Coincidentally most of these outliers were all observed to be capital cities of their respective member states.

As part of the research, analysis was also made to determine the impact of GERD/c directly on RGDP/c of the EU member states as well. In this analysis, the member states were assessed in light of NUTS 2 regional classification as well a country level analysis. With the country level analysis, the research sough to find the country that was able to best transform GERD/c into RGDP/c for their respective countries. However, as the EU has targeted to achieve R & D investment of three (3%) percent of GDP by 2020, it is interesting to note that only the two Northern European Union member states, Sweden and Norway had more than 3% investment. The table below will give further information for subsequent analysis.

Table 8: Results of linear regression between GERD/c (x) and RGDP/c (y), 2007.

Member States	**Area**	**GDP/c (euros)**	**Theoretical GDP/c (euros)**	**Difference (euros)**	**GERD/c as a PRGDP/c**
Bulgaria	E	5800	*2,169*	3,631	0.63
Czech Republic	E	14900	*22,726*	-7,826	1.91
Estonia	E	14400	*21,293*	-6,893	1.72
Hungary	E	10200	*15,805*	-5,605	1.40
Latvia	E	11300	*8,534*	2,766	0.61
Lithuania	E	11800	*13,363*	-1,563	0.95
Poland	E	10200	*11,214*	-1,014	0.89
Slovakia	E	13600	*13,452*	148	0.83
Slovenia	E	17400	*27,392*	-9,992	2.61
Finland	N	37400	*37,386*	14	3.29
Sweden	N	45400	*39,411*	5,989	3.32
Croatia	S	10200	*10,394*	-194	0.82
Cyprus	S	21000	*11,911*	9,089	0.46
Greece	S	16500	*15,115*	1,385	0.81
Italy	S	26500	*24,830*	1,670	1.33
Malta	S	18100	*16,463*	1,637	0.84

Portugal	S	16300	*19,922*	-3,622	1.32
Spain	S	22100	*22,495*	-395	1.26
Austria	W	38100	*36,544*	1,556	2.97
France	W	32100	*32,067*	33	2.26
Germany (until 1990 former territory of the FRG)	W	35000	*35,016*	-16	2.78
Ireland	W	39000	*30,189*	8,811	1.54
United Kingdom	W	31900	*28,978*	2,922	1.67

Source: Eurostat

Out of the data available for twenty-three (23) member states, we had 10 Eastern member states, two (2) Northern member states, six (6) Southern states and five (5) Western member states. From this data, we calculated the theoretical RGDP/c with the equation from the graph given as:

$$y = 10016\ln(x) - 33889$$

The difference between the actual GDP/c (PPP) and theoretical RGDP/c were used to assess the transformative ability of the member states assessed.

From Table 8, whilst keeping in mind that GERD/c is not the only factor contributing significantly to RGDP/c, it can be observed from the table that among the Eastern member states assessed, only Bulgaria and Latvia displayed a very high level of transformative ability of investment in research and development into a positive GDP/c (PPP). However, the rest of the eight (8) member states in Eastern Europe showed a rather negative ability to transform GERD/c into RGDP/c. The differences in transformation capabilities within the member states could be alluded to the different surrounding conditions such as local manpower of regions and skilled expertise available to regions from firms and Universities (Agrawal, Galasso, Cockburn and Oettl 2012).
In southern Europe, four-member states, namely, Cyprus, Italy, Greece and Malta recorded positive transformation of expenditure invested in Research and Development into RGDP/c except for Spain and Portugal.

Western European countries performed best on this scale such that all countries considered had positive transformations of GERD/c into RGDP/c except Germany who experience a marginally negative difference. The transformation among Northern European Union member states as well followed the same positive light of the Western European member states. To add up to this, from the results of this research, only the Northern European member states as well as Ireland, Austria, Germany and France had above the EU average for RGDP/c and GERD/c. United Kingdom however, had slightly below the EU average for GERD/c but recorded an above average for RGDP/c.

Efficiency of R & D expenditure: Patents per citizen's per capita income invested as a percentage of GDP.

However, to ascertain the efficiency of research and development, the research took two fronts. That is, analysis of the efficiency of R & D from the perspective of the policy makers which measures the impact on their standard of living and the analysis from the perspective of investors which measures the results from each euro invested into R & D activities. With this in mind, we calculated the patents produced by NUTS 2 regions per every one percentage of income of citizens invested (for policy makers) and also patents produced per each euro invested in research activities. The figures were separated by a median to show the regions that fell below the and those that performed well above the yardstick. The table below will show more details of the calculation and the regions.

In 2007, all German regions-except Braunscheweigh, Dresden and Saarland- regions in Belgium, Netherland, Denmark, France – except Midi-Pyrénées, Corse, Languedoc-Roussillon recorded higher than the median of 40.46 patents per each percentage of citizens' income sacrificed. The same could be said of the Northern member states of Europe- Sweden and Finland -excluding Pohjois- ja Itä-Suomi region which had lower than the median. Lastly, in United Kingdom, all regions recorded more than 40 patents produced per every percentage of citizens income invested excluding the region Highlands and Islands, Northern Ireland (UK), South Western Scotland, East Wales, Devon, Kent, Essex, West Midlands, South Yorkshire and Cheshire.

Among the Eastern European member states, all the NUTS 2 regions in Bulgaria, Czech Republic, Romania, Estonia Hungary, Poland- except Lubuskie all recorded figures below the median of 40 patents per every percentage of citizen's income invested.

Similarly, of the southern member states of the European Union, Italy has almost all regions above the median limit excluding Lazio, Sud, Molise, Campania, Puglia, Basilicata, Calabra, Isole, Sicilia and Sardegna. All other NUTS 2 regions of Portugal, Spain- except Catalunya, Aragon, Comunidad Foral de Navarra- Croatia, Malta achieved a below 40 patent productions per every percentage of citizen income invested.

Furthermore, in 2012, all regions in Belguim-except Province of Brabant Wallon and Hovedstaden, had above the median number of patents produced per every percentage of citizen income sacrificed. NUTS 2 regions in Ireland, France- excluding Midi-Pyrénées, Languedoc-Roussillon, United Kingdom- except Chesire, South Western Scotland and Kent- as well as both Northern European countries all recorded above the median of 22 patents produced per every percentage of citizens income sacrificed.

However, Eastern European member states, except for Lodzkie of Poland and Közép-Magyarország of Hungary and Severen tsentralen of Bulgaria, all other NUTS 2 regions in the Eastern member states recorded lower than the median number of patents produced per each percentage of citizens' income invested.

Among the southern member states in the European Union, Cyprus, Malta, regions in Portugal all had lower than the median figures. País Vasco, Comunidad Foral de Navarra, La Rioja, Aragón, Comunidad de Madrid, Comunidad de Madrid, Centro (ES), Castilla y León, Castilla-la Mancha, Extremadura, Este (ES), Cataluña, Comunidad Valenciana, Illes,Balears ,Sur (ES), Andalucía, Región de Murcia in Spain were the regions which had higher than the median of 22 patents per every percentage of citizen income invested. Piemonte, Valle d'Aosta/Vallée d'Aoste, Liguria,Lombardia, Nord-Est, Provincia Autonoma di Bolzano/Bozen, Provincia Autonoma di Trento, Veneto, Friuli-Venezia Giulia, Emilia-Romagna,Centro (IT), Toscana, Umbria, Marche, Lazio, Sud, Abruzzo were the only regions in Italy to have recorded above the twenty eight (22) patents per each percentage of citizens' income invested.

Efficiency of R & D expenditure: Patents produced per each Euro invested

In this perspective, we analysed the quantity of patents each classified region acquired whenever a single euro was invested in patent production. A median of 0.17 was set for the data acquired in 2007 for all member states to differentiate between the best performing and the worst performing.

Using data from appendix A, in 2007, among the organised European member states, the region with the most efficiency in patent production was the Northern member states of Europe which produced altogether an average of 0.34 patents per each euro invested, followed closely by the

Western member states figure of 0.33 patents/euro invested. However, regions in the southern member states had the highest of 0.4 patents per euro invested. Regions in the Eastern European member states rather had the lowest figure of 0.1 patents/euro. This could be conveniently explained that Southern member states are more efficient in utilizing R & D expenditure than all other regions stated above and hence investors would be better served considering this region for the best performing region if they are eager to acquire productive returns on investment.

In 2012, the figures however, patents produced per each euro invested were a little lower such that Northern member states recorded the highest returns per euro invested which was 0.29. This was followed by the Western member states which recorded an average of 0.14 patents per euro invested and then 0.12 for both regions in Eastern and Southern member states.

GDP vs R & D Efficiency of NUTS 2 regions

In the patent analysis, it could be seen that Eastern European NUTS 2 regions were perceivably experiencing a higher slope when patents per inhabitants when assessed against Real GDP per capita. However, a plain look would just lead to the premature conclusion of higher slopes implying a much more effective patent impact on RGDP. However, data from the analysis of slopes showed otherwise.

In Appendix B, efficiency of Western and Eastern NUTS 2 regions was picked and assessed against each other as they had the most number of regions in the range of higher and lower slopes of patent per million inhabitants exchanged for Real GDP/c. This analysis was done to understand their efficiency and assess their reason for their different impact on Real GDP/c.

It showed that regions that had higher slopes for patents per inhabitant vs Real Gross Domestic product per capita did not necessarily have the highest efficiency. However, from Appendix A, regions with higher efficiency were largely the Western and Northern EU NUTS 2 regions not the Eastern and Southern regions. This increase in slope of patents per inhabitants vs Real GDP per capita could be alluded to the increasing performance of such regions in to achieve their unfulfilled R & D potential hence although they have a high exchange of patents per million inhabitants for Real GDP/c, they have a lower efficiency compared to the Western and Northern EU NUTS 2 regions who have lower slope of patents per million inhabitants affecting Real

GDP/c and presumably have fulfilled and achieved most of their research potential that is now being attempted to be fulfilled by the Eastern and Southern NUTS 2 regions.

This analysis clearly shows why these regions with higher slope for patents per million inhabitants vs Real GDP/c cannot be said to be performing better in impacting real GDP/c than those with lower slope.

Patents per million inhabitant vs Employment Rate of Regions

To fulfil the aim of the research in assessing impact of patents on Regional development, the data for patents per millions was also analysed in light of the employment rates of the officially grouped Northern, Western, Eastern and Southern member states of the European Union. To assess the direct impact of patents per million on employment rates of the various regions in the member states, the research used strictly R^2 as a measure of the determinant of the impact of patents per inhabitants on Regional employment rates for the years of 2007 and 2012 as can be seen from the table below

Table 9: Patents vs Employment rate, 2007 and 2012.

	R^2		Adjusted R^2	
REGION/YEAR	**2007**	**2012**	**2007**	**2012**
Northern EU member states	0.01	0.00	-0.08	-0.00
Western EU member states	0.03	0.00	-0.00	-0.00
Eastern EU member states	0.01	0.03	-0.02	0.01
Southern EU member states	0.00	0.00	-0.00	-0.00

Source: Eurostat

As seen from the Table 9, in 2007, Western member states had the highest but almost insignificant impact of Patents on regional employment rate in 2007 such that 3% of the increase in employment rate is only influenced by the patents produced in the Northern member states. This was however followed up by the Northern member states and Eastern member states with both recording only a percentage of an impact of patents in raising the employment levels in these regions. Southern member states rather had almost no impact on regional employment.

In 2012, however, Northern, Western and Southern member states both had almost no impact of patents on regional employment except Eastern member states which recorded a patent figure explaining only 3% of the total employment in the region.

However, in 2007, when the adjusted co-efficient of determination is considered, it shows a negative impact of patents on employment rate of 8% and 2% for both Northern and Eastern EU NUTS 2 regions. Southern and Western regions had both zero impact but negative relationship between the two variables.

In 2012, using the adjusted coefficient of determination, there was observed to be a negative relationship but zero impact of patents on employment rate except Eastern NUTS 2 regions who had a 10% negative effect of patents on employment rate.

Patents vs Disposable Income of Private households

To further assess the impact of patents per millions on Regional productivity, disposable income of households was used as a third variable aside employment rates and Real Gross Domestic Product per capita. Specifically, the data will be assessed to track supposed effect patents has on the disposable income of households under investigation. Using coefficient of determination as a measure of determination of the impact, the table below will give further insights into this analysis.

Table 10: Patents vs Disposable Income 2007 and 2012

	R^2		Adjusted R^2	
REGION/YEAR	**2007**	**2012**		
Northern EU member states	0.33	0.38	0.26	0.31
Western EU member states	0.05	0.07	0.04	0.05
Eastern EU member states	0.33	0.22	0.32	0.21
Southern EU member states	0.14	0.00	0.13	-0.00

Source: Eurostat

From Table 10 above, it could be seen that 33% of the total disposable income of regions in Northern EU member states and Eastern EU member states were all affected by patents produced in 2007. Regions in the Southern EU member states recorded 14% whilst the Western EU regions had the lowest of merely 5% in 2007.

However, in 2012, regions in the Northern EU member states had the highest impact of patents on disposable income such that 38% of disposable income was determined by patents, 22% for the regions within the Eastern EU member states followed by 7% for Western EU NUTS 2 regions and almost zero for the Southern member states. This goes to establish that, Northern and Eastern member acquires more from patent production to their disposable income than regions in the Western and Southern member states.

As some researchers may prefer to consider the use of adjusted coefficient of determination, it could also be referred to from Table 10 above however, it only showed slight reduction in figures of coefficient of determination already calculated and discussed for the regions maintaining the same rankings of the differing impact of patents in classified NUTS 2 regions above**.**

4 Findings and Recommendations of the Research

This section will explain the discoveries of this study and the propositions that the researcher understands will solve the differences in patent utilization and production by the various member states.

4.1 Findings

As the research sought to identify the effects of innovation and research activities on Regional development in NUTS 2 regions, the findings will be outlined from the perspective of the individual member states and eventually by their classified location such as North, West, East and Southern Europe.

Regression analysis of inputs of Research and development with patents showed that there was a positive relationship such that a high percentage of the assessed regions recorded a high patent when high GERD/c or R & D personnel were employed.

To be able to also know the time lag that patents produced will require to influence regional development as represented by Real Gross Domestic Product per capita. A chi-square test that used a delay of six (6), three (3) and zero (0) years as seen from Table showed there was very trivial effect of time on how much patents affected real gross domestic product per capita as observed from the slope.

In Table 8, GERD/c was also mapped against GDP/c in (PPP) to also assess the transformative ability of the regions under consideration in 2007. Considering this analysis, NUTS 2 regions in Western Europe and Northern Europe had the best transformative ability of patents to RGDP/c (PPP), followed closely by Southern EU NUTS 2 regions and lastly Eastern EU NUTS 2 regions.

Moreover, from the empirical analysis shown in Table 8, it was revealed that regions of Western European member states were relatively more efficient in the usage and transformation of patents per inhabitants into gross domestic product per capita (PPP). The data assessed reinforced that development of these countries hinged a lot more on other sensitive growth factors and favourable regional policies. With regards to efficiency of patent production, shown in Appendix "A" regions of Southern member states were observed to be more efficient in producing patent with each euro invested. They were followed closely by the Northern member states and the Western member states. In 2012, however Northern member states exhibited more efficiency in producing patents per each euro invested rather than Western member states Southern and Eastern states.

Considering efficiency per every percentage citizen's/capita income invested, it was further observed that citizens of Northern member states had the most output from the investment of each percentage of their per capita income. This was followed closely Western member states then the southern and lastly the Eastern member states. This could be alluded to the surrounding and facilitating factors of patent production as outlined above.

In assessing the impact of patent on regional development, we used three variables to represent regional development: namely Gross Domestic Product per capita (PPP), Employment rate and Disposable income. With the use of R^2, with and without outliers, in 2007, it was observed that regions in the Eastern European member states rather had more much more patents reflecting in the Real Gross Domestic Product per capita (PPP) than the Western member states, the Northern member states and the lastly the southern member states as ranked in order of significance.

In considering the variable of employment, in 2007, Western member states had the highest impact of patents on Employment rate with a figure of 3%, followed by regions in Eastern and Southern member states and finally Northern member states. However, in 2012 only the regions in the Eastern members states recorded a definite figure of 3% as the impact of patents on employment rate. All other considered member states however, had nil figures.

Lastly, we measured patents against its impact on disposable income of private households. Northern member states showed the highest impact of patents on the disposable income of households as 37% followed closely by both regions in Western and Eastern member states with figures of 33% each and finally 14% for regions in the southern member states in the year 2007.

In 2012, Northern member states, regions in the Northern member states had a fair number of patents impacting 31% of disposable income. However, regions in the Western member states had the highest impact such that 38% of disposable income were determined by patents followed by 22% for regions in Eastern member states and finally an almost insignificant figure for southern member states.

4.2 Recommendations

Member states, especially the Eastern and Southern member states should realise that acquisition of patent and discoveries is not a solo variable in accelerating and enhancing the standard of living of inhabitants of a region. It is imperative that they set up infrastructures and policies to support regions deprived of valuable auxiliary development variables in education for producing a highly skilled and technical workforce, research infrastructures for supporting research propositions, relevant industries in line with the strength of the regions, public policies, and market entry difficulties to protect and support the adequate exploitation of discoveries and developments.

4.3 Limitations and significance

This section will seek to outline barriers encountered in this research and the essence of the research to relevant bodies.

Limitations of the Research

- The most heckling hiccup in this research was the absence and occasional inconsistency of data availability via the European Commission website. Most NUTS 2 regions had absolutely no data for the relevant years considered, especially Greece, whilst others also had inconsistent data for the available regions such as Chemnitz and Bayern in Germany, Hradtska in Croatia just to name a few. Other variables intended to be considered via multiple regression such as organisational cooperation, tertiary educated personnel and science and technology personnel had figures available for different dates altogether making it difficult to concurrent year assessment and analysis.
- The use of Patents per million inhabitants as a single measure of innovation was deemed to be not entirely enough due to the occurrences of patents being sold out by institutions to wealthy investors in different geographic locations, the possibility of patenting being ignored due to little relevance attached to the discovery and the informal possibility that some discoveries may not be patented.
- The years analysed were further from recent events due to the interference of global economic event that sparked a slump in 2008 to 2010. This was even more aided by the required legal delay in publishing patents data available by the European Union.

Significance of the Research

- This research will be useful for discovery of the NUTS 2 region that may require further focus and assistance in the crafting and implementation of European Union Regional policies.

- Findings of this research will be reliable source of information in debunking the myth about the true extent and impact of Patents of a region on the productivity of a geographical area.

- It will also reveal the level of importance and expenditure member states of the European Union shell out in support of regional research and development activities to measure against their continued progress to meeting the Europe 2020 objectives.

5 Conclusion

According to the linear model of innovation, Research and Development activities are deemed as the basis of innovation activities in regions. Due to this belief, regions invest expenditure, known as GERD, into business activities, public sector and educational sectors in the regions to develop and incite research activities which are, in turn, patented and measured as innovation. Even as investments in R & D, some non-monetary R & D activities also operate to incite a growth in R & D activities and also economic growth. However, this research only set up to assess the impact of research and innovation activities on regional development.

To discover this impact of the input variables of GERD/c and R & D as a PFTE was chosen as the variables of Research and Development activities and the inputs of innovation activities. To prove the first hypothesis set for this research, the relationship of these variables was assessed with the use of linear regression. Correlation coefficient was considered and used to assess the relationship of these variables with respect to the NUTS 2 regions of the EU member states. The regions were grouped into North, West, East and Southern member states. It was discovered that there was a strong relationship between these inputs among the Eastern and Northern European member states except Poland who recorded an 87% of GERD/c being determined by R & D as a PFTE. Equally, a strong impact of R & D as a PFTE on GERD/c was found for Western and Southern regions with United Kingdom and Italy recording the lowest figures.

To determine the significance of the relationship between the variables of R & D and patents per inhabitants, chi square was used to test this relationship. Results from the chi square tests confirmed the significance of the relationship between variables considered, that is patents per inhabitants, GERD/c as a PGDP/c (PPP) and R & D as a PFTE for the years of 2007 and 2012. This test effectively accepted the first hypothesis of the research between the input variables of research and patents.

GERD/c was also assessed against RGDP/c and the member states to discover the transformative abilities of member states individually on RGDP/c. It was further revealed that Bulgaria and Slovakia were the only Eastern countries to record a positive transformative ability of GERD/c into RGDP/c whilst almost all the Western and Northern member states recorded a positive transformation of R & D into RGDP/c. When the member states were however assessed in light of the EU average, only the Northern European member states as well as Ireland, Austria, Germany and France had above the EU average for RGDP/c and GERD/c. United Kingdom however, had slightly below the EU average for GERD/c but recorded an above average for RGDP/c. This showed generally a positive transformative ability by the Western and Northern member states contrary to the Eastern member states in transforming GERD/c into RGDP/c.

The second hypothesis was also proved when patents per million inhabitants was thereon assessed against RGDP/c to discover the impact of innovation on regional development, specifically the standard of living of inhabitants to fulfil the second hypothesis. However, due to data inconsistency, this analysis was only limited to a single year comparison, that is for only 2007. Results of this test for the year 2007 showed that the Eastern and Northern European member states had patents affecting their real Gross Domestic Product per capita much more than the Western and Southern member states.

Patents per million inhabitants were also assessed with disposable income also used as a measure of regional development for both 2007 and 2012. This also showed that Northern and Western EU NUTS 2 regions had above 30% of their disposable income directly affected by patents produced for both 2007 and 2012. Eastern member states also had quite an impact and even worse was Southern member states which almost had no impact on employment rates.

The reasons for the stark difference in performance of patents were stated to be caused by the stark differences in public policies that provided extreme support for research activities in Eastern and Southern member states, the inadequacy of highly skilled and technical workforce in these areas chiefly because of migration to the Western and Northern member states for "greener pastures" and better work opportunities as well as lack of auxiliary support for innovative research structures. However, some regions within the member states performed exceptionally well without patents than other regional counterparts and these were discovered to be mostly capitals of member states termed as outliers in this research. Further research into this showed the presence of attractive ventures, high pay grades and promise of variety of opportunities which highly facilitated migration of skilled workers into these areas.

Further research on this topic could be directed at discovering the exact the reason for the differences in efficiency among NUTS 2 regions and also the reality of trade of patents among the wealthy and the relatively poor or geographically close regions or member states.

Be that as it may, it could be conveniently established from the research that patents have a positive impact on regional development indicators of real gross domestic product per capita and disposable income but not so much in employment rate of regions. Western and Northern European member states also seemed to possess better transformative ability and are able to ensure a higher impact of patents on real gross domestic product per capita and disposable income of private households rather than Eastern and Southern member states. However, considering that regional development is also acquired non-monetary R & D processes such as trade intensities between regions, interaction in knowledge networks among firms and companies which also deeply supports monetary R & D activities, it will be difficult to conclude the outright superiority in performance of one NUTS 2 group over the other in contributing to regional development.

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LIST OF THE APPENDICES

Appendix A

Regions	Location	Patent/GERD/C % OF RGDP/C		Patent/Euro	
		2007	**2012**	**2007**	**2012**
		MEDIAN-40.46	**MEDIAN-22.11**	**MEDIAN-0.17**	**MEDIAN-0.11**
Belguim					
Région de Bruxelles-Capitale / Brussels Hoofdstedelijk Gewest	W	91.12	67.12	0.15	0.11
Prov. Antwerpen	W	85.83	55.65	0.22	0.14
Prov. Limburg (BE)	W	133.99	58.57	0.50	0.20
Prov. Oost-Vlaanderen	W	87.16	50.39	0.30	0.16
Prov. Vlaams-Brabant	W	86.92	59.40	0.26	0.16
Prov. West-Vlaanderen	W	101.23	68.89	0.33	0.21
Prov. Brabant Wallon	W	49.81	20.45	0.15	0.05
Prov. Hainaut	W	70.62	28.97	0.33	0.13
Prov. Liège	W	62.66	59.05	0.26	0.23
Prov. Luxembourg (BE)	W	250.58	434.23	1.14	1.91
Prov. Namur	W	55.32	54.46	0.25	0.22
Bulgaria	**E**				
Severozapaden	E	9.26	8.99	0.32	0.25
Severen tsentralen	E	3.59	30.77	0.12	0.79
Severoiztochen	E	11.03	6.91	0.30	0.15
Yugoiztochen	E	1.96	1.51	0.06	0.03
Yugozapadna i yuzhna tsentralna Bulgaria	E	0.00	0.00	0.00	0.00
Yugozapaden	E	4.85	8.68	0.07	0.09
Yuzhen tsentralen	E	2.22	11.22	0.07	0.28
Czech Republic	**E**				

Praha	E	16.95	12.01	0.06	0.04
Strední Cechy	E	12.16	9.88	0.10	0.07
Jihozápad	E	13.04	4.13	0.11	0.03
Severozápad	E	14.09	17.83	0.14	0.15
Severovýchod	E	19.35	17.68	0.18	0.14
Jihovýchod	E	19.65	10.55	0.17	0.07
Strední Morava	E	18.04	7.02	0.18	0.06
Moravskoslezsko	E	14.21	5.95	0.13	0.05
Denmark					
Hovedstaden	W	75.45	47.87	0.15	0.09
Sjælland	W	113.52	61.83	0.38	0.20
Syddanmark	W	153.11	80.79	0.40	0.20
Midtjylland	W	144.05	94.32	0.37	0.23
Nordjylland	W	104.56	72.47	0.28	0.19
Germany (until 1990 former territory of the FRG)	W	0.00	0.00	0.00	0.00
Baden-Württemberg	W	0.00		0.00	
Stuttgart	W	126.33		0.31	
Karlsruhe	W	146.76		0.41	
Freiburg	W	206.65		0.69	
Tübingen	W	144.36		0.44	
Bayern	W	0.00		0.00	
Oberbayern	W	151.12		0.34	
Niederbayern					
Oberpfalz					
Oberfranken	W	240.11		0.89	
Mittelfranken	W	187.98		0.58	
Unterfranken	W	230.78		0.75	
Schwaben	W	345.83		1.15	
Berlin	W	74.64		0.26	
Brandenburg	W	101.34		0.48	
Bremen	W	44.11		0.11	
Hamburg	W	114.23		0.21	
Hessen	W	0.00		0.00	

Darmstadt	W	150.54		0.34	
Gießen	W	102.92		0.36	
Kassel	W	146.82		0.50	
Mecklenburg-Vorpommern	W	47.18		0.23	
Mecklenburg-Vorpommern	W	0.00		0.00	
Niedersachsen	W	0.00		0.00	
Braunschweig	W	31.55		0.10	
Hannover	W	117.53		0.39	
Lüneburg	W	196.66		0.92	
Weser-Ems	W	202.03		0.76	
Nordrhein-Westfalen	W	0.00		0.00	
Düsseldorf	W	173.66		0.51	
Köln	W	115.92		0.34	
Münster	W	184.92		0.67	
Detmold	W	188.70		0.62	
Arnsberg	W	145.92		0.53	
Rheinland-Pfalz	W	0.00		0.00	
Koblenz	W	272.70		1.04	
Trier	W	114.76		0.47	
Rheinhessen-Pfalz	W	171.28		0.59	
Saarland					
Saarland	W	0.00		0.00	
Sachsen	W	0.00		0.00	
Dresden	W	39.00		0.17	
Chemnitz					
Leipzig					
Sachsen-Anhalt	W	46.30		0.22	
Sachsen-Anhalt	W	0.00		0.00	
Schleswig-Holstein	W	133.57		0.52	
Schleswig-Holstein	W	0.00		0.00	
Thüringen	W	66.79		0.32	
Thüringen					
Estonia					
Eesti	W	19.67	6.23	0.16	0.05
Ireland					

Éire/Ireland	W	0.00		0.00	
Border, Midland and Western	W	75.85		0.25	
Southern and Eastern	W	52.68		0.11	
Spain	S				
Noroeste (ES)	S				
Galicia	S	10.76	12.01	0.05	0.06
Principado de Asturias	S	19.07	10.07	0.09	0.05
Cantabria	S	9.55	16.25	0.04	0.08
Noreste (ES)	S	0.00	0.00	0.00	0.00
País Vasco	S	34.14	28.69	0.11	0.10
Comunidad Foral de Navarra	S	54.05	30.76	0.18	0.11
La Rioja	S	36.75	14.38	0.14	0.06
Aragón	S	65.71	56.38	0.25	0.23
Comunidad de Madrid	S	23.23	22.00	0.07	0.07
Comunidad de Madrid	S	0.00	0.00	0.00	0.00
Centro (ES)	S	0.00	0.00	0.00	0.00
Castilla y León	S	13.85	10.70	0.06	0.05
Castilla-la Mancha	S	15.91	13.25	0.08	0.07
Extremadura	S	1.87	1.79	0.01	0.01
Este (ES)	S	0.00	0.00	0.00	0.00
Cataluña	S	50.27	37.41	0.18	0.14
Comunidad Valenciana	S	24.22	20.53	0.11	0.11
Illes Balears	S	24.49	26.23	0.10	0.11
Sur (ES)	S	0.00	0.00	0.00	0.00
Andalucía	S	6.18	9.47	0.03	0.06
Región de Murcia	S	19.28	23.48	0.10	0.13
Ciudad Autónoma de Ceuta (ES)	S	0.00	0.00	0.00	0.00
Ciudad Autónoma de Melilla (ES)	S	0.00	0.00	0.00	0.00
Canarias (ES)	S	5.84	9.51	0.03	0.05
Canarias (ES)	S				
France	W	0.00	0.00	0.00	0.00
Île de France	W	94.54	67.55	0.20	0.13
Île de France	W	0.00	0.00	0.00	0.00

Bassin Parisien	W	0.00	0.00	0.00	0.00
Champagne-Ardenne	W	64.02	82.87	0.23	0.30
Picardie	W	76.31	37.93	0.32	0.16
Haute-Normandie	W	90.98	65.32	0.33	0.24
Centre (FR)	W	65.70	51.73	0.25	0.19
Basse-Normandie	W	67.29	27.81	0.27	0.11
Bourgogne	W	85.13	57.81	0.32	0.22
Nord - Pas-de-Calais	W	62.29	43.07	0.25	0.17
Nord - Pas-de-Calais	W	0.00	0.00	0.00	0.00
Est (FR)	W	0.00	0.00	0.00	0.00
Lorraine	W	61.84	45.08	0.25	0.19
Alsace	W	125.19	77.94	0.43	0.27
Franche-Comté	W	52.09	34.88	0.21	0.15
Ouest (FR)	W	0.00	0.00	0.00	0.00
Pays de la Loire	W	80.74	49.21	0.29	0.17
Bretagne	W	79.68	56.81	0.30	0.21
Poitou-Charentes	W	57.01	40.85	0.23	0.16
Sud-Ouest (FR)	W	0.00	0.00	0.00	0.00
Aquitaine	W	53.96	33.06	0.20	0.12
Midi-Pyrénées	W	29.43	19.82	0.11	0.07
Limousin	W	53.69	45.08	0.22	0.19
Centre-Est (FR)	W	0.00	0.00	0.00	0.00
Rhône-Alpes	W	106.32	76.86	0.35	0.24
Auvergne	W	60.59	41.74	0.24	0.16
Méditerranée	W	0.00	0.00	0.00	0.00
Languedoc-Roussillon	W	22.01	19.71	0.09	0.08
Provence-Alpes-Côte d'Azur	W	61.83	41.98	0.22	0.14
Corse	W	2.74	27.29	0.01	0.10
Départements d'outre-mer					
Croatia		0.00	0.00	0.00	0.00
Hrvatska	S	0.00	0.00	0.00	0.00
Jadranska Hrvatska	S		4.81		0.05
Kontinentalna Hrvatska	S		2.11		0.02
Italy	S				
Nord-Ovest	S	0.00	0.00	0.00	0.00

Piemonte	S	80.15	46.44	0.27	0.17
Valle d'Aosta/Vallée d'Aoste	S	60.83	110.21	0.18	0.31
Liguria	S	79.61	42.04	0.26	0.14
Lombardia	S	125.67	70.45	0.36	0.20
Nord-Est	S	0.00	0.00	0.00	0.00
Provincia Autonoma di Bolzano/Bozen	S	220.41	223.37	0.60	0.56
Provincia Autonoma di Trento	S	65.88	29.80	0.19	0.09
Veneto	S	169.57	94.59	0.55	0.32
Friuli-Venezia Giulia	S	104.58	146.11	0.35	0.51
Emilia-Romagna	S	132.48	81.93	0.40	0.25
Centro (IT)	S	0.00	0.00	0.00	0.00
Toscana	S	80.83	50.92	0.28	0.18
Umbria	S	69.99	37.86	0.27	0.16
Marche	S	138.06	72.11	0.51	0.28
Lazio	S	26.97	14.21	0.08	0.04
Sud	S	0.00	0.00	0.00	0.00
Abruzzo	S	51.27	23.84	0.22	0.10
Molise	S	17.14	6.62	0.08	0.03
Campania	S	12.33	7.81	0.07	0.05
Puglia	S	20.34	12.37	0.12	0.07
Basilicata	S	15.06	19.29	0.08	0.10
Calabria	S	16.03	17.55	0.10	0.11
Isole	S	0.00	0.00	0.00	0.00
Sicilia	S	11.02	5.12	0.06	0.03
Sardegna	S	19.33	7.68	0.10	0.04
Extra-Regio NUTS 1	S				
Extra-Regio NUTS 2	S				
Cyprus	S	0.00	0.00	0.00	0.00
Kypros	E	33.45	6.75	0.15	0.03
Latvija	E	12.84	18.10	0.12	0.17
Lietuva	E	3.79	9.76	0.04	0.09
Luxembourg	W	93.68	84.50	0.12	0.10
Hungary	E				

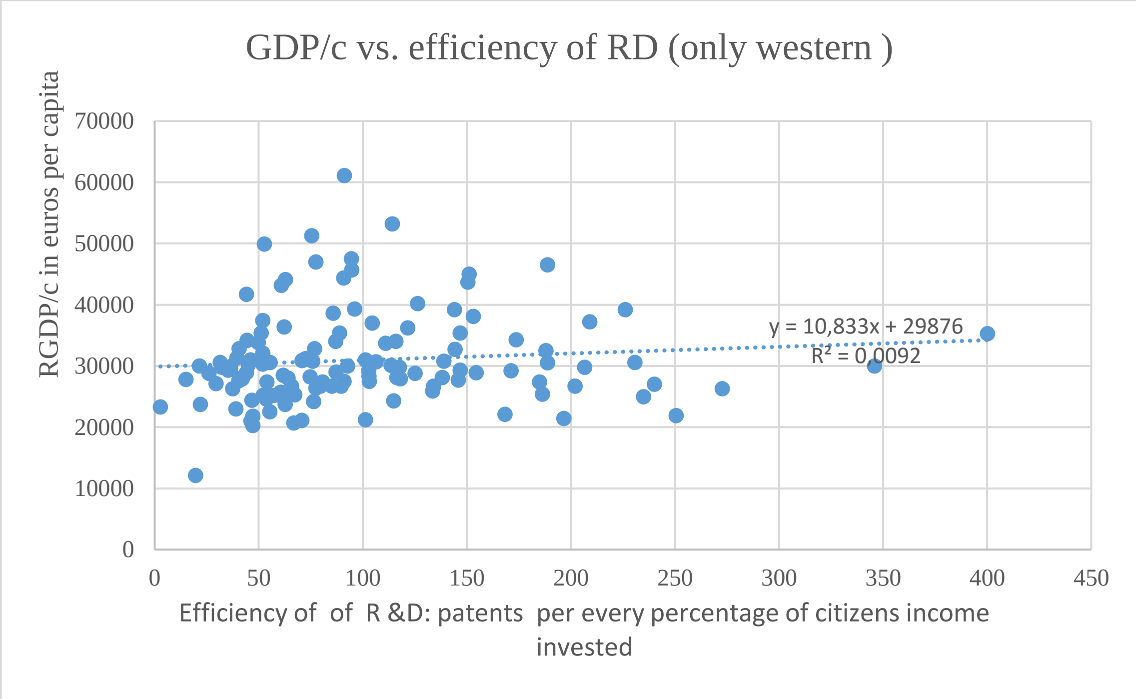
Közép-Magyarország	E	30.81	23.63	0.18	0.15
Közép-Dunántúl	E	15.98	8.96	0.17	0.10
Nyugat-Dunántúl	E	14.99	13.00	0.15	0.13
Dél-Dunántúl	E	32.89	6.49	0.48	0.10
Észak-Magyarország	E	28.32	4.85	0.44	0.08
Észak-Alföld	E	10.30	5.21	0.16	0.08
Dél-Alföld	E	15.75	14.80	0.24	0.22
Malta	S	22.47	11.14	0.16	0.06
Netherlands					
Groningen	W	60.87	24.23	0.14	0.04
Friesland (NL)	W	77.45	43.32	0.29	0.16
Drenthe	W	103.20	58.86	0.38	0.22
Overijssel	W	92.63	59.14	0.31	0.19
Gelderland	W	72.50	41.15	0.23	0.13
Flevoland	W	55.43	37.18	0.18	0.13
Utrecht	W	90.77	51.37	0.20	0.11
Noord-Holland	W	94.70	43.15	0.21	0.09
Zuid-Holland	W	96.12	63.03	0.24	0.16
Zeeland	W	138.17	103.83	0.49	0.35
Noord-Brabant	W	209.00	191.19	0.56	0.49
Limburg (NL)	W	138.96	91.71	0.45	0.29
Austria					
Ostösterreich					
Burgenland (AT)	W	168.39		0.76	
Niederösterreich	W	118.05		0.42	
Wien	W	62.82		0.14	
Kärnten	W	44.13		0.15	
Steiermark	W	51.90		0.17	
Oberösterreich	W	110.97		0.33	
Salzburg	W	226.18		0.58	
Tirol	W	88.80		0.25	
Vorarlberg	W	400.10		1.13	
Poland	E	0.00	0.00	0.00	0.00
Region Centralny	E	0.00	0.00	0.00	0.00
Lódzkie	E	11.64	24.68	0.15	0.26

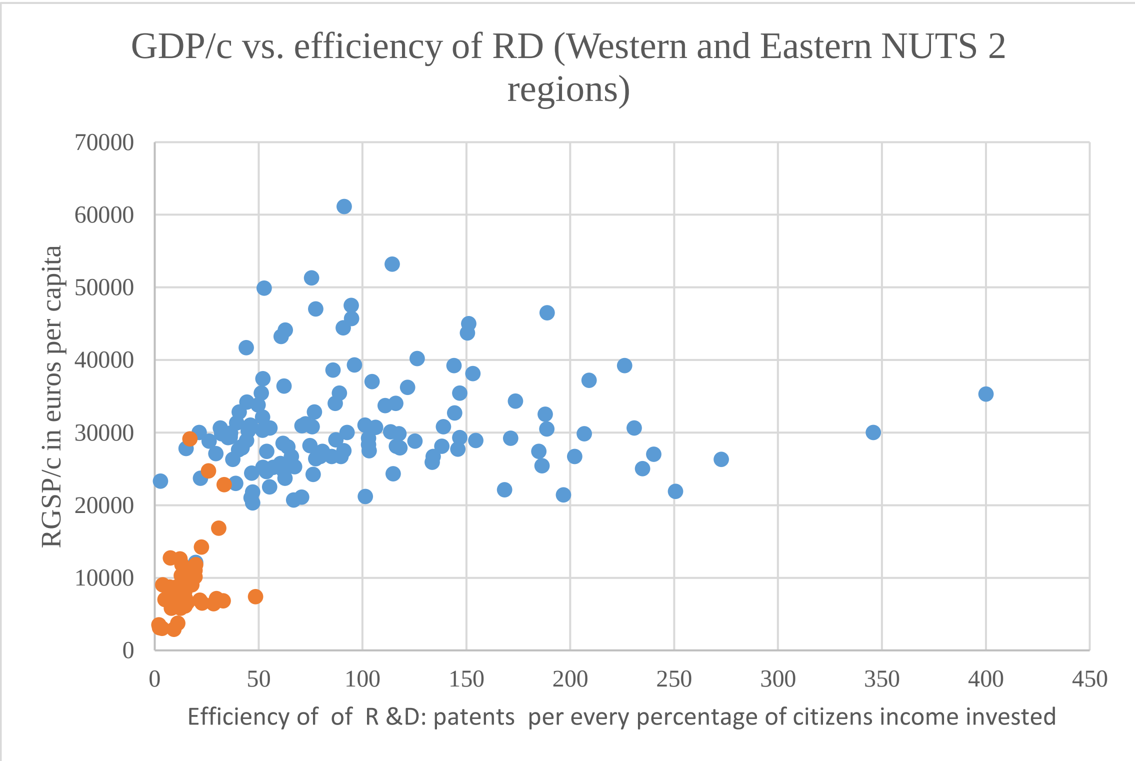
Mazowieckie	E	7.56	16.17	0.06	0.10
Malopolskie	E	8.99	13.89	0.12	0.16
Slaskie	E	7.20	12.63	0.08	0.12
Lubelskie	E	7.96	2.95	0.14	0.04
Podkarpackie	E	12.39	5.71	0.21	0.08
Swietokrzyskie	E	22.86	13.10	0.35	0.17
Podlaskie	E	14.63	2.61	0.24	0.04
Wielkopolskie	E	10.42	9.56	0.12	0.09
Zachodniopomorskie	E	11.71	21.38	0.16	0.25
Lubuskie	E	48.56	81.53	0.66	0.97
Dolnoslaskie	E	17.91	16.04	0.20	0.14
Opolskie	E	21.74	43.07	0.32	0.53
Kujawsko-Pomorskie	E	29.65	14.13	0.42	0.17
Warminsko-Mazurskie	E		4.50		0.06
Pomorskie	E	14.49	7.40	0.18	0.07
Portugal	S				
Norte	S	12.03	5.11	0.09	0.04
Algarve	S	25.68	8.93	0.15	0.06
Centro (PT)	S	8.08	9.05	0.06	0.07
Área Metropolitana de Lisboa	S	11.77	4.89	0.05	0.02
Alentejo	S	4.17	16.53	0.03	0.11
Região Autónoma dos Açores (PT)	S	10.05		0.07	
Região Autónoma da Madeira (PT)	S	0.68		0.00	0.12
Romania	E				
Nord-Vest	E	1.77	3.46	0.03	0.06
Centru	E	11.69	7.71	0.19	0.12
Nord-Est	E	0.29	1.12	0.00	0.00
Sud-Est	E		10.15		0.18
Sud - Muntenia	E	0.60	3.49	0.01	0.07
Bucuresti - Ilfov	E	4.51	14.21	0.03	0.09
Sud-Vest Oltenia	E	5.65	2.57	0.12	0.05
Vest	E	11.35	12.36	0.17	0.17
Slovenia	E				

Slovenija	E				
Vzhodna Slovenija	E				
Zahodna Slovenija	E				
Slovakia	E				
Bratislavský kraj	E	25.84	5.91	0.10	0.02
Západné Slovensko	E	19.38	20.17	0.19	0.16
Stredné Slovensko	E	9.67	3.01	0.12	0.03
Východné Slovensko	E	14.82	6.42	0.21	0.07
Finland	n				
Länsi-Suomi	N	60.37	68.77	0.19	0.20
Helsinki-Uusimaa	N		103.48	0.00	0.21
Etelä-Suomi	N		63.07	0.00	0.19
Pohjois- ja Itä-Suomi	N	39.41	40.08	0.14	0.13
Åland	N	306.20	315.67	0.75	0.69
Sweden	N			0.00	0.29
Stockholm	N	123.18		0.23	
Östra Mellansverige	N	85.87		0.25	
Sydsverige	N	94.15		0.26	
Västsverige	N	86.58		0.23	
Norra Mellansverige	N	76.19		0.24	
Mellersta Norrland	N	127.58		0.39	
Övre Norrland	N	62.97		0.18	
United Kingdom					
North East (UK)					
Tees Valley and Durham	W	46.70	36.76	0.19	0.17
Northumberland and Tyne and Wear	W	42.09	54.60	0.15	0.22
Cumbria	W	116.28	53.02	0.41	0.19
Greater Manchester	W	46.09	38.88	0.15	0.14
Lancashire	W	15.05	23.34	0.05	0.10
Cheshire	W		14.94		0.04
Merseyside	W		32.38		0.14
East Yorkshire and Northern Lincolnshire	W	154.53	26.60	0.53	0.11
North Yorkshire	W	76.81	34.01	0.23	0.12

South Yorkshire	W	37.52	25.78	0.14	0.11
West Yorkshire	W	70.83	41.47	0.23	0.15
Derbyshire and Nottinghamshire	W	41.50	27.31	0.15	0.11
Leicestershire, Rutland and Northamptonshire	W	51.94	48.08	0.16	0.17
Lincolnshire	W	186.32	209.70	0.73	0.89
Herefordshire, Worcestershire and Warwickshire	W	44.95	22.22	0.15	0.08
Shropshire and Staffordshire	W	89.57	81.64	0.34	0.34
West Midlands	W	32.25	46.25	0.11	0.18
East Anglia	W	40.58	27.73	0.12	0.09
Bedfordshire and Hertfordshire	W	52.01	33.15	0.14	0.10
Essex	W	21.44	23.78	0.07	0.09
Inner London -					
Outer London -					
Berkshire, Buckinghamshire and Oxfordshire	W	77.53	47.47	0.16	0.11
Surrey, East and West Sussex	W	121.65	76.13	0.34	0.22
Hampshire and Isle of Wight	W	51.23	37.74	0.14	0.11
Kent	W	26.11	15.61	0.09	0.06
Gloucestershire, Wiltshire and Bristol/Bath area	W	62.20	62.93	0.17	0.19
Dorset and Somerset	W	102.89	61.82	0.35	0.23
Cornwall and Isles of Scilly	W	234.81	159.19	0.94	0.67
Devon	W	40.34	34.61	0.15	0.14
West Wales and The Valleys	W	47.19	53.74	0.22	0.26
East Wales	W	39.44	26.78	0.13	0.10
Eastern Scotland	W	44.38	44.74	0.13	0.15
South Western Scotland	W	36.44	14.30	0.12	0.06
North Eastern Scotland	W	188.79	63.85	0.41	0.13
Highlands and Islands	W	36.38	41.50	0.12	0.15
Northern Ireland (UK)	W	35.28	24.37	0.12	0.10

Appendix B: Comparison of efficiency of Western and Eastern EU NUTS 2 regions





Red – Eastern EU NUTS 2 regions

Blue- Western EU NUTS 2 regions