CHARLES UNIVERSITY IN PRAGUE

FACULTY OF SOCIAL SCIENCES

Institute : Russian and East European Studies

Master thesis
Innovation Benefits from European Union Ascendancy: An Econometric Analysis

Master thesis
Prague 2016
Author: Lisa Nguyen

Supervisor: Michal Paulus, Fellowship at Charles University; Dr. Eugene Nivorozhkin, PHD University College London

Academic Year: 2012/2013
Bibliographic note


Abstract

This paper investigates the benefits of joining the European Union (EU) and its impact on innovation for two indicators: patents and R&D expenditure. Based on a sample size of 27 countries within the EU observed over the time period 1996 to 2013 and utilising the GMM, FE and OLS models, I showed that, overall, entry into the EU has provided substantial benefits. Nevertheless, not all of the indicators of EU benefits are significant and sometimes did not provide positive impact on innovative activities. My evidence also suggests that with a further breakdown into two different regions, Western and Eastern Europe, there is a further rift in gains. Financial integration, for starters, has had a negative impact on innovation for both Western and Eastern Europe. Nevertheless, for the entire EU, financial integration has a positive impact on the number of patents filed. I also showed that another benefit of joining the EU, free movement of labour, has a negative and significant effect on both innovative indicators. This is consistent with the idea not all benefits of the EU provide a positive impact on innovation. Further research is warranted due to the insufficient time period.

Abstrakt

Tato práce zkoumá přínosy vstupu do Evropské unie (EU) a jeho dopad na inovace u dvou indikátorů: výdaje na patenty a výzkum a vývoj (R&D). Na základě vzorku o velikosti 27 zemí v rámci EU pozorovaného v období od roku 1996 do roku 2013 a s využitím modelů GMM, FE a OLS jsem prokázal, že vstup do EU celkově přinesl podstatné výhody. Nicméně ne všechny indikátory výhod EU jsou významné a někdy neměly pozitivní dopad na inovativní aktivity. Mé důkazy také naznačují, že při dalším rozpadu na dva regiony, západní a východní Evropu, dochází k dalšemu rozdělení přínosů. Finanční integrace, pro začátek, měla negativní dopad na inovace v západní i východní Evropě. Nicméně v rámci celé EU měla finanční integrace pozitivní dopad na počet podaných patentů. Prokázal jsem také, že další z výhod vstupu do EU, volný pohyb pracovních sil, negativně a významně ovlivnil oba inovativní indikátory. To je v souladu s myšlenkou, že ne všechny výhody EU představují pozitivní vliv na inovace. Je nutný další výzkum z důvodu nedostatečného času.
Klíčová slova

Inovace, výdaje na patenty, výzkum a vývoj, Evropské unie, FE, OLS, GMM

Keywords

Innovation, European Union, Migration, Financial Liberalisation, R&D Expenditure, Patents

Range of thesis: 104 pages, 24757 words, including bibliography; 22424 without

Declaration of Authorship

1. The author hereby declares that she compiled this thesis independently, using only the listed resources and literature.

2. The author hereby declares that all the sources and literature used have been properly cited.

3. The author hereby declares that the thesis has not been used to obtain a different or the same degree.

Prague: 08.05.2016
Acknowledgments

Lisa would like to acknowledge gratitude towards her parents for providing her during her studies abroad. I would also like to thank my supervisor, Professor Michal Paulus, for his numerous help during my dissertation. I would like to especially thank Doina Chiselita, Laura Elvire Van Siclen, Mei Chen, and James Pepper for keeping me sane during this time period.
Table of Contents

Introduction.................................................................................................................. 13
Chapter 1: Theoretical Literature.................................................................................. 15
  1.1 European Union and Benefits of Integration....................................................... 15
  1.2 Schumpeter’s Theory on Finance & Innovation.................................................. 17
  1.3 The Change in link between finance & innovation during the 1990s................. 18
  1.4 Financial Integration & Innovation Theory....................................................... 19
II b. Changes & Differences in Innovation: Time & Region...................................... 21
  2.1 Patents & Innovation......................................................................................... 21
  2.2 Patents & Financial Integration......................................................................... 23
  2.3 R&D Expenditure and its effects upon number of patents filed....................... 25
II c. European, Western Europe & Eastern Europe.................................................... 26
  1 Europe’s Innovation............................................................................................... 26
  2. Central Eastern Innovation................................................................................... 28
II d. Innovation & Generalised Method of Moments, Fixed Effects and OLS........... 32

Chapter 2: Data & Data Description............................................................................ 33
Chapter 3: Methodology.............................................................................................. 43
  3.1 Estimation of innovation function ...................................................................... 43
Chapter 4: Results....................................................................................................... 50
  1.1 European Union Results for Patents and R&D Expenditure......................... 52
    4.1.1 Has Joining the EU have an impact on Patents ......................................... 52
    4.1.2 The impact of ascension on the EU on R&D expenditure ....................... 52
    4.1.3 Correlation Test......................................................................................... 55
  2.1 Western Europe ................................................................................................. 58
    4.2.1 Western Europe & Patents ........................................................................ 60
    4.2.2 Western Europe and R&D Expenditure .................................................... 62
    4.2.3 Correlation Test......................................................................................... 65
  3.1 Central & Eastern Europe Innovation Indicators .............................................. 63
    4.3.1 CEE & Patents Filed.................................................................................. 67
    4.3.2 CEE & R&D Intensity .............................................................................. 71
    4.3.3 Correlation Test ......................................................................................... 73

Chapter 5: GMM: Sargan & Arellano Bond-Estimator Tests..................................... 74
  5.1 Arellano-Bond Estimator for Europe ................................................................. 75
  5.2 Arellano-Bond Estimator for Western Europe ................................................... 77
  5.3 Arellano-Bond Estimator for Central Eastern Europe ...................................... 79
Chapter 6: Discussion .......................................................... 80
Chapter 7: Conclusion .......................................................... 84
Bibliography ........................................................................... 86
Appendix .................................................................................. 94
Appendix 1: Data Sources ......................................................... 94
Appendix 2: Breusch-Pagan Test .............................................. 94
Appendix 3: Hausman Test ....................................................... 96
Appendix 4: Sargan Test .......................................................... 101

List of Formula Content
Financial Development
Financial Integration (IFIGDP) .................................................. 38
Portfolio Debt (IEQ) ............................................................... 41
Archen's Lagged Dependent Variable ........................................ 46
Cobb-Douglas Technology ...................................................... 46
R&D Expenditure .................................................................. 46
Patents ................................................................................... 47

List of Tables
Table 1: Summary Statistics ..................................................... 45
Table 2: All Countries within EU & Innovation Indicators – Patents 52
Table 3: Countries within the EU & Innovation – R&D Expenditure. 55
Table 4: Western Europe & Patents Result ................................ 60
Table 5: Western Europe & R&D Expenditure .......................... 62
Table 6: CEE Patents Filed ..................................................... 67
Table 7: R&D Expenditure ....................................................... 71
Table 8: European Union Estat Test for R&D .......................... 76
Table 9: Estat Exam for Number of Patents Filed ...................... 76
Table 10: R&D Expenditure within Western Europe ABOND Test ...... 77
Table 11: Western Europe Patent Estat Abond Test ................. 78
Table 12: CEE’s Linear Dynamic Panel-Data Estimation R&D Expen...

List of Figures
Figure 1 : Patents ................................................................ 22
Figure 2: R&D Expenditure (% of GDP) .................................... 29
Figure 3: Western & CEE patents in term of US Patents ............ 31
Figure 4: Value Added Chain .................................................. 32
Figure 5: R&D Expenditure Differentiation between countries ..... 35
Figure 6: Trade Openness ....................................................... 37
Figure 7: IFIGDP for Eastern Europe ....................................... 39
Figure 8: IFIGDP for Western Europe ...................................... 39
Figure 9: International Equity Portfolio for Eastern Europe ....... 41
Figure 10: International Equity Portfolio for Western Europe ...... 42
Figure 11: Correlation Table for European Union ..................... 58
Figure 12: Western Europe & Correlation ................................ 65
Figure 13: Variables within CEE & Correlation .......................... 73
I. Introduction

After World War II, there was political disintegration within various countries. Countries that did not exist prior to the 1945 came into being. However, the opposite situation has occurred, where political and economic unity has also taken place been occurring. Numerous states have banded together to integrate both politically and economically, thereby, creating the entity called the European Union. The original concept for the creation of the European Union was for peace, which then changed into a customs union and common market and finally, transitioned into a single market in 1993 as the EU. When political integration occurred, nation states had to concede numerous traditional sovereign powers (i.e. monetary policies) and delegated control over certain competencies, such as antitrust and external trade policy, over to the European Union (Ruta, 2011).

After the great wake and instability that was brought forth by the Financial Crisis in 2008 and the Eurozone Crisis, many have begun doubting the benefits of joining and remaining in the European Union. There has been a rise in nationalism and increasing demands to leave the European Union. Due to this rise, we would like to study the benefits of joining the European Union and how it has increased the level of innovative projects.

Joseph Schumpeter (1912) defines innovation in the three following ways:

1. The inception of a contemporary commodity – one in which consumers have not yet been familiarised with – or of an advanced quality of a previous familiar good.
2. The installation of an ameliorated or better method of assembly, which doesn’t need to be discovered in a new scientific manner. (Schumpeter, 2004).

There have been some researchers who have hypothesised that the purpose of political integration is a way to deepen the markets if economic integration is not viable. Brou & Ruta (2007) disagrees and postulates that economic and political integration are complementary forces to each other. The authors argue that, holding all other variables constant and equal, political integration actually makes competition within both the
political and economic markets malleable and thusly, will have an impact on innovation (Ruta, 2011).

We do so by implementing Hausman et. al’s (1984) methods, but with some minor changes. Instead of running the Poisson model, we decided to switch it with a GMM-diff to control for the various countries’ fixed effects. Additionally, after performing the Hausman test to gauge which model should be used, fixed or random effects, our results came out to be fixed instead of random, which is different from the Hausman study. Additionally, we ran the ordinary least square (OLS) as a check to ensure that our GMM results were in-lined. Our results indicate that for the lagged variables, our GMM results are consistently higher than the OLS coefficients, whilst the fixed effects estimators remain consistently estimated downwards. We were not able to include an instrumental linear regression due to time and paper constraints.

Unfortunately, we were not able to compare and contrast the impacts of Western Europe’s and Eastern Europe’s ascension to the EU because of the different time periods of their entry. The majority of Western Europe joined during the 1980s, while most of the Central Eastern European countries joined during 2004. Moreover, the large deficit of numbers caused the number of observation to decrease even further after the removal of missing/incomplete data. Therefore, we are not able to study the full effects of the impact of Western Europe joining the European Union and its influence on innovation; especially for patents and R&D expenditure indicators.

Although there have been numerous papers addressing the benefits of financial integration, there has been a dearth of literature on the benefits joining the EU and its impact on innovation. Many would assume that numerous studies would have been done before because of the vast amount of literature on the benefits of openness to trade, the single market and the euro, but this is vastly untrue. Due to the inefficient time period and incomplete data from multiple data sources, most literature has used a theoretical framework instead of an empirical framework.

The main findings of our paper is that both political and economic integration has benefitted innovation within the whole of the European Union. Although our lags for
patents and increases in R&D expenditure, whilst in the EU, suggest there was an increase in the number of patents filed and an increase in R&D expenditure. Financial integration and an increase in knowledge stock has a positive effect on patents. Nevertheless, the results differ with R&D expenditure for the member states of the European Union, where financial integration has a negative impact on R&D expenditure rather a boon. Altogether though, with the exception of Central Eastern Europe’s number of patents filed, all of our ascension into European Union variables were insignificant and would need further research.

However, when we delineated the member states within the EU into two main regions, Western and Central Eastern Europe (CEE), our results drastically changed. Although the 1st and 2nd lag of the patents are positive and significant, the two benefits of EU integration – financial integration and the free movement of labour – have a negative impact on patents filed. Conversely, for R&D expenditure, our 1st lag yields a positive effect whilst the 2nd lag has a negative effect. This could stem from the increase in financial integration that lead to a negative effect on R&D expenditure. Additionally, openness to trade also has a harmful impact on R&D expenditure. Upon further research, it could stem from a lack of unity for intellectual property rights within the 27 nation states, and ergo a failure of political integration. The increase of knowledge stock yields a positive effect on the number of patents filed within CEE, whilst entry into the European Union has a negative effect.

The paper is organised as follows: Section 2 discusses the theoretical framework of economic and political integration. Section 3 exhibits the literature review, which contains previous literature that supports our findings and methodology. Section 4 introduces our data and our description. Section 5 discusses our methodology whilst Section 6 indicates our findings. Section 7 contains various tests to ensure that there are no over-restrictions and proper usage of our models and instruments. Section 8 is our discussion on our findings. Section 9 is the wrap up.

**Chapter 1: Theoretical Framework**

We chose to demarcate our theoretical framework into four main sections: (1) the links between finance, financial integration and innovation; (2) patents and innovations &
their effects on one another; (3) Innovation within the European Union, Western Europe and Eastern Europe; (4) Findings of GMM-difference and/or GMM-system, Fixed Effects/Random Effects and OLS model. By doing so, we hope it will be easier to follow.

**Linkage between Finance, Financial Integration & Innovation**

**1.1 European Union and the Benefits of Integration**

The single market is the centre of the European Union economic integration plan. The single market guaranteed the free flow of capital, labour, goods, and services within the European Economic Area, and has been continuously modified. Research has shown that, overall, entry into the EU has increased GDP by 2-3% (Vetter, 2014). Additionally, membership into the European Union (EU), especially for larger and developed countries, has a positive impact on the overall average salary, except for one - Greece (Campos, Coricelli and Moretti, 2014). The more financially developed a country is, the higher the likelihood of growing faster after joining the EU (Campos, Coricelli and Moretti, 2014). According to the author’s findings, Denmark, Ireland, UK, Portugal, Poland, Hungary, Estonia and Latvia have benefitted the most from entry into the EU. Spain, Austria, Finland, Sweden, Slovenia, Czech Republic, Slovakia and Lithuania have also received benefits, but less than the aforementioned countries. Only Greece has received negative benefits, in terms of lower level of GDP per capita, over entry into the EU (Campos, Coricelli and Moretti, 2014). Nevertheless, if the 27 countries did not join the EU, their overall GDP per capita, in terms of salary, would have been 12% lower (Campos, Coricelli and Moretti, 2014). According to the author’s findings, the older member states received positive benefits from the single market, whilst the newer member states received the most gains from joining the Euro.

Brou & Ruta concurred with Martin et. al's (2010) findings, where Martin et. al (2010) believed that political and economic integration should occur alongside each other. Brou postulated that when economic integration is not furthered alongside with political integration, it can lead to a reduction of innovative activities and slower economic growth because firms respond to competition by focusing on rent-seeking (2012).
Nonetheless, when political and economic integration accompanies one another, innovation and economic growth will increase (Ruta, 2011).

Baldwin (2008) & Seghezza’s (1996) results showed that European integration has enhanced European economic development, since trade liberalisation increased investment within Europe. Similarly, Batiz and Romer (1991) argued that economic integration for nations with comparable income per capita tends to lead to long term economic growth if there is also an increase within technology R&D. In essence, the effects of economic integration depend upon certain transmission channels which may lead to long-term advancement that can either come from an inflow of tradable goods or ideas (Ventura, 2005).

Trade theory asserts that with a closer integration between advanced economies that are comparable with one another, goods and services tend to converge with one another. Suppliers, in trying to differentiate themselves from their newly arrived challengers, are then forced to differentiate themselves from each other and to grow in a way to respond to a more sophisticated consumer palate. By enlarging the EU in 2004, there was an increase in FDI and remittances of migrants, which then lead to risk-sharing and promotion of a higher level of country specialisation and efficiency within the EU (Marco Buti, 2009).

According to Buti (2009), because of the way European countries chose to integrate with one another through various policies and institutions, such as the Stability and Growth Pact, the Lisbon agenda, Single Market rules and the EU transfer system, the benefits of EU enlargement went beyond the limits of the normal benefits of economic integration. Due to rapid financial integration, cheap foreign investment led to an increase and the further deepening level of finances within these countries. The households within these countries could exploit new investment opportunities within productive sectors, but can also increase their consumption and raise their housing investment.

1.2 Schumpeter’s Theory on Finance & Innovation
Schumpeter's "Theory of economic development" (1934) is an important frontrunner in reference to the topic of finance and innovation. Schumpeter extolled the key role of entrepreneurs in the progression of development and innovation. In his opinion, competitive development within capitalist economies was bound to lead to an efficient usage of existing assets. Nevertheless, innovation, in turn, required large amounts of capital that entrepreneurs or individual entrepreneurs could not straightforwardly afford. Access to finance was thus central in his view to the dynamics of innovation.

Thusly, this helped established the linkage between finance and innovation. Finance was supposed to be used to support innovations, especially innovations that required a substantial new investment and were operated by new entrepreneurs who were setting up new companies.

Nevertheless, Schumpeter mark II was conceived after the changes in the US before World War II and in Europe after World War II. After WWII, the creation of R&D departments within large firms, especially the designing and planning part of innovation, was created. Hence why, Schumpeter revised his theories on finance and innovation in *Capitalism, Socialism and Democracy* (1934). The role of finance had become more intricate in a post-World War II world. Large companies had various ways of gaining more finance; this could range from self-financing, to borrowing and/or to issuing stocks.

Nevertheless, the Schumpeterian theory on the linkage between finance and innovation in the reverberation of the 1970s and the crisis of capitalism became archaic (Petit, 2009, p.7). There has been a deficit within this literature as noted by Petit (2009). Hence why two streams of theory came about to fill this vacuum. On one side, Petit notes, “the study on innovation came about and was developed, outlining new patterns of innovation more interactive, combining various actors and taking into account various processes” (Petit, 2009, p.7). These studies were more focused on innovation structures that were advanced by small and large firms. On the other hand, this theory focused more on Schumpeter II and took on a more general and ideological view. Petit opines, “It stated that, in a competitive process that is increasingly based on non-price
competition, innovation plays a key role that liberalisation of all product markets can efficiently boost” (Petit, 2009, p.8).

1.3 The Change in linkage between finance & innovation during the 1990s

With the advent of the information communication technology age (ICT), there was a techno-economic paradigm shift in most of the organisations and their departments. Nevertheless, the diffusion of ICTs with a growth of multinational and large firms does allow for a contemporary intersection between established finance and innovation. Financial liberalisation and the internationalisation within economies have changed and outgrew the different methods for financing innovation. Petit opined that “The new financial and liberalised capitalism that emerged in the 1990s has indeed led to new rules of governance at odds with the kind of long term investment that financing of innovation requires” (Petit, 2009, p.10). The change in finance became more prominent as shareholder value became one of the most critical criteria for governance for firms listed on stock markets. Short term results that increased shareholder value and worth became extremely important. Although, innovation was motivated by competition within the global economy, developing countries and low wage countries contains most of the manufacturing, and therefore should give rise to innovation. Internationalisation also provides boons such as aggregating the numerous and various types of research and development.

With the onset of the ICT age, the outdated model, where R&D departments of large corporations played a decisive role in innovation, both in terms of product and the process, transformed drastically because of the growth from the ability to pool together resources on a global level. Externalisation can be defined as the various ways of acquiring and selling patents, subcontracting of different types of assignments, creating a joint venture, cooperation, et cetera, and can be defined as the linear model of R&D.

The transformation of the R&D model became known as “open innovation”, whereby, the knowledge and creation of inventions by public resources can then be sold to multinationals or kept within the country.

1.4 Financial Integration & Innovation Theory
A common supposition within financial integration literature is that it should help speed up financial development in emerging countries, thereby, allowing for a convergence between emerging markets and developed. Voltz postulated that financial integration is expected to advance and promote the efficiency of financial intermediaries and markets (Volz, 2004, p.2)

Thusly, financial integration can help improve resource allocation from less efficient markets and industries to more efficient markets and industries. One of the crucial methods that integration can affect innovation is through institutions. According to Gregersen and Johnson, institutions can affect innovation through these ways “creation, storage, distribution, use and destruction of knowledge since they shape the cognition, the visions, and the patterns of communication and interaction of economic agents” (Gregersen and Johnson, 1996, p.1). Integration shapes the development of institutions within the economies who are participating in the activity and, therefore, affects the development of learning and innovation.

Innovation can be broadly defined as not only including core innovation, such as new types of production of new technologies, but also the processes and actions that bolsters knowledge transfers and adaption of the production process. As the world becomes more globalised, foreign institutions may enter foreign countries via through penetration or cross-border acquisitions of intermediaries and/or creation of joint ventures. Domestic enterprises are then forced to either cut costs and/or restructure organisations.

Knowledge and resource allocation plays an important part in driving innovation activity, hence why the financial system plays a crucial role in investments and in promoting inventions. There are two different types of knowledge – tacit and codified knowledge. Tacit knowledge is sticky knowledge and is unable to flow pass borders for neither country nor firms. According to Karlsson and Johansson (2005), knowledge remains tacit if it is complexed or mutable in quality; for instance, social relationships, skilful manual labour, or situations where several various components of human senses is crucial and necessary at the same point. At firm level, productivity levels are different within each industry, hence the financial system must be able to allocate and to re-direct capital from slower-growing to faster-growing enterprises.
Technological progress is predicated on “purposeful ways” to create new technology or, notably within emerging countries, by acclimating to existing technologies developed abroad (Lane, 2009, p.3). Furthermore, the conversion of extant technology is expensive hence making local R&D activity more necessary. If technological advances are incorporated within new companies, a financial system that is able to buttress early-stage growth is predicated.

There is growing number of studies that show, under certain conditions, international financial integration can help deliver a higher level of productivity, which is a driving force for longer and higher quality of living standards. Financial integration can entail two types of integration: equity-type and debt-type. Philip Lane (2009) studied the link between international financial integration and the level of innovation. Lane’s (2009) research indicates that, based on the level of development within a country, more integrated economies do exhibit higher levels of innovation activity.

Recent studies have indicated that international financial integration may be useful, due to financial globalisation expanding the development of indigenous financial systems within incipient countries. In addition, innovative activities can be exacerbated by the arrival of foreign investors.

With the advent of foreign investment and international financial integration, the gains may not be evenly dispersed across the various types of cross-border investment financing. Evidently, equity-type of investments (FDI or portfolio equity) are dissimilar to debt-type investments (bank loans and deposits or portfolio debt) (Lane, 2009, p.4).

Integration of national financial markets is founded on a broader force of worldwide integration of different economic apparatus within the formation of a single European market. The single market programme within the EU and financial liberalisation, including technological advancement and data management, puts a growing competitive pressure on financial institutions. An augmentation of international trade and investment is associated with closer economic and financial integration, thusly creating opportunities and growth for financial innovation. Financial innovation can also entail
improvements in technological advancement, especially within the areas of communication (Ernst Baltensperger, 1994, p. 2).

II b. Patents and R&D Expenditure & Its Effects On One Another

2.1 Patents & Innovation

Patents play an increasingly important role in innovation (OECD, 2004, p. 1). It allows for an observable measure for both public and privately-held organisations. Between 1996 and 2014, the number of patents filed by Western and Eastern Europe, into the World Intellectual Property Organisation (WIPO), has increased by more than 119.2% and 320.8%, respectively. Figure 1 depicts the growth of patents over the last 19 years in Europe.

Figure 1: Patent filings at the WIPO

The increased usage of patents has grown drastically over the last century, especially for the protection of trade secrets for businesses and public research publications (OECD,
The drastic increase of patents stemming from innovations, especially those from the fields of science, biotechnology, and telecommunications and information technology, has become less dependent on individual firms and rather more centred on cooperation between private and publicly held institutions. With global regulatory shifting to guarding intellectual property rights and a fundamental shift in the usage of a more expansive domains for patentable contents matter.

The changes in regulatory protection for patents has caused a shift in the OECD countries over the past two decades to foster the usage and safeguard of patents to encourage investments in innovation. The protection and dissemination of patents has grown over the past two decades. The growth in patenting correlates with a contemporary type of research where research is not dependent on individual firms, but instead is more reliant upon the knowledge apparatus and markets; where the innovation process within the OECD countries have become more competitive and have become more reliant on the new arrivals and technology based firms (OECD, 2004, p.7).

If policy makers choose to look at the role that patents have played on innovation, it can be seen that patents are supposed to help cultivate innovation within the private sector by granting inventors the right to profit off of their inventions. Empirical studies have shown that there is acknowledgment of the effectiveness of patents in supporting innovation. According to the OECD (2004), “In a series of surveys conducted in the US, Europe and Japan in the mid-1980s and 1990s, respondent companies reported patents as being extremely important in protecting their competitive advantage in a few industries, notably biotechnology, drugs, chemicals and, to a certain extent, machinery and computers (OECD, 2004, p.8).

Nevertheless, there are disadvantages to patents because they do not allow for the quick dissemination of knowledge within the public sphere. It can also hamper innovation and competition. If there are too many broad protections on basic inventions, this can also discourage inventors. For example, if the holder of the patent decides to hold off permission to his/her technology under equitable conditions. In addition, patents are, in essence, an interim monopoly, where the patent holder can set a higher market price than others would be willing to pay for and, therefore, limit the volume of sales.
2.2 Patents & Financial Integration

Europe has been lagging behind other parts of the world in terms of innovation. Johansson, Karlsson and Backman stated that, “The most important aspect is possibly the progress of becoming a knowledge economy which at the point has been slow in the EU…The main picture is a lack of investments in R&D, internet penetration and so forth” (Johansson, Karlsson, and Backman, 2010, p.3).

The Lisbon Agreement was enacted in 2000 and is a ten-year plan. The purpose of the Lisbon Agreement was to ensure that the EU becomes the most competitive, knowledge-based economy in the world, yet at the same time preserve and improve social cohesion. One of the main instruments of the Lisbon Agenda is to analyse innovation policies where R&D can be further enhanced.

International competitiveness in research can be augmented by worldwide cooperation in primary research areas where collaboration has been found to be fruitful. In addition, competition is proven to be a viable way to enhance and to improve inventions.

To ensure that innovation prospers, many different components are needed. Johansson et. al stated, “There must be (i) science, both hard and soft aspects; (ii) product development, with technological and social aspects; (iii) entrepreneurship, which plays a vital role (Johansson, et. al, 2010, p.4). There would be small to non-existent incentives for firms to innovate if people could dissipate the technology disparity within regions (Lundvall and Borras, 1997).

When new policies are enacted within the EU, both vertical and horizontal integration must be considered. Concerning innovation, vertical integration must be used because national and regional instruments must be reconciled with the new policy (Johansson, 2010, p.6). Nevertheless, the EU has serious problems with knowledge outflow from universities to the small number of university spinout corporations (Klomp and Roelandt, 2004). According to Johansson (2010), there is a multitude of variation within the NIS system in the EU for incentivising and creating patents for various universities. Numerous member states have weak enticements to commercialise their inventions.
Competition has a positive effect on innovation. Nevertheless, the incentives of an interim monopoly can be a strong deterrent for innovation. Recent literature on sequential innovation has argued that innovation should be “sequential” and “complementary”, and that patent protection is not useful for the overall betterment of society. Instead, advocates of “sequential” and “complementary” have argued that society and inventors may be better off without said protection. It is their belief that inventors may instead receive more profit from the creation of more patents because of the boost from competition. A “sequential” innovation is one that with “each successive invention builds in an essential way on its predecessors” and “complementary” when “each innovator takes a different research line” (Bessen & Maskin, 2009).

Bessen et. al. (2009) opined that the some of the most influential patents could be traced to the last forty years. An experiment entailing the software industry in the US occurred during the 1980s and 1990s. After a series of court decisions, software patent protection increased and was strengthened. Nevertheless, instead of spurring software innovation, the firms that had purchased the software patents decreased R&D expenditure relative to sales (Bessen & Mashkin, 2009, p.2). For industries such as software and hardware, there have been some theoretical research that have suggested imitation actually increases innovation, such as in the case of open source, and that strong patent protection actually inhibits change.

Innovation does have a spill-over effect, whereby, corporations can garner knowledge from their competitors’ R&D efforts. Therefore, the larger the spill-over exposure, the desire to innovate decreases. With fewer challengers, there will be less free-loaders, whereby, the inducements from innovation increases because the returns will be larger from their own R&D.

Knowledge flows have numerous and diverse characteristics, and thusly can include (1) transactional based and transactional related, or (2) knowledge spill-overs (Karlsson and Johansson, 2006). Nevertheless, knowledge tends to be tied within space and is harder to transfer over. Some studies have indicated that Europe needs to expand and increase its transportation infrastructure to improve the availability to new knowledge gathered.
outside the cities, and to improve and expand European knowledge ties with one another. Another way to speed up knowledge transfer could be to increase the speed of ICT devices to ensure a higher mobility for researchers and politicians (Lynee G. Zucker, 1998).

2.3 R&D Expenditure and its effects upon number of patents filed

Geisler (1994) opined that R&D research can be delineated into three main areas: input-based, output-based, and input-output-based. Where innovation output can be described as knowledge creation, enhancement of production and development of new devices. Nevertheless, R&D research has a certain degree of uncertainty where that it is not as clear, nor as measurable, as other indicators of innovation. In addition, its results would not be seen until years have passed if there are any gains.

Masayuki (1999) utilised four different models for patent application with R&D expenditure, as an output and input respectively, where his results indicate that the linear dynamic model has the highest coefficient of R&D expenditure. This result, thereby, shows the large influence R&D expenditure exerts on both patent applications and knowledge base. Furthermore, the result also implies that patent application rises in proportion to R&D expenditure. Prodan (2005) agrees with Masayuki’s (1999) overall results where the logarithmic model depicts a worse performance in comparison to the linear regression. Moreover, his main hypothesis is that the number of patent applications should rise if a country chooses to promote R&D within the business sector.

Within cross-sectional and time-series models, the most straightforward method for measuring knowledge-based stock is by utilising current and past R&D investment and utilising patents as an output measure for innovation. Numerous researchers have shown that with cross-sectional panel data, the patent and R&D relationship is strongly correlated and highly significant with one another. Nevertheless, this correlation drastically decreases with a time series model. According to Danguy, Rassenfosse, de la Potterie (2009), although the relationship with R&D expenditure does influence patents, it is less than what is to be expected. Levin et al. (1987) postulates that some industries rely more heavily on the number of patents filed, but file fewer patents in comparison to
other sectors with weaker protections for patent protection. Griliches concludes that “it is misleading to interpret such (patent) numbers as indicators of either the effectiveness of patenting or the efficiency of the R&D process” (Griliches, 1990, p. 27). Danguy et al. (2009) postulates that research productivity matters and elucidates part of the deviation in the patent-to-R&D ratio over time, in that, “If the long-term elasticity of patents with respect to R&D expenditures of about .12 is much lower than in cross-country or cross firm estimates, it is nonetheless significant, suggesting that more R&D leads indeed to more patents” (Jerome Danguy, 2009, p. 172).

II C. European, Western Europe & Eastern Europe

1. Europe Innovation

Europe has been creeping behind the US, Japan and South Korea in terms of innovation indicators such as: R&D expenditure, the number of those with tertiary education and the number of patents filed (European Commission, 2014). According to Europe Vision 2020, “The United States, Japan and South Korea are not only outperforming the EU in overall R&D to GDP, but also in terms of business enterprise R&D intensity” (European Commission, 2014, p. 6).

Moreover, when taken into context of the Europe Vision 2020, the intensity of the EU’s R&D expenditure has remained stable from 2002 to 2013, rising slightly from 1.81% of GDP to 2.02% in 2013 (European Commission, 2014).

With the most current knowledge is produced, there are knowledge spill-over effects into new inventions and private R&D expansions. According to Europe 2020 indicators, from 2002 to 2007, the number of patent applications from the manufacturing sector increased continuously until the global financial crisis in 2008 (European Commission, 2014, p. 6).

Currently, the EU has been investing heavily in the population’s digital literacy and improving ICT connections from businesses to domestic households, and vice versa. From 2007 to 2012, there was an increase of 47% to 50% within the EU population who
now possesses at least a moderate skill level of computer skills (European Commission, 2014).

Helmers, Schulte, and Strauss (2009) indicates that Europe’s truncated R&D capital covers the variation between various countries. The authors show that there is a mismatch between the allocation of R&D expenditure allocation in the EU where the Southern and Eastern Europe’s R&D expenditure is quite low in comparison to Western and Northern Europe. For instance, in 1995 Sweden had the largest stock of R&D capital within Europe; additionally, Sweden also had one of the largest increase in the stock in the 2000s.

There are numerous differences in organisational structures, networks, technological priorities and product ranges between Eastern, Northern, Southern, and Western Europe. Additionally, each region has a different focus within the EU. Northern European countries are the leaders in eco-innovation, according to Eurostat Statistics (European Commission, 2014). In 2013 alone, the numbers of eco-innovations ranged from 40 from Bulgaria, Poland and Cyprus to 130 or more from Denmark, Germany, Finland and Sweden (European Commission, 2014). This is why we chose to demarcate our regions into Western and Eastern Europe to measure the effects.

2. Central Eastern Innovation

In respect to Central Eastern Europe (CEE), the CEE region has been trying to catch up to the EU and, as shown in Table 5, there is a widening gap of innovation over the last 19 years. According to Hogselius, “One interpretation of this is that transition to capitalism has so far been associated with decreasing rather than increasing innovative capabilities and that the Eastern economies are becoming locked into a pattern of growth based on low value-added activities related to the exploitation of low-wage labour” (Hogselius, 2003, p.1).

After the fall of the USSR, CEE countries enacted numerous legislation to adopt Western Europe techniques and to enact reforms. Hogselius (2003) stated, “Dynamic innovation systems are expected to emerge as the long-term result of macroeconomic stabilisation, trade liberalisation and enterprise privatisation” (Hogselius, 2003, p.8).
After enacting these reforms, opening their countries to foreign trade and attracting foreign direct investment, this will indirectly open up the transmission channels for technology transfers. This should have a positive effect on productivity, then spill over into the domestic economy, and finally will channel the residuals into investment opportunities for entrepreneurs. By providing for more investments for entrepreneurs, this will help spur innovation growth.

Prodan (2005) stated that, for instance, Hungary has the lowest number of random effects influencing its patents filing. Although all of the CEE countries were former socialist countries, the differences in the way the country was managed and which enterprises were categorised as business units has an effect even now. This is because the variation of degree in which a country is considered economically open has an influence on how CEE countries modernised their manufacturing (Prodan, 2005).

According to traditional catch-up theory, the opening of a country enables the emerging country to catch up more quickly because a country would not have to invest as heavily in R&D as advanced countries (Gerschenkron, 1946). Therefore, it would help explain the low expenditure spending as a percentage of GDP within CEE countries, as shown in Figure 2.

**Figure 2: RD Expenditure (%) of GDP**
Numerous studies, such as Konings (2001), have conducted studies showing the effects between foreign direct investment and the performance of domestic firms. Konings (2001) showed that there is a negative outcome, overall, on FDI in regards to the performance of enterprises within Bulgaria and Romania, whilst having zero effects on domestic companies within Poland. Overall, the findings indicate that the positive effects of having foreign investors acting as actors of technological transfers outweighs the negative effects of competition stemming from foreign owned firms, to the point where it may destroy the ability to innovate within domestic organisations (Konings, 2001). However, in Estonia, Sinani & Meyer (2002) show that there is a significant amount of productivity stemming from foreign investors that came from knowledge and technology spill overs from FDI.

A different set of indicators must be used to assess the effect that international trade will spill over into innovation. Ainura Uzagalieva, Evzen Kocenda, and Antonio Menezes (2012) created a new model utilising intra-industrial bilateral trade flows as a substitute for technological advancement and innovation costs within the framework of a gravity
model. Utilising data from OECD & Eurostat MSTI database, the authors were able to analyse the role of innovation and its impact on the technological development of the newly ascendant European Union members: Czech Republic, Hungary, Poland and Slovakia. Grupp (1998) believes that intra-industrial bi-lateral trade flows can be taken as an approximate measure for technological innovation, because the greater the trade between an emerging country and a developed country, the higher the likelihood of convergence of the emerging country to the developed country on technological knowhow. Hogselius stated, “Sweden, Finland, and Germany submit between 7 and 10 times more patent applications domestically as compared to the Czech Republic, Hungary and Poland. In terms of the US patents, this gap is dramatically widening. The only CEE economies with any significant US patenting activity are Slovenia, Hungary and the Czech Republic…” (Hogselius, 2003, p.15). Figure 3 shows the gap between Western to CEE countries in terms of US patents per 10,000 inhabitants.

**Figure 3: Western & CEE patents in term of US Patents**

![Figure 3: Western & CEE patents in term of US Patents](image)

Source: WIPO, 2016; US Patent Office, 2016; author’s computation

According to Schumpeterian competition and growth theory, by including more pressure from foreign firms and knowledge spill over, domestic firms are expected to invest in new technologies and innovative engagements, thereby inducing innovation within their societies. Nevertheless, what isn’t accounted for during joint-venture agreements is that the cooperative agreements do not spur on technological innovation, but instead, is an adaptation to local environment and conditions (Sadowski, 2001). In
addition, Eastern firms primarily added to Western networks to be used on the lower stage of the industry value chain, Figure 4.

**Figure 4: Value Added Chain**

![Value Added Chain Diagram](image)

Source: Canadian Trade Commissioner Service, 2015

Although the aggregated patents level for CEE does not indicate innovative capabilities, they seem to cluster around certain specific industries, such as ICT for Estonia. What can be seen from this success is that the Estonians had a strong relationship with the Swedish and Finnish telecommunications. In Hungary, GraphiSoft has a niche within 3D drafting software for architects, which is sold in 80 countries and used by over 65,000 architects globally (Radosevic, 2002).

Moreover, Piekut (2015) depicts a graph in which she listed a cluster that contains the following countries: Bulgaria, Romania, Slovakia, Lithuania, Poland, Latvia, Hungary, Czech Republic, Estonia, etcetera, which depicts the lowest number of patents filed per one million capita. Additionally, within subsidiaries of multinational companies within CEE countries, innovation has also taken place. Electrolux lead a team of domestic engineers to work on refrigerator insulation.

**II d. Innovation & Generalised Method of Moments, Fixed Effects and OLS**

Hausman *et al.* (1984) researched whether or not there is a lag between patents & R&D expenditure. By running the Poisson “random effects” mode, Hausman *et al.*’s results show that the random effects model starts with a lower approximation of the R&D
coefficient, thereby, reducing the influence of the size variable (Jerry Hausman, 1984, p. 934). The R&D coefficient from the OLS model is higher than the random effects model, while the time lagged R&D yields an increase of an extra .08 in its coefficient (Jerry Hausman, 1984, p. 934).

Mehmood (2013) investigated innovative activities in which a macroeconomic perspective could help further access to the financial markets and thereby increasing economic development. His results indicate that an increase in external finance is positively and significantly correlated in affecting innovation, and thereby increase economic growth. Nevertheless, his results contradict Hausman’s results. Mehmood’s results indicates that OLS and FE coefficients are estimated upwards whilst the GMM-diff is estimated downwards. For instance, for the 1st lag of patents, OLS coefficient yields an increase of .083, while the time lagged patents for GMM-diff is associated with a decrease of .121 in comparison to OLS. When Mehmood increased the dependent variable up to three lags, however, GMM-diff’s coefficient is higher than GMM-SYS by .008.

Roy, Vertsey, and Vivarelli (2015) studied the employment benefits from increasing innovation, where they analysed a dynamic panel data set of nearly 20,000 patenting companies from Europe from 2003 to 2012. Employing a GMM-system and taking the 1st lag of his dependent variable, his results concurred with previous research findings: innovation helps create employment. Moreover, his findings confirm Hausman et al’s (1984) findings, where GMM-sys and OLS’ coefficients are higher than FE’s.

Chapter 2: Data Description

1. Data & Data Descriptive

Since we will be measuring the benefits of joining the European Union and entry into the EU, we will be using the main indicators the benefits that European Union brings: freedom of movement, single market, the Euro, an increase of institutions, financial liberalisation, deepening financial integration, increase of knowledge stock, and freedom of goods and services. Our dataset is based on the number of patents filed and recorded with the World Intellectual Property Organisation (WIPO) and the amount of R&D expenditure within a country by the World Bank. A number of other variable
came from the world bank: Trade openness, private domestic credit to GDP, market capitalisation, real GDP per capita, combination tax, number of researchers in R&D (per millions of people), R&D expenditure to GDP and researchers; these variables are being controlled. Patent data comprised of data gathered from the WIPO. Our dependent variable is quantifiable-type of innovation (patents) and innovative activities (R&D expenditure).

The WIPO, according to their website, “is the global forum for intellectual property services, policy information and cooperation” (WIPO, 2016). Patentscope database, a section within the WIPO, allows access to the international Patent Cooperation Treaty (PCT). WIPO consists of 188 member states and has data from 1980s to 2013. The WIPO Statistics Database consists of data collected from both national and regional IP statistics.

The financial development indicators - was retrieved from the Lane and Milesi-Ferretti (2007) database, which encompasses foreign assets and liabilities, from aggregated foreign stock, FDI and portfolio equity and debt.

Entry into the EU is a dummy variable, where 1 stands for the accession to the EU. The Euro is a dummy variable, where 1 is if the country’s predominate currency is the euro and the 0 denotes the member state within the European Union that has decided to keep its original currency. Another dummy variable was the single market, where 1 is denoted as entry into the single market, whilst 0 is outside the single market.

R&D expenditure, which will use interchangeably with R&D intensity, is defined as both public and private, current and capital expenditure on works to increase knowledge for new inventions. For this paper, the term R&D expenditure will mean two different things based on Equation. For Equation (3), R&D expenditure stands for process of innovation; whilst for Equation (4), number of applications filed; R&D expenditure denotes knowledge stock within a country. In our tables for patents, we will be calling our R&D expenditure, knowledge stock instead, to lessen the confusion.
A more detailed list of our sources can be found within Appendix 1. Within our sources, the economic data provided by World Bank, IMF, OECD, Eurostat and Lane-Milesi-Ferretti contains missing data. Countries with less missing data, such as the Netherlands, United Kingdom and Italy, are over-represented, whilst others, most notably Lithuania and Luxembourg, are under-represented. Part of the country’s imbalances can stem from the fact that a lot of countries do not provide their data to the aforementioned databases.

We had to drop the single market policy variable for some of our regions due to collinearity and the low variance between the single market policy variable and entry into the European Union.

For Equation (4), our dependent variable is the natural logarithm of the number of patents filed in the WIPO. Our explanatory variables are European Union, IFigDP\textsubscript{\textit{i,t-1}}, IEQ\textsubscript{\textit{i,t-1}}, the Euro, the number of researchers (per millions of people), and R&D expenditure (% of GDP). In particular, we measured IFigDP\textsubscript{\textit{i,t}}, IEQ\textsubscript{\textit{i,t-1}}, researchers, and R&D expenditure through natural log added.

Since 2000, the European Commission (EC) has increased the funding for R&D and increased the importance of easier access of data, dissemination of knowledge and the perpetuation of scientific information. To increase the knowledge stock within the EU, the EC wants to increase publicly fund scientific research and to make it publicly available (European Commission / European Research Area, 2011). According to Dean Parham, one way to capture the concept of knowledge stock is by utilising R&D expenditure.

Gross R&D expenditure data was obtained from the World Bank Database. It can be defined as the aggregated spending on R&D within a country’s territory during a given period. It includes: R&D expenditure within business enterprises, government sector, higher education and non-profit firms. In Figure 5, we have included the growth of R&D expenditure from 27 countries over a 19-year time span.

Figure 5 : R&D Expenditure
We gathered our Institution variable from the Heritage Foundation. The variable is comprised of the overall score of economic freedom comprises of four policy arenas: rule of law, freedom from corruption, regulatory efficiency and open markets (Weidman, 2016:1). The start point of this variable is from 1995 to 2016. The table ranges from the most economically free, i.e. Switzerland, and the “repressed” economies such as Ukraine and Belarus. Our data set consists of several of the most economically free countries, but also several of what is considered the “mostly unfree” economies such as Greece and Croatia. Additionally, within the span of 2015 to 2016 alone, numerous countries within the European Union have grown in economic freedom. According to Weidman (2016), approximately 21 out of Europe’s 44 countries increased in economic freedom, whilst 22 countries declined. Moreover, there are several countries within CEE, such as Estonia, Lithuania and Latvia, which managed to gain economic freedom and outperform several older EU member states, including Portugal, France and Italy, who declined in economic freedom last year.
As specified before in Section IV I A, our single market is a dummy variable. Single market allows for the freedom of movement, goods, services and capital allocation openness. Consumers and corporations can enjoy a large number of different products, and as such, can help enhance the bi-lateral trade movement. Therefore, bi-lateral trade flows can help bring about a convergence of technology and innovation from emerging countries and developed. Single market allows for companies, either big or small, to have the possibility to take full advantage of efficiency and therefore, become more competitive.

Trade Openness is the aggregated sum of imports and exports of goods and services as a percentage of GDP. Exports and imports of goods and services (% of GDP) may include the value of the items, freight, insurance, trademark goods, licensing, other services, etcetera (World Bank, 2016). Nevertheless, it does not include compensation for employees, nor the investment that was conducted by the firms (World Bank, 2016).

**Figure 6: Trade Openness**
Financial liberalisation was taken from Chinn-Ito Index. The Chinn-Ito index is a de jure index that measures the degree of capital account openness within a country (Chinn-Ito Index, 2015). The index focuses on the connection between capital account liberalisation, legal and institutional development, and financial development (Chinn-Ito, 2005:2). The range in value is from -2.396685 to 2.396685.

Financial integration is a quantifiable volume-based on

\[ \text{IFIGDP}_u = \frac{(\text{FA}_{i,t} + \text{FL}_{i,t})}{\text{GDP}_{i,t}} \]  

(1)

Where IFIGDP\(_u\) refers to international financial integration for a country within a \( t \) time period and \( i \) is country, FA\(_{i,t}\) and FL\(_{i,t}\) stands for financial assets and financial liabilities, respectively, for stocks and GDP\(_{i,t}\) is gross domestic products. The higher the ratio between IFIGDP to GDP, the larger the number of financial inflows into a country, thereby, increasing the degree of financial integration.
Figure 7: IFIGDP for Eastern Europe

Source: International Monetary Fund, 2016

Figure 8: IFIGDP for Western Europe
As shown by Figure 7 and Figure 8, IFIGDP has grown drastically from 1996 to 2016. If we compare Figure 7 to Figure 8, we can see that IFIGDP been more predominately beneficiary towards CEE than towards Western Europe. The CEE country that has received the most IFIGDP was Slovenia – with the IFIGDP ratio of 56.13 over the span of 15 years. On the other hand, the Western country with the highest level of financial integration, was the Netherlands at 6.03.

Another way to calculate the gains that may result from an uneven distribution of cross-border funds is by using equity-type investments, this consists of FDI or portfolio equity (Lane, 2009, p.4). Park’s (2014) findings indicate that financial integration allows for a reduction of equity home bias. Lerner, Sorensen and Stromberg’s (2011) results show that patents “by portfolio firms of private equity investors are of higher quality and are more concentrated in the most important areas of companies’ innovative portfolios” (Lerner et. al, 2011, p.2). The authors believe that private equity investors can increase innovation and discipline because the investors would be releasing managers from short-term pressures from the shareholders. R&D expenditures have the hallmark characteristics of long-run investments; their costs are immediate, yet benefits are not
immediate and, overall, aggregate to larger amounts over time without a guarantee of return. Hall’s (1992) examination of 25,373 manufacturing firms depicts a clear connection between lower R&D spending and greater leverage.

Nevertheless, it is also difficult to determine whether or not there is a correlation between debt leading to a decrease in R&D expenditure, or if struggling firms have more debt and therefore leading to a reduction in innovation spending (Josh Lerner, 2008).

In addition, there is a second way to measure financial integration based on equity – portfolio debt. Portfolio debt’s formula is depicted below:

$$IEQ_u = \frac{(PEQA_{i,t} + PEQL_{i,t} + FDIL_{i,t} + FDIA_{i,t})}{GDP_{i,t}}$$ (2)

IEQ stands for international portfolio equity where $i$ is country and $t$ is time, $PEQA_{i,t}$ and $PEQL_{i,t}$ refers to portfolio equity assets and portfolio equity liabilities, respectively, $FDIL_{i,t}$ and $FDIA_{i,t}$ is FDI equity assets and liabilities. Table 3 and Table 4 depicts the growth of $IEQ_u$ for Eastern & Western Europe respectively. Therefore, $IEQ_{i,t}$ and $IFIGDP_{i,t}$ comprises the degree of financial integration within CEE.

Figure 9: International Equity Portfolio for Eastern Europe
Figure 10: International Equity Portfolio for Western Europe

Source: International Monetary Fund, 2016
As we can see from IEQ, in Figure 9 and 10, there has been a steady increase over the last 17 years – 1996 to 2013. From 1996 to 2011, Lithuania has grown the most in comparison to the rest of the CEE countries, however Hungary comes at a close second. Bulgaria decreased by the most. In comparison, Western Europe is the greater beneficiary of IEQ. The country that has benefited the least by IEQ has been Norway.

Because of the high correlation between INFIGDP and IEQ within Western Europe, we decided to take the averages between INFIGDP and IEQ to create a new variable – Financial integration. If we compare our correlation between INFIGDP & IEQ with Financial Integration, we notice a significant drop in correlation between our variables.

GDP per capita is used as a substitute for the financial resources that are available within that country, but according to Radu, Bumbac, and Ciobanu (2013), is also used as an alternative for and a way to measure knowledge stock within a country. Stern, Porter and Furman (2000) agree with Radu et al (2013) and further postulates that it can also be used as a way to approximate the technological development within a nation. Hence why we will be using GDP per capita as a substitute for knowledge stock for Equation (3).

Due to high variance between the 11 CEE and 15 Western Europe countries, we had to transform multiple variables including control to ensure normality, such as: patents, financial integration, reserves, R&D expenditure (%) of GDP, to trade, GDP per capita, number of researchers per million capita, migrants and market capitalisation. Unfortunately, there was quite a bit of missing data from the World Bank, WIPO, and International Monetary fund, ergo systematic testing would be drastically limited.

**Chapter 3: Methodology**

We analyse the relationship between European Union ascendancy and its benefits and its impact on innovation activity by utilising country-level data. Firstly, we measured the effects of ascendancy into the EU for most of the countries within the European
Then we split the countries into Western and Eastern Europe to isolate the effects. The split was decided based on geography.

It is very difficult to measure innovation, hence why we will be using two different measures of innovative activities: number of patents filed and research and development expenditure (% of GDP). These two indicators will measure two types of innovation – the product (patents) and the process (R&D expenditure). Innovative activities take numerous years; hence it is possible that there are time-determinants of R&D such as inflation & tax law changes. We will be testing to see whether or not ascendency into the EU has brought along the positive boons to innovative activity as is stated by numerous aforementioned authors.

Prior research has shown that the impact of innovation can be measured through various inputs such as the number of patents filed, R&D expenditures, or “discrete output measures such as dummy variables” (Roy, Vertesy, Vivarelli, 2015, p.8). Nevertheless, there are numerous drawbacks to measuring innovation via the number of patents filed and R&D expenditures. According to Nelson and Winter (1982) and Dosi (1988), the linkage between R&D expenditure and successful innovation has too much uncertainty and lags. One of the issues that we have run into is that industries do not always patent their innovations. Furthermore, investments for innovative activities and products are different from other types of investment in that there is a higher degree of uncertainty especially in results, significant upfront costs that may not be recouped, and since research often depends on a researcher who may leave the company (Paunov, 2012, p.24) This is why we decided to use a second indicator to measure innovation – R&D expenditure. We came across these issues in Equation (3).

Conversely, patents can be seen as a better substitute for product innovation, especially in comparison to the process of innovation, if the appropriate instruments are used (Richard C. Levin, 1987). Although, new products are patented to protect the knowledge and to prevent imitation and reverse engineering, because of the single market, countries can adopt the products to fit within their standards and expectations, which can also be enhanced; this helps bring new knowledge into the companies. Another issue as to the

---

1 We had to drop Cyprus, Finland and Malta due to the high number of missing data.
problematic nature of R&D expenditure, especially within the process of innovation, is that this process is rarely quantifiable since it is more easily protected, and therefore does not need to be patented. According to Arundel and Kabla (1998), the process of innovation accounts for 20 to 30% of total patents. This is why we have decided to use both variables to measure innovation to create a fuller picture.

<table>
<thead>
<tr>
<th>Table 1: Summary Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>Patents (log)</td>
</tr>
<tr>
<td>Financial Integration (log)</td>
</tr>
<tr>
<td>Foreign Reserves (log)</td>
</tr>
<tr>
<td>GDP per Capita (log)</td>
</tr>
<tr>
<td>Financial Liberalisation</td>
</tr>
<tr>
<td>R&amp;D Expenditure (log)</td>
</tr>
<tr>
<td>Market Capitalisation (log)</td>
</tr>
<tr>
<td>Trade Openness (log)</td>
</tr>
<tr>
<td>Migrants (log)</td>
</tr>
<tr>
<td>Private Credit (log)</td>
</tr>
<tr>
<td>Patents.L1 (log)</td>
</tr>
<tr>
<td>Patents.L2 (log)</td>
</tr>
<tr>
<td>R&amp;D Expenditure.L1 (log)</td>
</tr>
<tr>
<td>R&amp;D *Expenditure.L2</td>
</tr>
</tbody>
</table>

N-sample: 486 originally

The following variables were all natural logged to ensure normality: patents, financial integration, researchers, R&D expenditure, foreign reserves, GDP per capita, GDP growth (%), trade openness, FDI, market capitalisation, migrants and private credit.

Moreover, we chose to lag only our dependent variable as per Achen’s (2001) study. Achen’s study indicates that “Yet when one or more lagged values of the dependent
variable are added as a ‘control’ and the regression is recomputed… the fit improves sharply, but the original sensible substantive effects of other variables disappear” (Achen, 2001, p. 1). The author opines that while, overall the fit is now better and the coefficient is now highly statistically significant, it has an adverse, in which many or all of the remaining explanatory variables are now impossibly small and insignificant. This could lead us to inaccurate extrapolations. The author believes this because the disturbances are now affected by the first-order autocorrelation (Achen, 2001). According to the formula provided by Achen’s study

\[
\text{Plim } \beta_1 = \left[1 - \rho_1 \rho_2 ((1-R^2)/(1-(\rho^2 R^2)))\right] \beta_1
\]

“where \( R^2 \) is the (asymptotic) squared correlation when OLS is applied” (Achen, 2001, p. 5). That when \( \beta_1 \) is decreased to the fraction of \( \rho_2 \), so that the substantive variable is now underestimated, where autocorrelation becomes worst and so does the bias (Achen, 2001, p. 5). Therefore, it was not possible to lag some of our independent variable because of the deepening of the bias.

### 3.1 Estimation of Innovation Function

This section examines the theory of R&D and the patent growth model, which are central for technological innovation. In the models used by Hausman et al. (1984) and Blundell et al. (1995), the average number of patents is depicted by Cobb-Douglas technology, in which research lags are the inputs (Crepon and Duguet, 1998).

\[
\log \lambda_{i,t} = \delta + \sum \beta_i \log(r_{i,t-1})
\]

Thusly, there will be two equations that we will be using:

\[
\Delta \log(R&D)_{i,t} = \Delta \log(\text{patents})_{i,t-2} + \alpha \Delta \log(R&D)_{i,t-1} + \Delta' \beta_1 \log(\text{Financial Integration}) + \Delta' \beta_2 \log(\text{migrants}) + \Delta' \beta_3 \text{European Union}_{i,t} + \\
+ \Delta' \beta_4 \text{Euro} + \Delta' \beta_5 \text{ (Financial Liberalisation)} + \Delta \beta_6 \text{(Knowledge stock)} + \alpha + \varepsilon
\]  

(3)

where \( i \) denotes country and \( t \) denotes years, R&D is the research development to GDP (%), Financial integration is the average of INFIGDP and IEQ, European Union is a dummy variable designed to capture the ascendancy into the politico-economic union,
net migration, and whether or not joining the euro, as a monetary currency, has a positive effect.

\[
\Delta \log(\text{patents}) = \Delta \log(\text{patents})_{i,t-1} + \alpha \Delta \log(\text{patents})_{i,t-2} + \Delta' \beta_1 \log(\text{Financial Integration})_{i,t} + \nonumber \\
+ \Delta' \beta_2 \text{European Union}_{i,t} + \nonumber \\
+ \Delta' \beta_3 \text{Euro} + \Delta' \beta_4 \log(\text{R&D expenditure})_{i,t} + \nonumber \\
\Delta' \beta_5 \text{Migrants}_{i,t} + \beta_6 (\text{Financial Liberalisation}) + \beta_7 (\text{Knowledge Stock}) + \alpha + \varepsilon \tag{4}
\]

where \( i \) denotes country and \( t \) signifies years, R&D is the research development to GDP (%) (\( \beta_4 \)), Financial integration (\( \beta_1 \)) is the average of INFIGDP and IEQ, European Union (\( \beta_2 \)) is a dummy variable in which 1 is the entry into the EU and 0 is not in the EU, number of migrants (\( \beta_5 \)), financial liberalisation (\( \beta_6 \)), knowledge stock (\( \beta_7 \)) and the euro (\( \beta_3 \)).

By utilising GMM analysis, the differences within the intimal levels of knowledge across the countries are accounted for. A dynamic specification can be seen in Equation (3) and Equation (4) can’t be approximated based on an ordinary least square (OLS), nor a fixed panel data regression, because it may lead to biased and inconsistent coefficients and estimators. This inconsistency can stem from a number of variables that are endogenous with one another, such as bilateral trade and patents in Equation (4). In addition, since the process of innovation, Equation (3), is also lagged due to the delayed effects, unfortunately the model may now be correlated with individual and time-invariant countries’ fixed effect \( \varepsilon \). As such, the coefficients of the dependent variable within the FE model may be biased. In addition, the deviation will also appear lower than the GMM model.

OLS is not an effective method, because it does not take into effect a country’s fixed effect and will suffer from endogeneity of the lagged variables. Moreover, the OLS regression with the lagged dependent variable will be positively correlated with the error term. We also decided to employ a two lagged dependent variable. We decided to employ a two lagged dependent variable because R&D expenditure and patents’ effects takes longer than one year to bear monetary fruit. In addition, countries within the EU have to engage in preparatory work for ascension into the EU.
The fixed model effects can solve the first issue, but it will only yield consistent estimators if the assumption behind the model is consistent – that exogeneity holds. This assumption, nevertheless, violates our two lagged dependent variable, ∆R&D expenditure,$_{t-1}^i$, with the error term ($\varepsilon$).

To solve these numerous issues, we decided to utilise the Arellano-Bond estimator, GMM-diff, thereby lessening endogeneity by utilising the lag of the explanatory variables as regressors (Bianchini, Pellegrino, Tamagni, 2015). Roy, stated that, “This approach is based on an instrumental variable technique that runs a system of equations in first differences and in levels simultaneously – with the level of equations also including the euro, year and country dummies as controls” (Roy et al., 2015, p.19). In addition, by using the Arellano-Bond estimator, we are able to use a higher order lags as an instrument if we have two lags for the dependent variable. Additionally, we will be able to eliminate autocorrelation by utilising Arellano-Bond first-differences to eliminate any country-country specific fixed effects. Moreover, we had to drop numerous values because of missing data. GMM-diff would have provided faulty results if we had not done so.

Our model suffers from endogeneity because of lagged dependent variables in Equation (3) and Equation (4). Nevertheless, endogeneity may also arise from the presence of other covariates within the model (such as bi-lateral trade and patents that can affect one another's innovation). Causality may go in both ways, thereby creating the aforementioned repressors to be correlated with the error term. Ergo, some of the explanatory variables can be potentially endogenous with each other in Equation (3) and Equation (4), and must be instrumented.

To solve for the endogeneity problem, it would be prudent to use either an instrumental or the GMM model. Our general preference is to use GMM over instrumental variables because GMM allows for a richer array of instruments. By utilising GMM, we will be able to lag the dependent variable as a regressor. If there is heteroscedasticity within our model, GMM would be more preferable than instrumental linear regression. In Appendix 2, we include the Breusch-Pagan test for heteroscedasticity for each region.
According to Baum (2002), the convention instrumental variable (IV) will be considered inefficient if there is heteroscedasticity within the independent variables. Baum et al. (2002), therefore, suggest that if heteroscedasticity is present and is unknown, it would better to be use GMM. GMM utilises orthogonality conditions that allow for efficient approximation in the company of heteroscedasticity, if unknown (Christopher F. Baum, 2002, p. 1).

This is not to say that our model is without flaws. Our initial observation was over 200 observations, which was decreased because of robustness, the numerous natural log to ensure normality within our region and the drop of numerous missing variables. Therefore, this will cause an issue of an overall weak identification and thusly, may cause the coefficients, hypothesis exams and confidence intervals to become unreliable, according to Stock et al. (2002). Stock et al. (2002) believe that a linear IV may yield more reliable inferences, nevertheless, our results are shown to be consistent overall with other researchers within the field. It is our belief, however, that instrumental linear regression may be the best fit for when researchers wish to break down the effects in a particular region if there are not a lot of observations available. Due to the limitations of this paper, we will only be able to perform three models: GMM, FE/RE and OLS. Moreover, a further empirical study on the economic benefits on a political and economic integration into the EU and its impact innovation is warranted, especially one that includes a comparison between GMM, OLS, FE/RE and IV models.

We chose our lags based on the importance of the variables, in particular, in identifying dynamic panic models. Reenen (1997) and Piva and Vivarelli’s (2005) findings indicate that it is common for innovation research be lagged because findings from the past has a profound impact on future inventions based on previous knowledge garnered. Moreover, Woodright (2009) advocates concentrating on the cumulative effect by including distributive lags to find the long-run effects if the number of observations are small. This is especially prudent in our case since our sample size ranges from 55 to 98.

To test for autocorrelation, after performing the GMM estimation we tested for joint validity by utilising the Sargan test (Newton, 2009).
Chapter 4: The Results

Due to the split of countries by geography within the EU, our main independent variable – European Union - is insignificant within the GMM and OLS models. The European Union coefficient is significant for our FE model. Our interpretation from this is that there are not enough observations. A key component of GMM is that it requires a high number of observations and a small time frame. Unfortunately, CEE country data from 1996 to 2013 does not contain enough observations.

Additionally, in order to best capture the same time period for Western and Eastern Europe, we were not able to fully capture the benefits of joining the EU for Western Europe at its inception. We decided to demarcate our results from our three main models – GMM-Diff, Fixed Effects Estimator, and OLS model and its two lagged dependent variables into 3 columns. For comparison purposes only, we have included both the OLS and FE estimators. In every section, we ran multiple tests to ensure that there is no heteroscedasticity within our model and that FE model is the correct model. Unless otherwise specified, Column (1) will denote the results from the GMM model; Column (2) stands for Fixed Effects Estimator model findings; Column (3) is the OLS results.

Furthermore, we decided to demarcate our results into three main regions: European Union, Western Europe and Central Eastern Europe (CEE). Hogselius (2003) believed that the technological innovation is tentatively connected between Western and Eastern Europe. By delineating the areas, we will be able to isolate the effects of European Union and its benefits within the two regions. This is important because several researchers have postulated that the EU innovation policies are predominately beneficiary within the core member states and within the EU, but not for the periphery states. Therefore, what may be good for the core member states would not be as beneficiary for the ascension states.

Due to the large amount of short time span and incomplete current data, the findings concluded at the end of this paper could not be established in a time-trend analysis.
4.1 European Union Results for Patents & R&D Expenditure

The Breusch-Pagan and White test is utilised to gauge if the hypothesis is homoscedastic. If Prob > chi2 falls below a .05 threshold, we can conclude that that our data set is soundly heteroscedastic. The results, in Appendix 2, indicates that our data is soundly heteroscedastic for the patent regressor, and therefore, GMM may be the better model to employ. After performing the Hausman test to gauge which model to use, fixed effects (FE) or random effects (RE), our p-value is less than .05, and therefore the fixed effects model would be the more applicable model.

Overall, our results for Equation 4 – GMM- for Table 2 shows that the 1st lag of the dependent variable is highly significant and yields a positive effect upon current number of patent applications. Additionally, our 2nd lag of number of patents filed is barely significant within the 10% level and yields a positive coefficient. Financial integration & knowledge stock is highly significant and positive, whilst the number of researchers yields a negative effect and is significant. Additionally, the number of migrants entering into European Union is negative and is barely significant within the 10% realm.

Concurrently, our results from the three models indicate that Hausman’s results are corrected. The GMM and OLS coefficients are estimated upwards whilst the FE estimators are biased downwards. However, although Hausman’s results indicate an increase of .08 percentage points from GMM, RE and OLS model from each other, our differences are much higher: our FE results is .454 percentage points less than our GMM results whilst our GMM is less than our OLS results by .218 percentage points.

For our R&D Expenditure model, our Hausman results are less than .05 and thusly, we will be utilising a FE model. We performed the Breusch-Pagan test for heteroscedasticity, results can be found in Appendix 3, where our Prob > chi2 is 0.00. Our results show that after the regression and the performance of our test, the result was Prob > chi2 is 0.000 and therefore, we have to reject our null hypothesis, essentially proving that our model has a heteroscedasticity problem. Hence why GMM is more preferable if used to model the whole EU region.
In Table 3, only our 1\textsuperscript{st} lag dependent variable is positive and significant whilst our 2\textsuperscript{nd} lag dependent variable is positive but insignificant. Our financial integration variable is negative and is highly significant. The openness to trade variable is insignificant. All of our other explanatory variables are insignificant. Our FE and OLS two lagged dependent variable performed as Hausman's results indicated.

We expected that the OLS model is closer in magnitude, in comparison to the 1\textsuperscript{st} lag of the FE model, in the 1\textsuperscript{st} lag and is highly significant, while our FE 1\textsuperscript{st} lagged dependent is also highly significant, but is biased downwards. On the other hand, our 2\textsuperscript{nd} lagged dependent variable for both OLS and FE are insignificant.

### 4.1.1 Has joining the EU had a positive and significant impact on patents?

**Table 2: All Countries within EU & Innovation Indicators – Patents**

<table>
<thead>
<tr>
<th></th>
<th>(1) Patents</th>
<th>(2) Patents</th>
<th>(3) Patents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GMM</td>
<td>FE</td>
<td>OLS</td>
</tr>
<tr>
<td>L.1 Patents</td>
<td>0.468</td>
<td>0.014</td>
<td>0.686</td>
</tr>
<tr>
<td></td>
<td>(3.67)**</td>
<td>(0.55)</td>
<td>(6.31)**</td>
</tr>
<tr>
<td>L.2 Patents</td>
<td>0.278</td>
<td>-0.001</td>
<td>0.101</td>
</tr>
<tr>
<td></td>
<td>(1.71)</td>
<td>(0.06)</td>
<td>(1.92)</td>
</tr>
<tr>
<td>European Union</td>
<td>4.117</td>
<td>-0.226</td>
<td>0.285</td>
</tr>
<tr>
<td></td>
<td>(0.79)</td>
<td>(2.67)**</td>
<td>(0.72)</td>
</tr>
<tr>
<td>Knowledge Stock</td>
<td>0.489</td>
<td>0.724</td>
<td>1.795</td>
</tr>
<tr>
<td></td>
<td>(2.13)*</td>
<td>(3.72)**</td>
<td>(3.93)**</td>
</tr>
<tr>
<td>Financial Integration</td>
<td>0.133</td>
<td>0.179</td>
<td>0.331</td>
</tr>
<tr>
<td></td>
<td>(2.08)*</td>
<td>(2.62)**</td>
<td>(2.50)*</td>
</tr>
<tr>
<td>GDP Growth (%)</td>
<td>0.010</td>
<td>0.000</td>
<td>0.066</td>
</tr>
<tr>
<td></td>
<td>(0.95)</td>
<td>(0.05)</td>
<td>(2.16)*</td>
</tr>
<tr>
<td>GDP per Capita</td>
<td>0.391</td>
<td>0.376</td>
<td>-0.085</td>
</tr>
<tr>
<td></td>
<td>(2.89)**</td>
<td>(2.94)**</td>
<td>(0.33)</td>
</tr>
<tr>
<td>Euro</td>
<td>-0.108</td>
<td>0.048</td>
<td>0.127</td>
</tr>
<tr>
<td></td>
<td>(1.60)</td>
<td>(0.63)</td>
<td>(0.75)</td>
</tr>
<tr>
<td>Single Market</td>
<td>-4.293</td>
<td>-0.429</td>
<td>-0.429</td>
</tr>
<tr>
<td></td>
<td>(0.83)</td>
<td>(1.00)</td>
<td></td>
</tr>
<tr>
<td>Researchers</td>
<td>-0.591</td>
<td>0.300</td>
<td>-0.914</td>
</tr>
<tr>
<td></td>
<td>(2.62)**</td>
<td>(1.54)</td>
<td>(2.63)**</td>
</tr>
<tr>
<td>Foreign Reserves</td>
<td>0.031</td>
<td>0.006</td>
<td>0.083</td>
</tr>
<tr>
<td></td>
<td>(0.53)</td>
<td>(0.12)</td>
<td>(0.86)</td>
</tr>
<tr>
<td>Corporate Tax</td>
<td>0.038</td>
<td>-1.894</td>
<td>-3.721</td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td>(1.98)</td>
<td>(2.89)**</td>
</tr>
<tr>
<td>Trade Openness</td>
<td>-0.027</td>
<td>0.166</td>
<td>-0.234</td>
</tr>
</tbody>
</table>
As we can see from Table 2, our results act precisely as expected. From the GMM-difference model, Specification (1), the first lag of the dependent variable has a positive effect upon current number of patents filed and is significant. This indicates that a one percentage point increase in the 1st lag of our dependent variable yields a .468 percentage point increase in the number of patents filed. Concurrently, the 2nd lag of number of applications for patents is barely significant at a 10% level and is positive, thereby indicating that a one percentage point increase in a 2nd lag of our dependent variable yields a .278 percentage point increase in the regressor. From this, it is possible to extrapolate that although the number of patents filed two years ago played a role in influencing the current number of patents, the 1st lag played an even larger part in the number of patents filed.

For our FE values, 1st lag and 2nd lag are insignificant and have a positive and negative influence respectively. However, if we compare our findings from FE estimator and OLS, the OLS coefficients for the 1st and 2nd lag varies drastically. The OLS coefficients for the 1st and 2nd lag are both positive, but only the 1st lag is highly significant and the 2nd lag is barely significant within the 10% level. This confirms our expectations in that the FE model estimates downward, whilst the GMM and OLS model estimates upward. However, if we compare the explanatory variables from the three various models, it becomes explicitly clear that the GMM produces the lowest coefficients. For instance, if we compare the variable financial integration between GMM, FE and OLS, the results are as follows: .133, .179 and .331. This could be that the coefficients from OLS and FE
are biased and inconsistent due to the lag variables.

The results obtained from the relationship between entry in the European Union and innovation (patent applications) allow us to make the following deduction from Specification (1): The short-term growth variable has a higher impact upon current number of patents filed over our long-term growth variable. This confirms our expectations since it is believed that after entry into the EU, there would be mild growing pains for number of patents filed, but will eventually surge due to the increase of competition, openness to trade, and efficiency in capital allocation, therefore leading to an increase in number of patents filed.

When we look at one of our standard explanatory variables, financial integration has a positive and significant impact on the number of patents filed. A one percentage point increase in financial integration yields a .128 percentage point increase in the number of patents filed. The purpose of deepening financial integration is to allow for financial stability, augment prospects for risk diversification, and promote and boost access to funding and liquidity in the financial markets (European Central Bank, 2009). The development of new technological projects is correlated with an exposure of technological failure and is also constituted as a financial risk; one that a non-specialised investor would be unable to properly appraise. Therefore, financial integration would allow for multinational corporations to access the credit markets. Recent literature has established that financial constraints reduces the likelihood that a firm would undertake innovative activities. According to the European Central Bank, “In addition, innovative effort tends to be stimulated by the emergence and deepening of risk capital markets” (European Central Bank, 2009, p. 64).

Our other standard explanatory variable, knowledge stock, is as expected: highly significant and a positive magnitude, which indicates that for a 1 percent increase in knowledge stock, holding all other variables constant, there is a .489 percentage points increase in number of patents filed. According to Eurostat Statistics Vison 2020, all of the member states within the EU are becoming more innovative, however, there are still vast differences within the member states (European Commission, 2014). Additionally, after the financial crisis and its detrimental effect on GDP growth, the governments of
most member states increased their governmental R&D spending – with the exception of Croatia, Luxembourg, Portugal, the UK, and Sweden (European Commission, 2014, p. 1).

Conversely, the number of researchers has a negative and significant effect on the number of patents filed. Our interpretation of this is that it could be the people filing the patent applications are not researchers hence the decrease. According to IP watch organisation, the number of publications has slowly been decreasing from 2004 to 2014 (Murphy, 2015).

Moreover, the number of migrants has a negative and significant effect on the number of patents filed. Our interpretation of this is that, the majority of immigrants into the EU are either high-skilled labourers, or low-skilled labourers who are not contributing to the number of patents filed. postulates that although there is a positive correlation between skilled migrants and patents, the effects of the highly-skilled workers and manual labourers varies between migration streams. Therefore, the structure of immigrants from various backgrounds is more important to innovation. Unfortunately, one of our main independent variable, European Union, is insignificant.

### 4.1.2 The impact of ascension into the EU on R&D expenditure

<table>
<thead>
<tr>
<th></th>
<th>(1) R&amp;D Expenditure</th>
<th>(2) R&amp;D Expenditure</th>
<th>(3) R&amp;D Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GMM</td>
<td>FE</td>
<td>OLS</td>
</tr>
<tr>
<td>L.1 R&amp;D Expenditure</td>
<td>0.842</td>
<td>0.129</td>
<td>0.564</td>
</tr>
<tr>
<td></td>
<td>(4.28)**</td>
<td>(2.84)**</td>
<td>(5.47)**</td>
</tr>
<tr>
<td>L.2 R&amp;D Expenditure</td>
<td>0.050</td>
<td>-0.017</td>
<td>-0.020</td>
</tr>
<tr>
<td></td>
<td>(0.26)</td>
<td>(0.41)</td>
<td>(0.41)</td>
</tr>
<tr>
<td>Patents</td>
<td>-0.017</td>
<td>0.129</td>
<td>0.039</td>
</tr>
<tr>
<td></td>
<td>(0.83)</td>
<td>(3.75)**</td>
<td>(3.10)**</td>
</tr>
<tr>
<td>European Union</td>
<td>-0.062</td>
<td>0.056</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(1.59)</td>
<td>(0.26)</td>
</tr>
<tr>
<td>Financial Integration</td>
<td>-0.047</td>
<td>-0.076</td>
<td>-0.018</td>
</tr>
<tr>
<td></td>
<td>(1.98)*</td>
<td>(2.70)**</td>
<td>(0.85)</td>
</tr>
<tr>
<td>GDP Growth</td>
<td>0.003</td>
<td>-0.006</td>
<td>-0.009</td>
</tr>
<tr>
<td></td>
<td>(0.45)</td>
<td>(1.92)</td>
<td>(1.98)</td>
</tr>
<tr>
<td>GDP per Capita</td>
<td>0.057</td>
<td>0.045</td>
<td>0.078</td>
</tr>
</tbody>
</table>
Unfortunately, one of our main independent variable, European Union, is insignificant. The results from our GMM, FE and OLS model for our dependent variable, R&D expenditure, yielded the expected results: that the 1st lag of the dependent variable for the GMM and OLS model are estimated upwards whilst FE’s estimators is estimated downward. If we compare our 1st estimators from GMM to the FE and OLS results, we can see that the closest in magnitude to GMM results would be the OLS model, at .564, and is highly significant too. On the other hand, the FE results indicate that a one percentage point increase in the 1st lag of R&D expenditure yields a .164 percentage point increase, and is significant. Both 2nd lag of the FE and OLS models are negative and is insignificant, which contradicts our GMM results.

The 1st lag of our dependent variable has a positive effect and is significant, indicating that a one percentage point increase in the 1st lag of the dependent variable yields a .842 percentage point increase in R&D intensity, holding all other variables constant.
Nevertheless, the 2nd lag of our dependent variable is positive and is insignificant. Our interpretation of this is that our 2nd lag of R&D intensity has a positive impact on current R&D expenditure, but the 1st lag is more influential- both in magnitude and in significance level.

Our results are similar to that Hausman et. al (1984) depict. If we compare the magnitude difference between our three models for our 1st dependent variable. The GMM is the one that is biased upwards, which differs from Hausman’s result. Our FE result is the least in magnitude of .129 percentage points. The difference between FE and GMM is that GMM’s results are .713 percentage points higher. On the other hand, the difference between GMM and OLS is .278 percentage points.

Table 3 indicates that financial integration is significant and has a negative impact on the R&D expenditure. Indicating that a one percentage point increase in financial integration, holding all other variables constant and at 0, yields a .047 percentage point decrease in R&D expenditure. According to Kneer, financial liberalisation has a detrimental effect upon labour productivity, factor productivity and value-added growth, which has a lopsided effect on industries that tend to rely heavily on skilled labour (Kneer, 2013). Additionally, she also postulates that financial liberalisation damages non-financial sectors through a brain-drain effect. Beck, Chen, Lin and Song (2012) concur with Kneer’s findings and indicate that, although there are numerous positive aspects of financial liberalisation, there are also negative sides. Beck et. al (2012) argue even further than Kneer’s finding that financial liberalisation hurts innovation due to brain drain. They claim that, since the growth from innovation has become reliant on external financing, the adverse effects from the current crisis has hurt innovation due to the lessening amount of credit available.

Additionally, when the financial crisis hit the EU in 2008, some of the member states, such as Germany, Austria and the Nordic countries, tried to encourage their economies to grow by increasing public R&D (European Commission, 2014). Nonetheless, there were several states, Poland, Slovakia, Croatia, Lithuania, Latvia, Cyprus and Greece, whose main source of R&D expenditure stems from the public sector and were therefore unable to so. With the exception of the aforementioned countries that relies
predominantly on public resources for R&D expenditure, other member states have two main funding for R&D: private and public. This had an adverse effect on R&D.

4.1.3 Correlation Tests

In Figure 11, a number of our standard explanatory variables are moderately correlated with the numbers of patent filed. R&D expenditure is moderately correlated with the number of patents at .6822, which is high but not high enough to warrant a drop in our equation. Additionally, financial integration and number of researchers are correlated with patent applications at .5199 and .5188, respectively. Nevertheless, the number of researchers and R&D expenditure is very high at .8126. Moreover, the European Union and the euro is highly correlated at .7915. Private credit to financial integration is highly correlated, .7394. Private credit to GDP per capital are moderately correlated to one another at .7291. We tested for auto correlation within our data set in Section 4. This warrants caution because a high correlation between two variables can cause one of the standard explanatory variables to become insignificant.\(^2\)

2.1 Western Europe

\(^2\) Unfortunately, our control variable – the single market policy – was dropped due to collinearity in our Column (2) results for Table 4 and 5.
We ran the Hausman test for our patent variable, results which can be found in Appendix 3, and it indicates that we need to use the FE model for comparison. We ran the Breusch-Pagan / Cook-Weisberg test for heteroscedasticity for our patent variable. The results for the Breusch-Pagan/Cook-Weisberg test denotes Prob > chi2 = 0.00, therefore, we can soundly reject the null hypothesis of homoscedasticity and can infer that our model contains heteroscedasticity. As such, although our observations (107) are quite low, our GMM estimators may be more reliable than the instrumental linear regression.

Table 4 results indicates that the two lags of the dependent variable have a positive and highly significant effect upon current number of patents filed. Financial integration and the number of migrants entering Western Europe, however, have a significant and negative effect on the number of patents filed. This correlates with our findings from the previous section. Additionally, the OLS result for the 1st lag is the closest in magnitude and significance to our GMM results. From this, it is able to extrapolate that an instrumental linear regression may be able to collaborate with our results. Although our results agree with Hausman (1984) in that FE’s coefficient is the lowest, the results from GMM are higher than the OLS model.

The Hausman test results for R&D Expenditure dictates that we utilise a FE model because the p-value is lower than .05. Table 5 depicts our results from the three various models for R&D expenditure. The GMM results for our two lagged dependent variable shows that the 1st lag is positive and highly significant in magnitude. However, GMM’s 2nd lag of R&D expenditure indicates a negative effect whilst being significant. The interpretation is that, although the 2nd lag of R&D expenditure yields a negative and significant effect on R&D intensity, the 1st lag’s percentage points is higher in magnitude and has a greater impact. The FE and OLS model’s 2nd lag of the dependent variable is insignificant and positive in magnitude. Only the OLS model’s 1st lag of the dependent variable is positive and significant in magnitude. The value of the 1st lag of the GMM and OLS model are biased upwards, in comparison to the FE estimators.

Accession into the EU is barely significant within the 10% level, but still has a positive impact on R&D intensity. Financial integration is highly significant, however, the variable has a negative effect on R&D expenditure. Nevertheless, financial liberalisation
is highly significant and has a positive effect on R&D expenditure within the EU. The other standard explanatory variables are insignificant.

### 4.2.1 Western Europe Patent

#### Table 4: Western Europe & Patents Results

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patents GMM</td>
<td>Patents FE</td>
<td>Patents OLS</td>
</tr>
<tr>
<td>L.1 Patents</td>
<td>0.614 (3.03)**</td>
<td>0.013 (0.53)</td>
<td>0.558 (3.98)**</td>
</tr>
<tr>
<td>L.2 Patents</td>
<td>0.357 (2.16)*</td>
<td>0.004 (0.21)</td>
<td>0.083 (1.08)</td>
</tr>
<tr>
<td>European Union</td>
<td>0.827 (0.73)</td>
<td>0.653 (1.25)</td>
<td></td>
</tr>
<tr>
<td>Knowledge Stock</td>
<td>-0.024 (0.17)</td>
<td>0.410 (1.55)</td>
<td>2.532 (3.35)**</td>
</tr>
<tr>
<td>Financial Integration</td>
<td>-0.198 (3.23)**</td>
<td>0.379 (3.01)**</td>
<td>1.202 (2.94)**</td>
</tr>
<tr>
<td>GDP Growth (%)</td>
<td>0.017 (4.61)**</td>
<td>0.005 (0.41)</td>
<td>-0.021 (0.28)</td>
</tr>
<tr>
<td>Euro</td>
<td>-0.090 (1.64)</td>
<td>0.052 (0.71)</td>
<td>-0.710 (2.20)*</td>
</tr>
<tr>
<td>Researchers</td>
<td>-0.033 (0.20)</td>
<td>0.699 (2.71)**</td>
<td>-1.576 (2.82)**</td>
</tr>
<tr>
<td>GDP per Capita</td>
<td>0.241 (2.23)*</td>
<td>0.089 (0.60)</td>
<td>-0.265 (0.55)</td>
</tr>
<tr>
<td>Foreign Reserves</td>
<td>-0.112 (4.08)**</td>
<td>-0.152 (1.96)</td>
<td>0.330 (1.80)</td>
</tr>
<tr>
<td>Corporate Tax</td>
<td>0.608 (1.13)</td>
<td>-2.386 (2.07)*</td>
<td>-9.425 (3.15)**</td>
</tr>
</tbody>
</table>


The results featured in Table 4 supports Table 2 patent’s results in that, the 2\(^{nd}\) lag of the dependent variable is positive, but has significant impact on the current amount of number of patents filed. For this GMM model, we can conclude that a one percentage point increase in the 2\(^{nd}\) lag of our dependent variable would yield a .349 percentage increase in the current number of patents filed. From Table 4, we are able to extrapolate the information that the 1\(^{st}\) lag of the dependent variable is positive and is highly significant. This indicates that a positive increase of 1 percentage point within the 1\(^{st}\) lag of number of patents filed, holding all other variables constant, should yield an increase of a .639 percentage point increase in number of patents filed. If we compare this result from the FE model, the values are both insignificant and are incredibly low in magnitude. This could be a result from endogeneity within the model and it has been recommended that one should not use lags with panel FE models, especially without instrumental variables. Nevertheless, in the OLS model, 1\(^{st}\) lag estimators are positive.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade Openness</td>
<td>14.099</td>
<td>-5.671</td>
<td>-30.114</td>
</tr>
<tr>
<td></td>
<td>(1.96)</td>
<td>(1.24)</td>
<td>(1.54)</td>
</tr>
<tr>
<td>Market Capitalisation</td>
<td>0.066</td>
<td>-0.026</td>
<td>-0.579</td>
</tr>
<tr>
<td></td>
<td>(2.33)*</td>
<td>(0.55)</td>
<td>(3.11)**</td>
</tr>
<tr>
<td>Financial Liberalisation</td>
<td>-6.250</td>
<td>2.748</td>
<td>16.630</td>
</tr>
<tr>
<td></td>
<td>(1.87)</td>
<td>(1.15)</td>
<td>(1.59)</td>
</tr>
<tr>
<td>Institution</td>
<td>-0.006</td>
<td>-0.029</td>
<td>-0.066</td>
</tr>
<tr>
<td></td>
<td>(0.63)</td>
<td>(2.30)*</td>
<td>(2.50)*</td>
</tr>
<tr>
<td>Private Credit</td>
<td>0.123</td>
<td>0.016</td>
<td>-0.241</td>
</tr>
<tr>
<td></td>
<td>(1.31)</td>
<td>(0.14)</td>
<td>(0.84)</td>
</tr>
<tr>
<td>Migrants</td>
<td>-0.000</td>
<td>-0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(3.23)**</td>
<td>(5.12)**</td>
<td>(0.44)</td>
</tr>
<tr>
<td>Single Market</td>
<td>0.260</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>_cons</td>
<td>2.258</td>
<td>4.208</td>
<td>4.485</td>
</tr>
<tr>
<td></td>
<td>(0.96)</td>
<td>(1.25)</td>
<td>(0.47)</td>
</tr>
<tr>
<td>N</td>
<td>66</td>
<td>107</td>
<td>107</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.77</td>
<td>0.91</td>
<td></td>
</tr>
</tbody>
</table>
and are significant. Additionally, the 1\textsuperscript{st} lag of the GMM and OLS model are close in magnitude and are highly significant. From this, we are able to infer that GMM and OLS estimators are biased upwards, whilst FE model is biased downward.

While our findings concur with Hausman (1984) in that FE’s coefficient is the lowest, there is a difference in the results where GMM are higher than the OLS model coefficients. Our results’ difference between the 1\textsuperscript{st} lagged dependent variable between the three models for Western Europe are not as large as it was for the entirety of the European Union. As before, our results from FE are incredibly low and insignificant. The difference between FE and GMM is that GMM is .601 percentage points higher. On the other hand, the difference between GMM and OLS is .056 percentage points. Our interpretation of this is that the number of our observations are a lot smaller. Moreover, we are not using the Poisson model.

With the exception of financial integration, trade openness and the number of migrants entering into Western Europe, all of our other standard variables are insignificant. Financial liberalisation is barely significant within the 10\% significance level. Openness to trade has a significant and positive effect upon the number of patents filed, where a one percentage point increase of openness to trade yields a 14.10 percentage point increase in number of patents filed. Financial integration and the number of migrants, however, has a negative and significant impact on the number of patents.

### 4.2.2 Western Europe R&D Expenditure

**Table 5: Western Europe R&D Expenditure**

<table>
<thead>
<tr>
<th></th>
<th>(1) R&amp;D Expenditure</th>
<th>(1) R&amp;D Expenditure</th>
<th>(2) R&amp;D Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GMM</td>
<td>FE</td>
<td>OLS</td>
</tr>
<tr>
<td>L.1 R&amp;D Expenditure</td>
<td>1.230</td>
<td>0.087</td>
<td>0.421</td>
</tr>
<tr>
<td></td>
<td>(8.42)**</td>
<td>(1.98)</td>
<td>(3.68)**</td>
</tr>
<tr>
<td>L.2 R&amp;D Expenditure</td>
<td>-0.407</td>
<td>0.011</td>
<td>-0.015</td>
</tr>
<tr>
<td>Variable</td>
<td>Coefficient 1</td>
<td>Coefficient 2</td>
<td>Coefficient 3</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Patents</td>
<td>0.012</td>
<td>0.092</td>
<td>0.041</td>
</tr>
<tr>
<td>European Union</td>
<td>0.115</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>Financial Integration</td>
<td>-0.086</td>
<td>-0.231</td>
<td>-0.036</td>
</tr>
<tr>
<td>GDP Growth (%)</td>
<td>-0.002</td>
<td>-0.004</td>
<td>0.005</td>
</tr>
<tr>
<td>Euro</td>
<td>-0.024</td>
<td>0.015</td>
<td>-0.034</td>
</tr>
<tr>
<td>GDP per Capita</td>
<td>0.052</td>
<td>-0.006</td>
<td>0.174</td>
</tr>
<tr>
<td>Foreign Reserves</td>
<td>-0.043</td>
<td>-0.064</td>
<td>-0.047</td>
</tr>
<tr>
<td>Researchers</td>
<td>0.219</td>
<td>0.474</td>
<td>0.448</td>
</tr>
<tr>
<td>Corporate Tax</td>
<td>-0.244</td>
<td>-0.179</td>
<td>0.645</td>
</tr>
<tr>
<td>Trade Openness</td>
<td>-10.753</td>
<td>-1.782</td>
<td>5.068</td>
</tr>
<tr>
<td>Market Capitalisation</td>
<td>0.006</td>
<td>0.012</td>
<td>0.047</td>
</tr>
<tr>
<td>Financial Liberalisation</td>
<td>5.025</td>
<td>0.951</td>
<td>-2.429</td>
</tr>
<tr>
<td>Institution</td>
<td>-0.000</td>
<td>-0.007</td>
<td>-0.008</td>
</tr>
<tr>
<td>Private Credit</td>
<td>-0.032</td>
<td>0.097</td>
<td>0.005</td>
</tr>
<tr>
<td>Migrants</td>
<td>-0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Single Market</td>
<td>-0.075</td>
<td></td>
<td>(0.88)</td>
</tr>
</tbody>
</table>
Accession into the EU is barely significant within the 10% level, but still has a positive impact on R&D intensity. Table 5 indicates that the last year has a significant and positive impact on current R&D Expenditure. We are able to infer that the 1st lag of the dependent variable is positive and is highly significant. This shows that a positive increase of 1 percentage point within the 1st lag of number of patents file, holding all other variables constant, and should yield an increase of a 1.23 percentage point increase in number of patents filed. Nevertheless, the 2nd lag of our dependent variable suggests that the effects of 2 years ago still have an adverse and significant effect upon our dependent variable. This indicates that a one percentage point increase in the 2nd lag would yield a -.407 percentage point decrease in R&D expenditure. Conversely, our FE results, concerning our 1st and 2nd lag dependency variable are positive and insignificant. The OLS model results are both positive in magnitude, but the 1st lag dependent is significant whilst the 2nd lag is not.

Financial integration has a negative effect and is significant for R&D expenditure. As specified in Section 1B, there are two types of financial funding: equity-type and debt-type. In Figure 8, IFIGDP is the predominant type of funding within Western Europe. Baldwin and Gellatly (2003) opined that firms vary between different types of financial structures. The authors postulated that innovative companies tend to prefer equity financial structures whilst financing their innovative activities (John Russel Baldwin, 2003, p. 315). In addition, if there is a high debt-to-equity ratio, it is less likely to be innovative. Conversely, Browyn Hall and Josh Lerner (2009) postulate that companies in Europe require a steady and focused ownership that helps encourage R&D because they are less likely to require immediate returns. These authors may help explain why our financial integration variable, where IFIGDP dominates IEQ, is negative.

Additionally, financial liberalisation is significant and has a positive magnitude. Nevertheless, openness to trade is negative and highly significant, where a one
percentage point increase in openness to trade is correlated with a 10.753 percentage point decrease in R&D expenditure. There have been numerous papers that indicates the incentive to innovate decreases from international competition, and vice versa. Arrow (1962), Gilbert and Newbury (1982) and Grossman and Helpman’s (1991) findings concur that, although the decrease in barriers to trade has generated numerous profits, there have been several negative side effects such as the monetary benefits or knowledge stock decrease with the increase of competition. According to Albu (2011), spending on R&D expenditure declines as we go from North and West, to South and East. Additionally, the differences in R&D expenditure and the number of patents filed, the convergence between North and West to South and East hasn’t yet occurred. Moreover, Keller postulated that eight OECD countries from 1970 to 1991 received more benefits from domestic R&D than foreign. Furthermore, the import makeup of a nation matters only if it is favoured towards or away from technological leaders (Keller, 1999, p. 1).

### 4.2.3 Correlation

![Figure 12: Western Europe & Correlation of its variables](image)

This was why we decided to test for correlation to ensure that the values are not large enough to warrant a drop from our formula. In Figure 12, R&D expenditure is positively and moderately correlated to our patents variable, .6797, but is not high enough to
warrant a drop. Additionally, the correlation between R&D expenditure and the lagged patent variable drops as time decreases, for example the 1st lag and R&D expenditure correlation is .6325, whilst the 2nd lag is at .5111. GDP per capita is moderately correlated with foreign reserves and the single market at .6153 and .5991. Our lagged variables are highly correlated to one another, but that is to be expected. Financial integration and institution variable are highly correlated to one another at .7516. This warrants a bit of caution.3 4

2. Eastern Europe Innovation Indicators

After performing the Breusch-Pagan/Cook-Weisberg test for heteroscedasticity within our model, we have differentiating results from our two innovative indicators. The Breusch-Pagan test results depicts the Prob > chi2 = .0703 for the patent dependent variable, whereas the test for the R&D expenditure variable shows Prob >chi2 of 0.000. We can conclude from these tests that we fail to reject the notion heteroskedasticity within the model of patents, but we soundly reject the null hypothesis for R&D expenditure. From this result, we can infer that results from our GMM model for patents would be less reliable than an instrumental linear regression model. This will be further discussed in Section 5, our policy, discussion and limitations page, as to why we did not choose to include in an instrumental linear regression model. Conversely, since we can soundly reject the null hypothesis of heteroskedasticity within the R&D Expenditure’s GMM model, the GMM model would be better.

In Table 6, the results indicate that entry into the European Union and openness to trade has a significant and a negative impact on the number of patents filed for CEE. Moreover, the results also indicate that the 2nd lag of the dependent variable still has a

3 Our European Union variable was dropped due to multicollinearity in Table 6 for & FE model. This could be because our time frame is not adequate enough to capture the full effects of the difference before joining the European Union and afterwards. Additionally, the single market policy was dropped in our GMM & FE model.

4 In Table 7, R&D Expenditure for Western Europe, our European Union and single market variables were omitted due to collinearity for GMM & FE model. We believe that the European Union variable and single market variable were omitted due to a lack of variance between the variables after the numerous drops of missing data.
significant and positive effect upon the number of patents filed currently than the 1\textsuperscript{st} lag. R&D expenditure has an overall positive magnitude and is significant. Similarly, to our Western European and European Union Hausman results, our Central Eastern European results indicates that fixed effects would be a better gauge of the model and is situated within Column (2) (\textit{as can be seen in Appendix 2}) in Table 6.

For Table 7, within Column (2) the Hausman test results (.0044) dictates that we utilised the FE model (\textit{Appendix 3}). Our results within Table 5 from our FE and OLS models show that our explanatory variables are statistically insignificant. Additionally, our two lagged dependent variables are both statistically insignificant along with the majority of our standard explanatory variables. Both OLS and FE models do not allow for lagged variables, additionally we did not employ any instrumental variables.

The Table – results indicate that the 1\textsuperscript{st} lag of our dependent variable has a more significant and positive impact in comparison to our 2\textsuperscript{nd} lag. Financial integration for CEE has an adverse impact on R&D Expenditure and is significant. Additionally, the migrants variable is also negative and has a significant effect upon R&D expenditure.

### 4.3.1 Central & Eastern Europe Innovation Indicators

\textbf{Table 6: CEE’s Number of Patents Filed}

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patents</td>
<td>Patents</td>
<td>Patents</td>
</tr>
<tr>
<td></td>
<td>GMM</td>
<td>FE</td>
<td>OLS</td>
</tr>
<tr>
<td>L.1 Patents</td>
<td>0.220 (1.51)</td>
<td>0.185 (2.93)**</td>
<td>0.229 (2.98)**</td>
</tr>
<tr>
<td>L.2 Patents</td>
<td>0.285 (2.03)*</td>
<td>-0.212 (3.89)**</td>
<td>-0.131 (1.74)</td>
</tr>
<tr>
<td>European Union</td>
<td>-0.219 (3.70)**</td>
<td>0.131 (1.00)</td>
<td>-0.067 (0.47)</td>
</tr>
<tr>
<td>Financial Integration</td>
<td>0.071 (0.87)</td>
<td>0.075 (0.73)</td>
<td>0.227 (1.57)</td>
</tr>
<tr>
<td></td>
<td>Coefficient</td>
<td>Standard Error</td>
<td>t-Statistic</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------</td>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Euro</td>
<td>0.016</td>
<td>(0.04)</td>
<td></td>
</tr>
<tr>
<td>GDP Growth</td>
<td>0.023</td>
<td>(2.68)**</td>
<td></td>
</tr>
<tr>
<td>Researchers</td>
<td>-0.049</td>
<td>(0.24)</td>
<td></td>
</tr>
<tr>
<td>Corporate Tax</td>
<td>-0.988</td>
<td>(1.10)</td>
<td></td>
</tr>
<tr>
<td>Knowledge Stock</td>
<td>0.442</td>
<td>(2.23)*</td>
<td></td>
</tr>
<tr>
<td>Foreign Reserves</td>
<td>0.150</td>
<td>(1.11)</td>
<td></td>
</tr>
<tr>
<td>GDP per Capita</td>
<td>-0.045</td>
<td>(0.23)</td>
<td></td>
</tr>
<tr>
<td>Trade Openness</td>
<td>-0.112</td>
<td>(3.30)**</td>
<td></td>
</tr>
<tr>
<td>Financial Liberalisation</td>
<td>0.090</td>
<td>(0.94)</td>
<td></td>
</tr>
<tr>
<td>Market Capitalisation</td>
<td>0.045</td>
<td>(0.84)</td>
<td></td>
</tr>
<tr>
<td>Institution</td>
<td>-0.003</td>
<td>(0.49)</td>
<td></td>
</tr>
<tr>
<td>Private Credit</td>
<td>0.483</td>
<td>(1.81)</td>
<td></td>
</tr>
<tr>
<td>Migrants</td>
<td>0.118</td>
<td>(1.99)*</td>
<td></td>
</tr>
<tr>
<td>_cons</td>
<td>-3.116</td>
<td>(0.89)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>47</td>
<td></td>
<td>53</td>
</tr>
<tr>
<td>R²</td>
<td>0.91</td>
<td></td>
<td>0.97</td>
</tr>
</tbody>
</table>

* p<0.05; ** p<0.01

By delineating Central Eastern Europe from Western Europe, we were able to isolate the effects of European integration, predominately economically, within this region alone.
Our results from FE and OLS with the 1st lag has indicated that our results are statistically significant and yields a mild and a positive magnitude. Nevertheless, the results in FE differs from the OLS findings in significance, but are close to each other in magnitude. These findings have shown that if future researchers choose to measure the benefits of the European Union, it would be prudent to do either panel data with instrumental variables or GMM modelling with more observations.

Moreover, if we look at our GMM results, some of our results are significant: the 2nd lag of our dependent variable, European Union, number of migrants, knowledge stock and Openness to Trade. Our 2nd lag of number of patents filed has a positive effect upon the current number of patents filed in respect to our 1st lag, this indicates that a one percentage point increase in our 2nd lag denotes a .285 percentage point increase in current number of patents filed. Knowledge stock also has a positive and significant impact on the number of patents applied, however, as in the Western Europe result, our results are negative, yet significant. Additionally, contrary to Western Europe’s results, migration yields a positive and significant impact upon number of patents filed. Our interpretation of this is that joining the European Union allowed for greater inflow of capital, although insignificant amongst our results, which allowed multinationals to purchase local corporations and bring in new migrants who help produce more innovation.

Nevertheless, entering the European Union has an adverse and significant impact upon current number of patents filed. A one percentage increase in joining the EU, holding all other variables constant, yields a .219 percentage point decrease in the number of patents filed. This also goes against our expectations, but with further research it goes in-line with recent literature that was released by Europa Eurostat Statistic explained. According to Europa, from 2005 to 2012, the amount of applications, both in relative and absolute terms, filed to the European Patent Office (EPO) fell for 15 member states: Malta, Cyprus, Greece, Germany, Italy and Netherlands (Eurostat, 2015). Additionally, although joining the EU does bring in more trade, and thusly increasing competition, the Anti-Counterfeiting Trade Agreement (2012) has actually harmed the number of patents filed by countries within the European Union. In addition, there are 27 different and
divisive laws for companies, which makes it harder for companies to file patents. This could have an effect on our study.

According to Minniti and Levesque (2010), although the majority of the R&D expenditure within CEE is incredibly low, as can be seen in Figure 5, yet exceptional growth to yield technological change. Hogselius (2003) findings have indicated that part of the reason for negative results is the “catch-up” theory, where the difference in innovative activities is rooted in the low value-added due to the utilisation of low-wage labour. Concurrently, Lengyel, Sebestyen, and Leydesdorff’s (2013) work indicate that, although the patenting at the city level of the CEE countries outpaces those of Western counties and nations, nevertheless, the likelihood of CEE catching up within the innovative sphere is unlikely unless innovation policy changes so that the policies focus on both international relations of companies and indigenous inventors. Berglof et al (2009) stated that during the financial crisis in 2008, there was a noticeable decline for 70% of corporations within CEE countries for their products. This would have an adverse effect on their innovation activities because the National Innovation System (NIS) in CEE would not be able to play a part in stabilising investments. According to Osamu Onodera (2008), openness to trade is supposed to induce competition within a domestic market and therefore contributes to innovative gains and productivity. According to most theoretical research, the higher the level of openness to trade between an emerging market and a developed market, the higher the probability of convergence of the emerging country with the developed country. Nevertheless, Onodera also believes that the role of trade can also have a detrimental impact on innovation, such as having an adverse consequence on imports within scale economies and a reduction on accessible for inventions (Onodera, 2008). Development economic researchers believe that the current multilateral rules on intellectual property rights (IPR) favour industry leaders, and that, under the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIP), industry followers will be unable to attain the technological know-how. Therefore, the followers will be unable to extrapolate the information that is required to create imitative technology (Onodera, 2008). Migration has an insignificant effect on R&D expenditure.

Although some of our results are in-line with Minniti and Levesque (2010) and Onodera
(2008), our sample size is incredibly small. It is our belief that our results are skewed because of the small group of observation, which goes against the GMM model’s purpose. The GMM model was created to estimate for short and wide panels, additionally, to fit within a linear regression where there is one dynamic dependent variable, supplementary controls and fixed effects (Goodman, 2008:2).

4.3.2 Central & Eastern Europe R&D Expenditure

Table 7: R&D Expenditure within CEE

<table>
<thead>
<tr>
<th></th>
<th>(1) R&amp;D Expenditure</th>
<th>(2) R&amp;D Expenditure</th>
<th>(3) R&amp;D Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GMM</td>
<td>FE</td>
<td>OLS</td>
</tr>
<tr>
<td>L.1 R&amp;D Expenditure</td>
<td>0.798 (5.34)**</td>
<td>0.147 (0.89)</td>
<td>0.548 (3.33)**</td>
</tr>
<tr>
<td>L.2 R&amp;D Expenditure</td>
<td>-0.018 (0.14)</td>
<td>0.137 (1.00)</td>
<td>0.168 (1.04)</td>
</tr>
<tr>
<td>Patents</td>
<td>0.043 (0.57)</td>
<td>0.111 (1.45)</td>
<td>0.080 (0.98)</td>
</tr>
<tr>
<td>European Union</td>
<td>0.048 (0.73)</td>
<td>-0.009 (0.15)</td>
<td>0.072 (1.27)</td>
</tr>
<tr>
<td>Financial Integration</td>
<td>-0.086 (3.10)**</td>
<td>-0.010 (0.20)</td>
<td>-0.126 (2.47)*</td>
</tr>
<tr>
<td>Euro</td>
<td>0.124 (0.69)</td>
<td>0.418 (2.43)*</td>
<td>0.140 (0.91)</td>
</tr>
<tr>
<td>GDP Growth</td>
<td>-0.007 (2.55)*</td>
<td>0.000 (0.06)</td>
<td>-0.004 (0.74)</td>
</tr>
<tr>
<td>Researchers</td>
<td>0.208 (1.35)</td>
<td>0.249 (2.29)*</td>
<td>0.286 (2.10)*</td>
</tr>
<tr>
<td>Corporate tax</td>
<td>0.200 (0.47)</td>
<td>-1.306 (1.71)</td>
<td>1.496 (2.77)**</td>
</tr>
<tr>
<td>Foreign Reserves</td>
<td>0.067 (0.83)</td>
<td>0.201 (3.12)**</td>
<td>0.086 (1.64)</td>
</tr>
</tbody>
</table>
Knowledge stock    -0.256     -0.244     -0.240
                  (1.86)    (1.33)    (1.79)
Trade Openness    0.036      -0.038     0.024
                  (1.11)    (0.63)    (0.89)
Financial Liberalisation  0.037     -0.016     0.057
                          (1.79)    (0.34)    (0.96)
Market Capitalisation -0.014     -0.071     -0.050
                          (0.47)    (1.82)    (1.05)
Institution        -0.008      0.004     -0.009
                          (1.43)    (0.58)    (1.65)
Private Credit     0.327     0.136     0.411
                          (1.96)*    (0.68)    (2.32)*
Migration          -0.034     -0.014     -0.030
                          (2.35)*    (0.29)    (0.59)
 _cons              -1.415     -5.039     -3.336
                          (0.87)    (3.93)**   (3.07)**
N                   47        53        53
$R^2$               0.85      0.97

* $p<0.05$; ** $p<0.01$

By isolating CEE, we are able to see whether or not ascension to the EU helped CEE like it did with Western Europe. Unfortunately, all of our results are statistically insignificant. Our interpretation of this is that $\rho$’s (2003) theory is correct. The author believed that by lagging the dependent variable, that some of the explanatory variables’ values would be drastically reduced and be rendered insignificant. The results from the OLS model indicates that our 2nd lag is statistically insignificant, yet its 1st lag results indicate a positive magnitude and is highly significant. Our first lag depicts a negative coefficient, meanwhile, our second lag shows a positive magnitude. Whilst the FE model depicts the same – positive in magnitude and statistically insignificant. From the results available in Table 7, it is possible to extrapolate that the 2nd lag of the dependent variable does not affect the current R&D expenditure. Nevertheless, our 1st lag of the dependent variable has a highly significant and positive percentage point for current R&D expenditure, where a one percentage point increase in the 1st lag of the dependent variable, holding all other variables constant, yields a 79.8 percentage point increase in
R&D expenditure.

By running all three models, we are able to see that OLS is the closest in magnitude and signs to our GMM results. Therefore, for further research, it would be highly prudent to use an instrumental linear regression model. With the exception of GDP growth (%), Liberalisation, and private credit to GDP, the control variables are all insignificant within the .05 range.

Financial integration has a negative effect upon R&D expenditure, indicating that a one percentage point increase is associated with an 8.56 percentage point decrease in R&D expenditure, holding all other variables constant. Additionally, the results from Table – indicates that an influx of migrants yields a decrease and significant impact on R&D expenditure; where a one percentage point increase in number of migrants entering CEE is associated with a 3.44 percentage point decrease of R&D expenditure.

According to our data set, with the exception of Slovenia and Estonia, most of the CEE countries depict a very low percentage of spending in R&D expenditure relative to their GDP. According to Albu (2011), this can have an adverse effect upon innovation because it implies a weak business infrastructure and weak business investment for R&D. This could help explain our negative results. Additionally, Minniti and Levesque (2008) opined that, due to the low returns on R&D expenditure, in numerous emerging countries the high presence of imitative works increases competition, but does not lead to a higher input into innovative activities.

4.3.3 Correlation

Figure 13: Variables within CEE & Their Correlation
Figure 13 exhibits the correlation between multiple variables within our equation. If there is a deep correlation between the variables, it would be recommended that we should omit the variable from the equation. For immigration and the number of patents, the 1st lag of number of patents and 2nd lag of the patents filed depicts a strong correlation between one another at .7803, .6063, .4856. Where the 1st and 2nd lag R&D spending and the number of researchers are highly correlated with one another at .9634 and .9342, respectively. Single market and the number of researchers are inversely correlated with one another at -.6238. Whilst openness to trade and financial liberalisation are highly correlated with one another at .8278. We believe this stems from our lack of data prior to 1996 to allow for more variance within our data set. Additionally, the overall institutions index is inversely correlated with the number of migrants at -.6256. Nevertheless, the equations should be considered with caution because there is a slight relationship between these variables.5

Chapter 5: GMM: Sargan & Arellano Bond-Estimator Tests

The Arellano-Bond estimator test utilises the linear dynamic panel-data model which includes the \( p \) lags of the dependent variable and utilises them as covariates, and contains the unobserved fixed and random effects of panel-level data (Stata manual, 2016). To test for the validity of the dynamic panel data, we decided to use the GMM test of over identifying restrictions within our model by utilising the Sargan test (1958). Therefore, Section 4.1 to 4.3 comprises of information on the estat abond test and the

5 Within our GMM, FE and OLS models, single market was omitted due to collinearity and was therefore dropped from the equation.
Sargan results to ensure that our models are correctly specified; that there are no over-identifying restrictions.

According to the Stata Manual, “The conditions of estat abond is valid only if there is no autocorrelation in the idiosyncratic errors” (Stata Manual, 2014, p. 3). If the results from Estat Abond are greater than .05, this signifies that the moment conditions may not be valid (Stata Manual, 2014). The Sargan test is utilised to examine the null hypothesis of the model and to ensure that the over-identifying conditions are correctly specified (Drukker, 2008:13).

The Sargan results can be found within the Appendix 4. This section will be delineated into two main areas for the estat and Sargan test within the three regions of our model – Patent & R&D Expenditure.

According to Goodman, “demonstrates in simulations of very small samples (50 – 75 observations that the bias of GMM rises as more instruments, based on deeper lags of variables, are introduced” (Goodman, 2008:4). This could help explain our high Prob > chi2 values for our Sargan test model. Furthermore, we ran a robustness test to see that if we decrease the number of lags, our Prob > chi2 decrease.

Goodman (2009) postulated that small-samples but numerous instruments have two main issues. The first is that, when there are too many instruments, by virtue, may over-fit the endogenous variables. Additionally, although this problem is more specific to the feasible efficient GMM, in which sample moments are utilised to approximate an optimum weighting matrix to ascertain moments between the various instruments and errors (Goodman, 2009, p.3). Whereby, the weakened specification from these two problems can cause the results appear both valid and invalid at once (Goodman, 2009, p.3). Windmeijers’ findings postulated that when the author reduced the amount of instruments from 28 to 13, an 8 by 100 panel, thereby diminishing the GMM bias by 40% (Winmeijer, 2006)

The high level of instruments could come from a wide-sized T-sample, since Goodman (2008) believed that the number of instruments could rise easily relative to the sample size, therefore causing some specification tests to become misleading. Our results from
the Sargan tests indicate that the number of instruments may be relatively too high for our observations. The only results that differ from one another in the European Union is for the CEE area.

5.1 Arellano-Bond Estimator for countries within the European Union

A. Table 8: European Union Estat Test for R&D

<table>
<thead>
<tr>
<th>Order</th>
<th>Z</th>
<th>Prob &gt; z</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.6094</td>
<td>.1075</td>
</tr>
<tr>
<td>2</td>
<td>.73823</td>
<td>.4606</td>
</tr>
</tbody>
</table>

**H0: No Autocorrelation**

Order 1 and Order 2 both fail to reject the null hypothesis for Estat Abond. Therefore, the abond test for autocorrelation for the 1st lag and 2nd lag is insignificant. We can conclude that the instruments are warranted and the model is accurately specified.

After utilising the Sargan test, our Prob > chi2 is .7622. The number of observation is 66, whilst the number of instruments is 71. Therefore, we fail to reject the null hypothesis of the Sargan test because approximations with a high number of instruments are prone to various problems. Nevertheless, since we failed to reject the null hypothesis, our instruments may be valid. This warrants further study.

Whilst running the robustness test, the prob > chi2 is now .0237 (Appendix 1) and therefore, we can soundly reject the null hypothesis of the Sargan test. Additionally, by decreasing our lag by one, the number of observations increased by 13 and the number of instruments also increased by 10. This is a noticeable decrease of 96.89%.

B. Table 9: Estat Exam for Number of Patents Filed

<table>
<thead>
<tr>
<th>Order</th>
<th>Z</th>
<th>Prob &gt; z</th>
</tr>
</thead>
</table>
Within this section, we did an overview Sargan and an Estat Abond test within the European Union for the number of patents applied. The Estat Abond test for serial correlation yields a statistical insignificant result. Thereby, causing us to fail to reject the null hypothesis for the 1st and 2nd lag of our model. Our interpretation of this is that the instruments were justified.

Unfortunately, for the Sargan test, the Prob > chi2 = .7564, therefore we have failed to reject the null hypothesis for the Sargan test. The number of observations within this region is 127, whilst the number of instruments utilised to control for endogeneity is 106.

A way to test our robustness is to decrease our lag by one, the results can be seen in Appendix 4. Our original Prob > chi2 was .7564, after our robustness test it increased to .9932 – a 31.30% increase. This could be due to the fact that, since we removed one lag there was an increase of observations to 142, whilst the number of instruments also increased to 109.

5.2 Arellano-Bond Estimator for Western Europe

A. R&D Expenditure within Western Europe Estat Test

<table>
<thead>
<tr>
<th>Order</th>
<th>Z</th>
<th>Prob &gt; z</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.629</td>
<td>.1033</td>
</tr>
<tr>
<td>2</td>
<td>.66937</td>
<td>.5033</td>
</tr>
</tbody>
</table>

H0: No Autocorrelation

The number of instruments that was provided by running GMM for this model is 71, whilst the number of observations is 66.
The Arellano-Bond estimator autocorrelation test with the 1st lag is insignificant, whilst the 2nd lag is significant. From this, we can conclude that the instruments are valid and therefore, the model is accurately specified.

As we have specified before, when the number of observations is close to the number of instruments, the model may be over-fitted by endogenous variables. This could result from our tests where Prob > chi2 is .8320, thereby causing us to fail to reject the null hypothesis.

As specified by David Rood (2008), since our results include too many instruments relative to the number of observations, we will need to run a robustness test. After running our robustness test, the Prob > chi2 decreased from .8320 to .0372, a noticeable decrease of 95.5%. Nevertheless, contrary to Windmeijer’s (2005) results, the number of our instruments grew in respect to our robustness test: from 71 to 81, an increase of 22.5%.

B. Number of Patents Filed in Western Europe GMM Tests

Table 11: Western Europe Patent Estat Abond Test

<table>
<thead>
<tr>
<th>Order</th>
<th>Z</th>
<th>Prob &gt; z</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.6955</td>
<td>.0900</td>
</tr>
<tr>
<td>2</td>
<td>.42844</td>
<td>.6683</td>
</tr>
</tbody>
</table>

H0: no autocorrelation

Although the Estat Abond test results shows that the 1st lag is barely significant within the 10% level, we fail to reject the null hypothesis for our 2nd lag. Our interpretation is that our model is accurately specified, is serially correlated, and that the usage of instruments was warranted.

The Sargan test indicates that we fail to reject the null hypothesis, but that the over-identifying premises are valid, since our Prob > chi2 value is .7115 whilst our degree of freedom 53. Since we failed to reject our null hypothesis, some of the instruments did
not pass the test. We attribute our results to the low number of observations, 66, and relatively high number of instruments, 71, and therefore can over-fit the endogenous variables. Our results agree with the results produced by Tauchen (1986) and Ziliak (1997), where the GMM results were biased due to the small sample.

To ensure that our results are valid, we ran a robustness check by decreasing our lagged dependent variable by one. Our robustness test results can be found in Appendix 4. By reducing our two lagged dependent variable to one lag, there is an increase from .7115 to .9755 – an increase of 37%. The increase for Prob > chi2 is because there was an increase of 13 observations and an increase of 10 instruments.

5.3 Arellano-Bond Estimator for Central Eastern Europe

A. Table 12: CEE’s Linear Dynamic Panel-Data Estimation R&D Expenditure

<table>
<thead>
<tr>
<th>Order</th>
<th>Z</th>
<th>Prob&gt;z</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-2.0809</td>
<td>.0374</td>
</tr>
<tr>
<td>2</td>
<td>-.6068</td>
<td>.5440</td>
</tr>
</tbody>
</table>

H0: no autocorrelation

However, the results from the Estat Abond test for CEE & the innovation indicator – patents – differs from the overall European Union and Western Europe. The Abond estimator test indicates that, although the 1st lag of the dependent variable is significant, our 2nd order is insignificant. From this result, it is possible to deduce that the usage of instruments is warranted and that the model is accurately specified.

Our Sargan test is available in Appendix 4, where our Prob > chi2 is equal to 0.7752. This indicates that we fail to reject our null hypothesis. Nevertheless, this could be that we have too many instruments (57) for our model, especially with the low amount of observations (47). Our interpretation of this is that the test does not contain enough power due to the limited number of observations, especially since the number of instruments is similar to the number of observations.
We ran a robustness test to see if this would be rectified by decreasing the number of lags from two to one to see if Prob > chi2 would decrease, our results can be found in Appendix 4. Our results indicate that although the Prob > chi2 value is .6627, a reduction of 14.51%, we fail to reject the null hypothesis. Our number of observations and number of instruments increased, although the number of our instruments continues to be higher than our observations.

B. Table 13: CEE’s Arellano-Bond Estimator Test for Patents

<table>
<thead>
<tr>
<th>Order</th>
<th>Z</th>
<th>Prob&gt;z</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.6747</td>
<td>.0940</td>
</tr>
<tr>
<td>2</td>
<td>-.9593</td>
<td>.3374</td>
</tr>
</tbody>
</table>

H0: no autocorrelation

According to the Melbourne Institute, “If there is no autocorrelation in the error term, when taking the first differences, we expect to find the first order serial correlation but no second order serial correlation” (Pudney, 2012, p. 13). In this case, we found both 1st and 2nd order serial correlation, suggesting that there may be a specification issue.

The Sargan test results are available in Appendix 4. The Prob > chi2 value is .8415 and our degree of freedom is 38. As in the previous Sargan results, the number of instruments (57), overlaps our number of observations (47). Nevertheless, when there are more instruments than there are numbers of observations, it means that our model is over-identified with more moment restrictions than there are parameters to estimate. Therefore, we can assume that the estimations from IV and GMM would have been the same. As such, our interpretation is that we fail to reject the null hypothesis.

After running a robustness test by decreasing to one lag to see if this would have a high impact on Prob > chi2, Appendix 4, decreasing our 2nd lag by one, our Prob > chi2 decreased from .8415 to .7309, an approximately 13.1% reduction. The number of observations is still less than the number of instruments. Our interpretation still holds.

Chapter 6: Discussion
Crescenzi and Rodriguez-Pose stated, “The progressive liberalisation of the movements of capital and labour, the sharp reduction in the cost of international and intercontinental travel as well as the purportedly progressive convergence…the frictionless availability of information…” (Crescenzi, 2011, p. 8). The foundation of the European Union created a frictionless movement of labour, capital, services and goods, a “single market”, and deepening financial and political integration that embodies Crescenzi’s statement.

As a result of joining the European Union, countries now have access to new capital markets, increased knowledge stocks and exchange between, and a liberalisation of trade. The barriers between nations have been significantly decreased, thereby creating more competition to induce innovation projects. Since the Lisbon strategy, the European Union has switched to a new economic development model: a knowledge based economy (Crescenzi, 2011). Change in technology is more territory specific, whilst innovation is dependent on tacit knowledge, codified knowledge, and cultural social processes. Hence why we decided to delineate the European Union into two main regions: Western Europe and Eastern Europe.

Hausman et al. (1984) focused on creating a model that compared the results of the Poisson distribution model, random effects and the OLS regression, on the effects that R&D expenditure has on patents. Their results indicate that the coefficients from the random effects model tend to be estimated downward, whilst the coefficients from the Poisson and OLS regression model tends to estimate upwards. One of their main results is that there is a decreasing benefit that can be generated from R&D expenditure overtime for new research into patents. We utilised their model but with several adjustments such as, instead of using the Poisson model, we used GMM. Our Hausman tests indicate that since our p-value is less than .05, it would be prudent to use the fixed effects model. Additionally, we ran an OLS regression on our equations. Due to the limitations of this paper, we were unable to include in an instrumental linear regression.

The results exhibited in previous sections depict some limitations and will require further analysis between the variables. Additionally, due to numerous incomplete data
sets from the World Bank, IMF, OECD and Eurostat, we were forced to drop numerous variables, such as business density and the number of venture capitalist funds. Although our results are in-line with previous research, the small set of observations created a limitation for our regression, such as our failure in the Sargan test model in Section 4, except for the 3.1A robustness model.

Our results confirm Hausman et. al’s (1984) findings – where the two lagged dependent variables for GMM and OLS are estimated upwards whilst the Fixed Effects’ results are estimated downwards. However, our GMM results are sometimes substantially higher than the OLS’ coefficients. Our interpretation of this is that the small sample size of our model may lead to an unreliable conclusion. Goodman exhibits that “in simulations of very small samples (50 – 75 observations that the bias of GMM rises as more instruments, based on deeper lags of variables, are introduced” (Goodman, 2008:4).

Although our predominate independent variable, ascension to the European Union is predominately insignificant. The financial integration benefit of joining the EU is significant and positive, where it is associated with an increase of .133 percentage point for the number of patents filed. Nevertheless, the financial integration also has an adverse effect on R&D expenditure within the EU. Although financial integration allows for companies to access capital markets that they normally would not have access to, this may lead contagion from other countries’ financial crises. Although Sahay et al. (2015) believe that financial integration has numerous boons, financial development is shaped like a bell-curve since it has a weakening effect at higher levels of financial development. This has a detrimental effect on R&D expenditure since, with the increased financial integration, it is more likely for a country’s fiscal policies to cross over and affect other countries; like in 2008. During the financial crisis in the EU in 2008, several of the member states such as Germany, Austria and the Nordic countries tried to stimulate their economy by increasing public R&D (European Commission, 2014). However, there were some countries, Poland, Slovakia, Croatia, Lithuania, Latvia, Cyprus and Greece, whose main source of R&D expenditure stems from the public sector and were therefore unable to so. This had an adverse effect on R&D.
When we delineated our European Union member states based on their geographical location, Western and Eastern, we were able to isolate the benefits. As Sahay, Cihak, and N’Diaye (2015) stated, financial development has an adverse impact on higher integrated economies. Due to the high reliance on foreign capital, Central Eastern Europe was also adversely effected, hence the negative effect on R&D expenditure.

The free movement of labour, which is categorised by the variable migrants, is predominately negative depending on the region and the innovation indicator. Venturini and Sinha (2012) postulate that, although there is a positive correlation between skilled migrants and patents, the effects of highly-skilled workers and manual labourers varies between migration streams. Therefore, the structure of immigrants from various backgrounds is more important to innovation.

With the exception of knowledge stock for CEE regarding patents, all other knowledge stock variables were insignificant. Part of the issue is that knowledge stock can be delineated into two different ways: tacit and codified knowledge. Tacit knowledge is hard to transfer as it is predominately rooted in one place. Our interpretation of the increase in knowledge stock for CEE derives from an increase of multinational corporations opening up branches within the region and imitative innovation, which helped increase the number of patents & R&D expenditure.

Our results correlated with the reports released from the European Central Bank and Eurostat R&D reports. Alfaro & Charlton (2006) investigated the relationship between entrepreneurial activity and international financial integration within a country. From their results, we are able to infer that financial integration confers positive and significant effects, and occurs within industries that are more dependent on external finance. In addition, entrepreneurial activity is greater within industries that contain a larger share of foreign firms. Moreover, Manova (2008) agrees with Alfaro (2006). The author examines the sector growth within the growth of international financial liberalisation for equity markets, where the results show that the sectors that grew the most had a high dependence on external financing.
We tested to see whether there were benefits in joining the European Union. Our result for European Union countries was that: a one percentage increase in financial integration yields a .128 percentage point increase in the number of patents filed within the EU. Overall, our results indicate that there are both financial and political gains from EU integration, but there are negative aspects such as a deepening of financial integration, which can lead to a spread of contagion. Additionally, the influx of migrants, which needs to be delineated into high-skilled and low-skilled labourers, would have been a better gauge rather than only the influx itself. For instance, knowledge stock is positive and is significant for Western and Eastern Europe for both R&D expenditure and patents.

Chapter 7: Conclusions

In conclusion, this paper has investigated whether or not there are benefits for two innovation indicators, R&D expenditure and number of patents filed, after ascension to the European Union. The variables were based on the benefits of joining the European Union, such as single currency, single market, political integration, a greater degree of financial integration, by using the nation’s international investment and quantity-based measure, knowledge stock: R&D expenditure for the number of patents filed and GDP per capita for R&D expenditure, and the freedom of movement of goods, services and labour, which are categorised as openness to trade, researchers and number of migrants. Afterwards, we delineated the European Union into two main regions to measure the benefits of joining the EU: Western Europe and Eastern Europe.

Our results indicate that, although financial integration has positive effects overall for European Union countries, it has negative effects depending on the region. For instance, although financial integration has a positive effect on the number of patents filed, it had an adverse impact on R&D expenditure. This could stem from exposure from the financial crisis in 2008, where corporations were less likely to extend credit to even those of good credit standing. Inessa Love stated, “Financing constraints tighten for many firms, leading them to cut investments in capital as well as research and development (R&D) and to bypass attractive investment projects” (Love, 2015, p. 1).
As Campos et. al (2014) postulated, “deep integration” has substantial benefits for the member states within the EU. By joining the EU, the GDP per Capita and labour productivity have increased within certain member states. Our research agrees with Campos et. al (2014) that for Western Europe this is barely significant at 10% level, with a positive effect on R&D expenditure. Whilst for Central Eastern Europe, entering the European Union has a highly significant and negative effect. Unfortunately, we do not know if the percentage point would have increased or decreased if CEE countries did not join the EU.

There are two main directions for further research. First, if one would like to measure the benefits of joining the EU for Western countries, it would be more prudent to do a counter-factual method or to do an instrumental linear regression. Due to the incomplete data and small sample set, our results may be skewed, however, there has been research that has been published that believes our methods are correct and may be heading in the correct direction. Secondly, for Central Eastern Europe, we believe that more time needs to pass to properly measure the gains that CEE may or may not reap from being in the EU. As of right now, their low R&D expenditure is indicative that they are predominately doing imitative innovation projects as Minniti and Levesque (2010) postulated. In conclusion, as an overall whole, the countries within the European Union has reaped numerous benefits of the single union. However, by delineating between the regions, a different picture is painted. With further time, it would be prudent to do this type of research again, as there would be more observations available.
Bibliography


Anon., n.d.

Anon., n.d.


IIIs, P. R. L., 2009. *Innovation and Financial Globalisation*, Dublin: s.n.,


Kneer, C., 2013. *Finance as a Magnet for the best and brightest: implications for the real economy*, Amsterdam: De Netherlandsche Bank NV.


89 | P a g e


## Appendix

### Appendix 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patents</td>
<td>World Intellectual Property Organisation</td>
</tr>
<tr>
<td>GDP</td>
<td>World Bank</td>
</tr>
<tr>
<td>Financial Assets</td>
<td>International Monetary Fund</td>
</tr>
<tr>
<td>Financial Liabilities</td>
<td>International Monetary Fund</td>
</tr>
<tr>
<td>IFIGDP</td>
<td>Author’s Calculation</td>
</tr>
<tr>
<td>Portfolio Assets</td>
<td>Lane &amp; Mileti-Ferretti Database</td>
</tr>
<tr>
<td>Portfolio Liabilities</td>
<td>Lane &amp; Mileti-Ferretti Database</td>
</tr>
<tr>
<td>Portfolio Debt GDP</td>
<td>Author’s Calculation</td>
</tr>
<tr>
<td>Institutions</td>
<td>Heritage Foundation</td>
</tr>
<tr>
<td>Foreign Reserves</td>
<td>World Bank</td>
</tr>
<tr>
<td>GDP per Capita</td>
<td>World Bank</td>
</tr>
<tr>
<td>Corporate Tax</td>
<td>World Bank</td>
</tr>
<tr>
<td>Openness to Trade</td>
<td>Author’s calculation</td>
</tr>
<tr>
<td>Tertiary Population</td>
<td>World Bank</td>
</tr>
<tr>
<td>Private Credit</td>
<td>World Bank</td>
</tr>
<tr>
<td>Market Capitalisation</td>
<td>World Bank</td>
</tr>
<tr>
<td>R&amp;D Expenditure (% of GDP)</td>
<td>World Bank</td>
</tr>
<tr>
<td>Foreign Direct Investment</td>
<td>United Nations</td>
</tr>
<tr>
<td>Financial Liberalisation</td>
<td>Chinn-Ito Index</td>
</tr>
</tbody>
</table>

### Appendix 2: Breusch-Pagan Tests

**Breusch-Pagan Test For European Union**

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity  
Ho: Constant variance  
Variables: lnpatents_1 lnpatents_2 EuropeanUnion infin GDPGrowth euro lnpdpcap single_market inresearch lnreserves corporatetax lntrade lnmarket Liberalisation Institution lnpriv lnmigrant

\[
\chi^2(17) = 301.36 \\
\text{Prob} > \chi^2 = 0.0000
\]

**Breusch-Pagan / Cook-Weisberg Test for Heteroskedasticity for European Union & R&D Expenditure**
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

H0: Constant variance

Variables: lnrdexpen_1 lnrdexpen_2 lnpatents EuropeanUnion lnfin GDPGrowth lngdpccap lnreserves euro single_market lnresearch corporatetax lntrade lnmarket Liberalisation Institution lnpriv lnmigrant

\[ \text{chi}^2(18) = 105.81 \]
\[ \text{Prob} > \text{chi}^2 = 0.0000 \]

Breusch-Pagan Test for Western Europe’s Number of Patents Filed

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

H0: Constant variance

Variables: lnrdexpen_1 lnrdexpen_2 lnpatents EuropeanUnion lnfin{lngdpccap GDPGrowth}

\[ \text{euro single_market lnresearch lnreserves corporatetax lntrade lnmarket Liberalisation Institution lnpriv lnmigrant} \]

\[ \text{chi}^2(17) = 112.43 \]
\[ \text{Prob} > \text{chi}^2 = 0.0000 \]

Breusch-Pagan Test for Western Europe’s R&D Expenditure

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

H0: Constant variance

Variables: lnrdexpen_1 lnrdexpen_2 lnpatents EuropeanUnion lnfin{lngdpccap GDPGrowth}

\[ \text{lnreserves euro single_market lnresearch corporatetax lntrade lnmarket Liberalisation Institution lnpriv lnmigrant} \]

\[ \text{chi}^2(10) = 56.79 \]
\[ \text{Prob} > \text{chi}^2 = 0.0000 \]

Breusch-Pagan Test for CEE Europe’s Number of Patents Filed

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

H0: Constant variance

Variables: lnpatents_1 lnpatents_2 EuropeanUnion lnfin{lngdpccap GDPGrowth}

\[ \text{lnresearch corporatetax lnrdexpen lnreserves lngdpccap lntrade lnmarket Liberalisation Institution lnpriv lnmigrant} \]

\[ \text{single_market} \]

\[ \text{chi}^2(17) = 26.23 \]
\[ \text{Prob} > \text{chi}^2 = 0.0703 \]

Breusch-Pagan Test for CEE Europe’s R&D Expenditure
Appendix 3: Hausman Test

Hausman Test for the European Union’s Patents

<table>
<thead>
<tr>
<th></th>
<th>Coefficients</th>
<th>(b)</th>
<th>(E)</th>
<th>(b-E)</th>
<th>sqrt(diag(V_b-V_E))</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>fixed</td>
<td>random</td>
<td>Difference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnpatents_1</td>
<td>0.0410428</td>
<td>0.0607082</td>
<td>-0.054651</td>
<td>.0007427</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnpatents_2</td>
<td>-0.0001671</td>
<td>0.0031291</td>
<td>-0.0041902</td>
<td>.00042673</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lngdp_cap</td>
<td>0.3755369</td>
<td>0.2698172</td>
<td>0.1057197</td>
<td>.0722834</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EuropeanU-n</td>
<td>-0.2264642</td>
<td>0.0353655</td>
<td>-0.2660207</td>
<td>.0008583</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnrdexpen</td>
<td>0.7241428</td>
<td>1.251388</td>
<td>-0.5272449</td>
<td>.1377079</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnfin</td>
<td>0.179274</td>
<td>0.2843014</td>
<td>-0.1050279</td>
<td>.0339858</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDFGrowth</td>
<td>0.0005942</td>
<td>0.0120531</td>
<td>-0.0114589</td>
<td>.00025097</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnreserves</td>
<td>0.064447</td>
<td>0.0768571</td>
<td>-0.0124123</td>
<td>.0324648</td>
<td></td>
<td></td>
</tr>
<tr>
<td>euro</td>
<td>0.0477005</td>
<td>0.0441233</td>
<td>0.0035772</td>
<td>.00422353</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnresearch</td>
<td>0.2996487</td>
<td>0.0503346</td>
<td>0.2493142</td>
<td>.1107135</td>
<td></td>
<td></td>
</tr>
<tr>
<td>corporatetax</td>
<td>-1.894387</td>
<td>-2.664018</td>
<td>-0.7696316</td>
<td>.8621373</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lntrade</td>
<td>0.16597</td>
<td>0.070288</td>
<td>0.0956821</td>
<td>.0620318</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnmarket</td>
<td>0.0302774</td>
<td>-0.0339696</td>
<td>0.064247</td>
<td>.0309612</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liberalisa-n</td>
<td>-0.141977</td>
<td>-0.0561288</td>
<td>-0.0858199</td>
<td>.0288305</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institution</td>
<td>-0.0128181</td>
<td>-0.0134548</td>
<td>0.0006367</td>
<td>.0047695</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnpriv</td>
<td>0.1277116</td>
<td>0.1295519</td>
<td>-0.0018403</td>
<td>.0547273</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immigrant</td>
<td>-1.056-06</td>
<td>-1.056-06</td>
<td>0.00000</td>
<td>1.27e-07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b = consistent under Ho and H1; obtained from xtregr
B = inconsistent under H1, efficient under Ho; obtained from xtregr

Test: Ho: difference in coefficients not systematic

\[
\chi^2(16) = (b-B)'[(V_{b-V_E})^{-1}](b-B)
\]
\[
= 65.53
\]
\[\text{Prob} > \chi^2 = 0.0000 \] (V_b-V_E is not positive definite)

Hausman Test R&D Expenditure within European Union
<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (b)</th>
<th>Coefficient (B)</th>
<th>Difference (b-B)</th>
<th>sqrt(diag(V_b-V_B)) S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnrdexpen_1</td>
<td>.1287231</td>
<td>.563678</td>
<td>-.4349549</td>
<td>.0443163</td>
</tr>
<tr>
<td>lnrdexpen_2</td>
<td>-.0165058</td>
<td>-.0204983</td>
<td>.0039925</td>
<td>.0035499</td>
</tr>
<tr>
<td>npatents</td>
<td>.1293497</td>
<td>.0390712</td>
<td>.0902785</td>
<td>.062078</td>
</tr>
<tr>
<td>EuropeanUn-n</td>
<td>.0364549</td>
<td>.0147124</td>
<td>.0217424</td>
<td>.043853</td>
</tr>
<tr>
<td>lninf</td>
<td>-.0763741</td>
<td>-.0184658</td>
<td>-.0579083</td>
<td>.0434274</td>
</tr>
<tr>
<td>lnindpcap</td>
<td>.0446249</td>
<td>.0775519</td>
<td>-.0329271</td>
<td>.0894673</td>
</tr>
<tr>
<td>lnreserves</td>
<td>-.0095809</td>
<td>-.0363458</td>
<td>.0267569</td>
<td>.0360691</td>
</tr>
<tr>
<td>GDPgrowth</td>
<td>-.0058307</td>
<td>-.0094834</td>
<td>.0036527</td>
<td>.0031083</td>
</tr>
<tr>
<td>euro</td>
<td>-.0187655</td>
<td>-.0344173</td>
<td>.0156518</td>
<td>.0422473</td>
</tr>
<tr>
<td>lnresearch</td>
<td>.3175931</td>
<td>.3138804</td>
<td>.039127</td>
<td>.1256439</td>
</tr>
<tr>
<td>corporatetax</td>
<td>.5688826</td>
<td>.2862132</td>
<td>.2826694</td>
<td>.7063339</td>
</tr>
<tr>
<td>lntrade</td>
<td>-.0225949</td>
<td>-.0053065</td>
<td>-.0172884</td>
<td>.0768323</td>
</tr>
<tr>
<td>lmmarket</td>
<td>-.0155421</td>
<td>.0211648</td>
<td>-.0367060</td>
<td>.0271391</td>
</tr>
<tr>
<td>Liberalisa-n</td>
<td>-.0205111</td>
<td>.0567764</td>
<td>-.0772875</td>
<td>.0502762</td>
</tr>
<tr>
<td>Institution</td>
<td>-.0073683</td>
<td>-.004522</td>
<td>-.0028463</td>
<td>.0055794</td>
</tr>
<tr>
<td>lnpriv</td>
<td>.0610869</td>
<td>-.0363005</td>
<td>.0973874</td>
<td>.0711282</td>
</tr>
<tr>
<td>lnmigrant</td>
<td>1.45e-07</td>
<td>9.12e-08</td>
<td>5.38e-08</td>
<td>1.57e-07</td>
</tr>
</tbody>
</table>

b = consistent under Ho and Ha; obtained from xtreg  
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

\[
\chi^2(16) = (b-B)'[(V_{b-V_B})^{-1}](b-B) \\
= 112.10
\]

Prob>\chi^2 = 0.0000  
\(V_{b-V_B} \text{ is not positive definite})

Hausman Test for Western Europe
### Coefficients

<table>
<thead>
<tr>
<th></th>
<th>fixed</th>
<th>random</th>
<th>(b-B)</th>
<th>sqrt(diag(V_b-V_B))</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnpatents_1</td>
<td>.0125275</td>
<td>.5579669</td>
<td>-.3454394</td>
<td>.0736739</td>
<td></td>
</tr>
<tr>
<td>lnpatents_2</td>
<td>.0042669</td>
<td>.0829019</td>
<td>-.0765349</td>
<td>.032038</td>
<td></td>
</tr>
<tr>
<td>lnrdexpen</td>
<td>.4098813</td>
<td>2.531862</td>
<td>-2.121981</td>
<td>1.270528</td>
<td></td>
</tr>
<tr>
<td>lnfin</td>
<td>.3790192</td>
<td>1.201533</td>
<td>-.8226339</td>
<td>.530859</td>
<td></td>
</tr>
<tr>
<td>GDPGrowth</td>
<td>.00552707</td>
<td>-.0208992</td>
<td>.0261699</td>
<td>.0324295</td>
<td></td>
</tr>
<tr>
<td>lnrdcap</td>
<td>.0891259</td>
<td>-.2645613</td>
<td>.3536872</td>
<td>.5583639</td>
<td></td>
</tr>
<tr>
<td>lnreserves</td>
<td>-.151742</td>
<td>.330042</td>
<td>-.481784</td>
<td>.3619902</td>
<td></td>
</tr>
<tr>
<td>euro</td>
<td>.0518659</td>
<td>-.7093914</td>
<td>.7614572</td>
<td>.217908</td>
<td></td>
</tr>
<tr>
<td>lnresearch</td>
<td>.6993806</td>
<td>-1.576339</td>
<td>2.27572</td>
<td>1.231231</td>
<td></td>
</tr>
<tr>
<td>corporatetax</td>
<td>-2.385663</td>
<td>-9.423462</td>
<td>7.039797</td>
<td>5.315006</td>
<td></td>
</tr>
<tr>
<td>intrade</td>
<td>-5.670735</td>
<td>-30.11389</td>
<td>24.44315</td>
<td>16.14586</td>
<td></td>
</tr>
<tr>
<td>lnmarket</td>
<td>-.0257328</td>
<td>-.5792405</td>
<td>.5535077</td>
<td>.2049291</td>
<td></td>
</tr>
<tr>
<td>Liberalisa-n</td>
<td>2.748058</td>
<td>16.62979</td>
<td>-13.88174</td>
<td>8.553946</td>
<td></td>
</tr>
<tr>
<td>Institution</td>
<td>-.0291269</td>
<td>-.0659631</td>
<td>.0368362</td>
<td>.0593394</td>
<td></td>
</tr>
<tr>
<td>lnpriv</td>
<td>.0164111</td>
<td>-.240608</td>
<td>.2570191</td>
<td>.4272206</td>
<td></td>
</tr>
<tr>
<td>lnimmigrant</td>
<td>-1.20e-06</td>
<td>3.46e-07</td>
<td>-1.54e-06</td>
<td>9.54e-07</td>
<td></td>
</tr>
</tbody>
</table>

\[ b = \text{consistent under } H_0 \text{ and } H_a; \text{ obtained from } xtr \]

\[ B = \text{inconsistent under } H_a, \text{ efficient under } H_0; \text{ obtained from } xtr \]

Test: \( H_0: \) difference in coefficients not systematic

\[ \chi^2(12) = (b-B)'[\text{diag}(V_b-V_B)^{-1}](b-B) = 85.16 \]

\[ \text{Prob}>\chi^2 = 0.0000 \]

(V_b-V_B is not positive definite)

Hausman Test for R&D within Western Europe
### Coefficients

<table>
<thead>
<tr>
<th></th>
<th>(b) fixed</th>
<th>(b) random</th>
<th>(b-B) Difference</th>
<th>sqrt(diag(V_b-V_B))</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnrdexpen_1</td>
<td>0.0874682</td>
<td>0.4208311</td>
<td>-0.3333629</td>
<td>0.0473544</td>
<td></td>
</tr>
<tr>
<td>lnrdexpn_2</td>
<td>0.0110512</td>
<td>-0.149645</td>
<td>0.260157</td>
<td>0.0343072</td>
<td></td>
</tr>
<tr>
<td>lnpatents</td>
<td>0.0924545</td>
<td>0.0414556</td>
<td>0.0509989</td>
<td>0.0950514</td>
<td></td>
</tr>
<tr>
<td>lnrdpcsp</td>
<td>-0.062635</td>
<td>0.174059</td>
<td>-0.23805</td>
<td>0.0349504</td>
<td></td>
</tr>
<tr>
<td>lnfin</td>
<td>-0.2308395</td>
<td>-0.0355034</td>
<td>-0.1953361</td>
<td>0.0767003</td>
<td></td>
</tr>
<tr>
<td>lnreserves</td>
<td>-0.0640662</td>
<td>-0.0473156</td>
<td>-0.0167526</td>
<td>0.0554624</td>
<td></td>
</tr>
<tr>
<td>GDPgrowth</td>
<td>-0.0039387</td>
<td>0.0047459</td>
<td>0.0086846</td>
<td>0.0053292</td>
<td></td>
</tr>
<tr>
<td>euro</td>
<td>0.015409</td>
<td>-0.0336015</td>
<td>0.0490106</td>
<td>0.0334324</td>
<td></td>
</tr>
<tr>
<td>lnresearch</td>
<td>0.4736564</td>
<td>0.4477162</td>
<td>0.0259402</td>
<td>0.1806154</td>
<td></td>
</tr>
<tr>
<td>corporatetax</td>
<td>-0.1792027</td>
<td>0.644946</td>
<td>0.8242287</td>
<td>0.6902054</td>
<td></td>
</tr>
<tr>
<td>lntrade</td>
<td>-1.782458</td>
<td>5.068471</td>
<td>-6.85093</td>
<td>2.545889</td>
<td></td>
</tr>
<tr>
<td>lnmarket</td>
<td>0.122913</td>
<td>0.0466491</td>
<td>-0.076358</td>
<td>0.0325073</td>
<td></td>
</tr>
<tr>
<td>Liberalisa-n</td>
<td>0.9514965</td>
<td>-2.428907</td>
<td>3.380403</td>
<td>1.337542</td>
<td></td>
</tr>
<tr>
<td>Institution</td>
<td>-0.006777</td>
<td>-0.0083227</td>
<td>0.001545</td>
<td>0.0095523</td>
<td></td>
</tr>
<tr>
<td>lnpriv</td>
<td>0.097409</td>
<td>0.0048387</td>
<td>0.0925704</td>
<td>0.0613734</td>
<td></td>
</tr>
<tr>
<td>lnimmigrant</td>
<td>1.03e-07</td>
<td>3.61e-08</td>
<td>6.67e-08</td>
<td>1.98e-07</td>
<td></td>
</tr>
</tbody>
</table>

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

\[
\text{chi2}(12) = (b-B)'[(V_b-V_B)^{-1}](b-B)
\]

\[
= 69.45
\]

Prob>chi2 = 0.0000

(V_b-V_B is not positive definite)

Hausman Test for Central Eastern Europe
### Coefficients

<table>
<thead>
<tr>
<th></th>
<th>(b) fixed</th>
<th>(B) random</th>
<th>(b-B) Difference</th>
<th>sqrt(diag(V_b-V_B)) S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnpatients_1</td>
<td>0.1845632</td>
<td>0.2293516</td>
<td>-0.0447884</td>
<td>0.0314964</td>
</tr>
<tr>
<td>lnpatients_2</td>
<td>-0.2116047</td>
<td>-0.1310279</td>
<td>-0.080577</td>
<td>0.0209149</td>
</tr>
<tr>
<td>EuropeanUn-h</td>
<td>0.1309167</td>
<td>0.0671225</td>
<td>0.1980332</td>
<td>0.0924031</td>
</tr>
<tr>
<td>lnfin</td>
<td>0.0745734</td>
<td>0.2272477</td>
<td>-0.1526743</td>
<td>0.0700582</td>
</tr>
<tr>
<td>euro</td>
<td>0.3635639</td>
<td>0.2809414</td>
<td>0.0846225</td>
<td>0.278637</td>
</tr>
<tr>
<td>GDPGrowth</td>
<td>0.0106081</td>
<td>0.0058179</td>
<td>0.0047902</td>
<td>0.0080376</td>
</tr>
<tr>
<td>lnresearch</td>
<td>-0.2477829</td>
<td>-0.2956269</td>
<td>0.0478471</td>
<td>0.1385195</td>
</tr>
<tr>
<td>corporatetax</td>
<td>-0.1309785</td>
<td>-3.976459</td>
<td>3.845481</td>
<td>1.986529</td>
</tr>
<tr>
<td>lnrdsxpen</td>
<td>1.047988</td>
<td>0.9743965</td>
<td>0.0735913</td>
<td>0.3560796</td>
</tr>
<tr>
<td>lnreserves</td>
<td>0.2647868</td>
<td>0.2610945</td>
<td>0.0037024</td>
<td>0.1442338</td>
</tr>
<tr>
<td>lnodpcap</td>
<td>-0.4800632</td>
<td>-3.296487</td>
<td>-1.504144</td>
<td>0.4157863</td>
</tr>
<tr>
<td>lntrade</td>
<td>0.3609373</td>
<td>0.657054</td>
<td>0.3151519</td>
<td>0.1219428</td>
</tr>
<tr>
<td>Liberalisa-n</td>
<td>-0.287763</td>
<td>-2.968062</td>
<td>0.0090432</td>
<td>0.0716008</td>
</tr>
<tr>
<td>lnmarket</td>
<td>0.0807874</td>
<td>0.0975896</td>
<td>-0.0168022</td>
<td>0.0654654</td>
</tr>
<tr>
<td>Institution</td>
<td>-0.0060915</td>
<td>-0.0067911</td>
<td>0.0006975</td>
<td>0.0127502</td>
</tr>
<tr>
<td>lnpriv</td>
<td>1.089032</td>
<td>0.692632</td>
<td>0.3963999</td>
<td>0.3267821</td>
</tr>
<tr>
<td>lnmigrant</td>
<td>0.2531767</td>
<td>0.3536725</td>
<td>-0.1004958</td>
<td>0.096233</td>
</tr>
</tbody>
</table>

b = consistent under Ho and Ha; obtained from xtregr
B = inconsistent under Ha, efficient under Ho; obtained from xtregr

**Test:** Ho: difference in coefficients not systematic

\[
\chi^2(5) = (b - B)'[V_{b-V_B}]^{-1}(b - B)
\]

\[
= 16.66
\]

Prob>\chi^2 = 0.0032

(V_{b-V_B} is not positive definite)

**Hausman Test for CEE & R&D Expenditure**
### Coefficients

<table>
<thead>
<tr>
<th>Variable</th>
<th>(b) fixed</th>
<th>(B) random</th>
<th>(b-B) Difference</th>
<th>sqrt(diag(V_b-V_B)) S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnrdexpen_1</td>
<td>0.2613515</td>
<td>0.6214529</td>
<td>-0.3601014</td>
<td>0.106818</td>
</tr>
<tr>
<td>lnrdexpen_2</td>
<td>0.0906584</td>
<td>0.1679645</td>
<td>-0.0773061</td>
<td>0.0775756</td>
</tr>
<tr>
<td>EuropeanUn-n</td>
<td>-0.010904</td>
<td>0.0681399</td>
<td>-0.0790438</td>
<td>0.0410267</td>
</tr>
<tr>
<td>lnfin</td>
<td>-0.007941</td>
<td>-0.1114535</td>
<td>0.1035123</td>
<td>0.0415237</td>
</tr>
<tr>
<td>euror</td>
<td>0.4490621</td>
<td>0.1759822</td>
<td>0.2730799</td>
<td>0.112572</td>
</tr>
<tr>
<td>GDPGrowth</td>
<td>0.0002804</td>
<td>-0.0046044</td>
<td>0.0048849</td>
<td>0.0036469</td>
</tr>
<tr>
<td>lnresearch</td>
<td>0.2352132</td>
<td>0.295027</td>
<td>-0.059896</td>
<td>0.0617613</td>
</tr>
<tr>
<td>corporatetax</td>
<td>-1.418666</td>
<td>1.213911</td>
<td>-2.632577</td>
<td>0.901866</td>
</tr>
<tr>
<td>lnreserves</td>
<td>0.2301288</td>
<td>0.116606</td>
<td>0.1135229</td>
<td>0.0561365</td>
</tr>
<tr>
<td>lnqdocp</td>
<td>-0.2802131</td>
<td>-0.26016</td>
<td>-0.020051</td>
<td>0.1950033</td>
</tr>
<tr>
<td>lntrade</td>
<td>0.0068678</td>
<td>0.0301239</td>
<td>-0.0232562</td>
<td>0.0593843</td>
</tr>
<tr>
<td>Liberalisa-n</td>
<td>-0.0426334</td>
<td>0.0346931</td>
<td>-0.0773765</td>
<td>0.0331078</td>
</tr>
<tr>
<td>lnmarket</td>
<td>-0.0810996</td>
<td>-0.030388</td>
<td>-0.0507108</td>
<td>0.0252135</td>
</tr>
<tr>
<td>lninstitute</td>
<td>-0.0019114</td>
<td>-0.0101350</td>
<td>0.0120473</td>
<td>0.00717</td>
</tr>
<tr>
<td>lnpriv</td>
<td>0.2865209</td>
<td>0.4896387</td>
<td>-0.2031178</td>
<td>0.1790115</td>
</tr>
<tr>
<td>lnmigrant</td>
<td>0.0066638</td>
<td>-0.0012685</td>
<td>0.0079323</td>
<td>0.0464435</td>
</tr>
</tbody>
</table>

\[ b = \text{consistent under } H_0 \text{ and } H_a; \text{ obtained from } \text{xtr} \text{reg} \]

\[ B = \text{inconsistent under } H_a, \text{ efficient under } H_0; \text{ obtained from } \text{xtr} \text{reg} \]

Test: \( H_0: \text{difference in coefficients not systematic} \)

\[ \chi^2(5) = (b-B)'[(V_{b-V_B})^{-1}](b-B) \]

\[ = 17.06 \]

\[ \text{Prob} > \chi^2 = 0.0044 \]

\((V_{b-V_B} \text{ is not positive definite})\)

### Appendix 4: Sargan Test

**Sargan’s Test for Patents Filed within European Union**

Sargan test of overidentifying restrictions

\( H_0: \text{overidentifying restrictions are valid} \)

\[ \chi^2(87) = 77.52913 \]

\[ \text{Prob} > \chi^2 = 0.7564 \]

**Robustness Test for Sargan & Patent within EU**

Sargan test of overidentifying restrictions

\( H_0: \text{overidentifying restrictions are valid} \)

\[ \chi^2(91) = 61.11762 \]

\[ \text{Prob} > \chi^2 = 0.9932 \]

Sargan Test for R&D with EU
Sargan test of overidentifying restrictions

H0: overidentifying restrictions are valid

\[ \text{chi}^2(54) = 46.30820 \]
\[ \text{Prob} > \text{chi}^2 = 0.7622 \]

Sargan Test EU’s Expenditure Robustness Test
Sargan test of overidentifying restrictions

H0: overidentifying restrictions are valid

\[ \text{chi}^2(64) = 88.33283 \]
\[ \text{Prob} > \text{chi}^2 = 0.0237 \]

Sargan Test for Patent in Western Europe
Sargan test of overidentifying restrictions

H0: overidentifying restrictions are valid

\[ \text{chi}^2(53) = 46.84096 \]
\[ \text{Prob} > \text{chi}^2 = 0.7115 \]

Robustness Sargan Test in Western Europe

Sargan test of overidentifying restrictions

H0: overidentifying restrictions are valid

\[ \text{chi}^2(63) = 42.87696 \]
\[ \text{Prob} > \text{chi}^2 = 0.9755 \]

Sargan Test for R&D Expenditure in Western Europe
Sargan test of overidentifying restrictions

H0: overidentifying restrictions are valid

\[ \text{chi}^2(65) = 89.96231 \]
\[ \text{Prob} > \text{chi}^2 = 0.0219 \]

Sargan Test for CEE & R&D
Sargan test of overidentifying restrictions

H0: overidentifying restrictions are valid

\[ \text{chi}^2(53) = 43.10878 \]
\[ \text{Prob} > \text{chi}^2 = 0.8320 \]

Robustness Test for R&D to See if Our Interpretation is correct
Sargan test of overidentifying restrictions
H0: overidentifying restrictions are valid

\[
\chi^2(63) = 84.4166
\]
Prob > \chi^2 = 0.0372

Sargan Test for CEE & Patents
Sargan test of overidentifying restrictions
H0: overidentifying restrictions are valid

\[
\chi^2(39) = 30.24036
\]
Prob > \chi^2 = 0.8415

Sargan Robustness Test for CEE & Patents
Sargan test of overidentifying restrictions
H0: overidentifying restrictions are valid

\[
\chi^2(43) = 36.9204
\]
Prob > \chi^2 = 0.7309