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# Foreign direct investment – understanding the position of Portugal in a European FDI network

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Proposal for Dissertation presented as partial requirement for obtaining the Master's degree in Information Management

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação
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# Foreign direct investment – understanding the position of Portugal in a European FDI network

by

Pedro Matos

Dissertation presented as partial requirement for obtaining the Master's degree in Information Management

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# DECLARATION OF ORIGINALITY

I declare that the work described in this document is my own and not from someone else. All the assistance I have received from other people is duly acknowledged and all the sources (published or not published) are referenced. This work has not been previously evaluated or submitted to NOVA Information Management School or elsewhere.

Lisboa, 27/02/2019
Pedro Afonso Vasconcelos Vilar Cadete de Matos

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## Abstract

In an increasingly global world and interconnected economies, understanding the role of foreign direct investment (FDI) is of utmost importance. The existence of many data sources, with different data details, pose a challenge to the analysis of FDI in its various dimensions. The main contribution of this study is to apply the network analysis methodology, to construct a presentation of the European Network FDI, identifying patterns, establishing trends and describing the relations between different countries over time. The position of Portugal in this EU network is also assessed. The results are presented by using specific visualisation tools that graphically illustrate the interlinkages between the economies.

## Keywords

Foreign direct investment; Network Analysis; European Union; Investment relations; Economic partners.

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## List of abbreviations and acronyms

| | |
|---|---|
| **BdP** | Banco de Portugal |
| **BMD4** | Balance of Payments and International Investment Position Manual |
| **BPM** | Balance of Payments and International Investment Position Manual |
| **ECB** | European Central Bank |
| **EU** | European Union |
| **FDI** | Foreign Direct Investment |
| **GDP** | Gross Domestic Product |
| **GI** | Greenfield investment |
| **IMF** | International Monetary Fund |
| **M&A** | Mergers and Acquisitions |
| **MNE** | Multinational Enterprises |
| **OECD** | Organisation for Economic Co-operation and Development |
| **UNCTAD** | United Nations Conference on Trade and Development |
| **USD** | United States Dollar |
| **WTW** | Word Trade WEB |

# 1. Introduction

Foreign Direct Investment (FDI) aims to describe the investment relations between different countries. It is commonly used to analyse the role of foreign companies and investors in the performance of the host economy and represents the transfer of technologies and capital between economies (Damgaard and Elkjaer, 2017). According to Rozanski (2014) foreign direct investments are crucial in the modern global economy with a role as boosters of economic activity worldwide. In recent years the share of FDI stock in global GDP has increased from 22% in 2000 to 35% in 2016 (ECB, 2018). More recently FDI took an important role in the international connections with implications not only to the investing country but also in the hosting country with an impact on the technological transfers, economic growth, increases in productivity, and other implications (ECB, 2018).

Despite the positive externalities to the host economy, there is still some debate on its consequences, especially when economic or financial crisis occur and the way it affects international relations between different countries.

From the policy maker perspective it is important to understand the dynamics of FDI to identify the sources of international investments and adapt it to the economic policy. In fact, FDI takes a major role especially during a financial crisis. In the 2008 financial crisis, for example, there was an increase on the policies to attract FDI not only to obtain external financing in a weak financial sector but also as a way to finance the economic agents (Silva, 2015).

The lack of agreement on this subject is mainly due to the different methodologies that each author uses to analyse a complex variable such as FDI. Each methodology can provide different conclusions specially when combined with data from different periods and countries (Simionescu, 2016). In this respect, FDI data presents high granularity and as such it is important to make a detailed analysis to fully capture the various dimensions of this variable.

Most authors use econometric methods to analyse the FDI, usually comparing with other economic variables, such as the gross domestic product (GDP). These methods are mainly obtained from Bayesian random effects models. The main constraints of these methodologies are related to the need for a short period analysis of the data and their dependency on other variables (Simionescu, 2016).

Taking into consideration these limitations, we will focus on FDI from a network perspective, considering total inward FDI stocks to analyse its behaviour not only for the European Union (EU) countries but in particular for the Portuguese economy. This methodology allows to trace the different relationships between the EU countries, defining the main and the peripheric players, interdependency level and the closeness between the economies. This perspective will allow to visualise the results with a deep detail, which cannot be performed in some other methodologies.

In a nutshell the main objective of this paper is to use network analysis tools to understand the behaviour of FDI in the EU context and in the Portuguese economy. To achieve this goal we will use data from different sources: Banco de Portugal (BdP), International Monetary Fund (IMF) and United Nations Conference on Trade and Development (UNCTAD).

This paper goes beyond the typical two-variable (FDI and GDP) assessment and uses network analysis to examine international FDI stocks in a long series period. The variable and methodology used will be the same as Li, Liao and Sun (2018), but focusing on a European Union network, providing a more detailed analysis on the FDI. The methodology was also applied by Amador and Cabral (2016), but with a different aim. We will consider the Balance of Payments and International Investment Position Manual (BPM6) by IMF, as a theoretical support for the practical analysis of the European Union network of foreign investment.

The rest of the paper is structured as follows: in chapter 2 it is briefly presented the variable in study, FDI, with some statistical data referring to its main behaviour trends, its importance for the EU countries and a brief background analysis of the used methodology. Chapter 3 presents our problem definition and what limitations we aim to overcome. In chapter 4 it is presented our main objective and the different specific objectives that we need to achieve. Chapter 5 briefly

presents the benefits that may be obtained from this work, specifically by using the network analysis methodology. Chapter 6 discusses the relevant literature on FDI, the different methodologies used to study it, and some literature on network analysis, the main methodology used. In chapter 7 we present the main data sources and the characteristics of the variables studied, and in chapter 8 we briefly present the methodology used to study the FDI in Europe and the definition of network analysis. In chapter 9 we present a European Union network and we study its metrics. In chapter 10 and 11 we study with more detail the Portuguese position in an European Union network of investment, presenting its metrics and main investors. In chapter 12 we analyse what were the main limitations faced and what future works should analyse. Finally, in chapter 13 we present some concluding remarks.

# 2. Background

According to the OECD Benchmark Definition of Foreign Direct Investment[1] "Direct investment arises when an investor resident in one economy makes an investment that gives control or a significant degree of influence on the management of an enterprise that is resident in another economy. Direct investment refers to the flows and positions that arise between parties in a direct investment relationship". The investment must assign to the direct investor at least 10% of the voting power of the direct investment enterprise. It must also give to the direct investor access to the host/invested economy. This means that the investor has at least two benefits from investing in an enterprise located in a different country: he gains some control over the enterprise and the access to that market.

As explained in ECB (2018) the investment is made through greenfield investments (as through a subsidiary abroad) or through mergers and acquisitions (M&As). Greenfield investment (GI) is made by multinational enterprises (MNEs), with the goal of pursuing economic activities that are very similar or complementary to those already developed by the investor company. Merges and acquisitions concern the achievement of at least 10% of the shares in the existing firm. M&As are driven by the following main objectives:

1) To exploit possible synergies between the investor and the target enterprise (e.g. in terms of production methodologies, patents or technologies);
2) To increase the market share by purchasing competitors;
3) To ensure access to goods or assets that are unique to the target company country.

However not all firms can invest abroad. Generally there are three basic conditions that allow a company to internationalize (Helpman, Melitz and Yeaple, 2004):

- High productivity that allow give the company the capability to invest;

[1] Fourth edition.

- The existence of advantages that are firm-specific and that define the business core;
- A strong market position in the home country.

From the perspective of the host economy there are many benefits that can be obtained from foreign investment. New enterprises can improve domestic economy's efficiency through new technology. This can increase competitiveness and spillovers as MNEs integrate domestic companies into their production chain. Depending on the hosting country the existence of foreign companies in a country may also increase qualifications and wages of the locals (Blomstrom and Kokko, 1998).

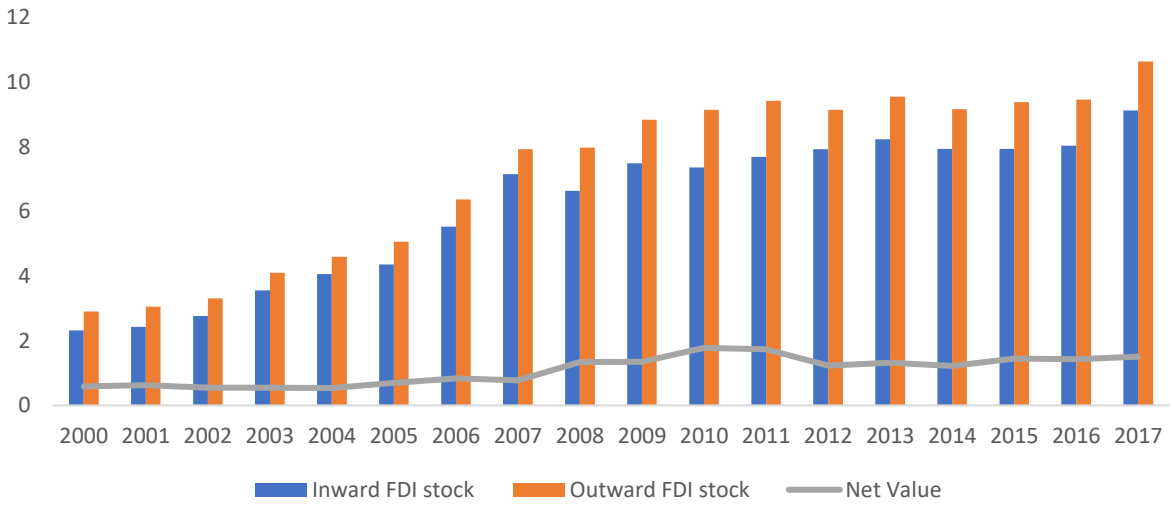
In addition, one of the main drivers for the capital movement among countries is firms' financial needs. With globalization most economies have turned to FDI as a tool to finance the economy. The external financing can be obtained through domestic agents, for example banks, or by foreign investment, from external economic agents (European Commission 2014).

Endogenous and exogenous factors should be considered to surpass financial needs. Endogenous variables, for example, consider the company characteristics, and their access to the financial market. As for the exogenous variables, market behaviour, interest rates, and other economic variables should be taken into consideration. In the last years, these exogenous variables have become more evident, especially during the 2008 financial crisis that caused great difficulties in the financial sector and in the banking sector. In this respect, many economies found in FDI a source of investment (Silva, 2015).

FDI contributions to a country economy however are not limited to cover its financial constraints. During a crisis period, one of the main issues of FDI is to promote the country's economic growth (Guris et all, 2015). Figure 1 represents the total FDI inward and outward stock in the current 28 EU countries. It can be observed that since 2000 there has been an increase on the total FDI stock (inward and outward). Inward stocks increased from 2.3 billions of dollars in 2000 to 9,1 billions of dollars in 2017 (75% increase).The outward stocks increased from 2,9 billions of dollars in 2000 to 10 billions of dollars in 2017 (73% increase).

Accordingly, the net value (the difference between outward inward), has maintain in a stable position during these 17 years.

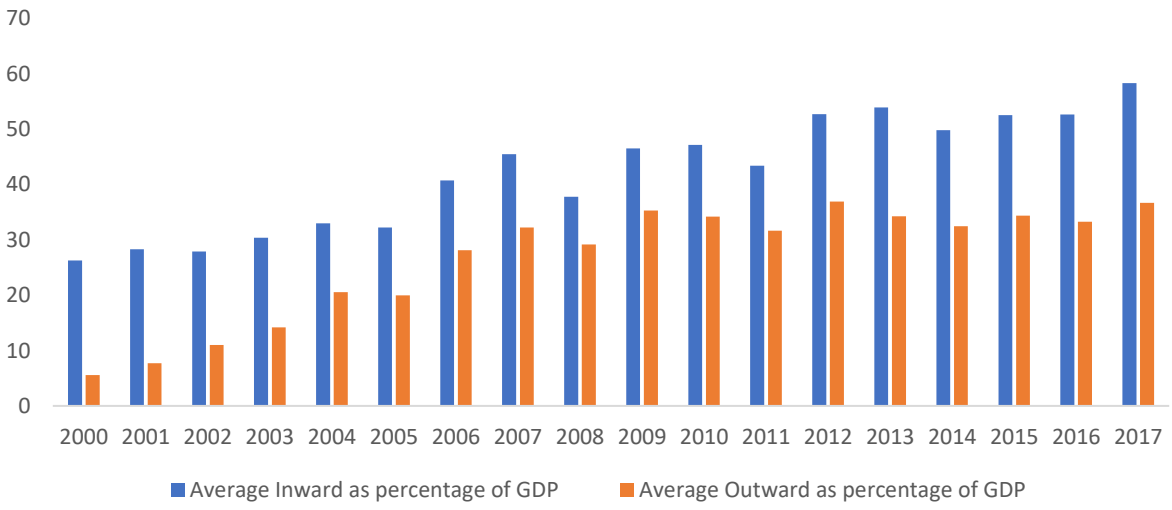
Figure 1 - Inward and Outward FDI Stock for the EU 28 countries ($10^9$ of USD)




Source: United Nations Conference on Trade and Development (UNCTAD)

The importance of both inward and outward FDI has increased over the period in analysis. To better understand the importance of FDI in the European economies it must be analysed in percentage of its GDP. The average of FDI stocks for the 28 European countries, as percentage of their GDP, is presented in figure 2. The average FDI inward stocks as percentage of the EU GDP has increased from 26% to 58%. The average FDI outward stocks increased from 5% to 36%.

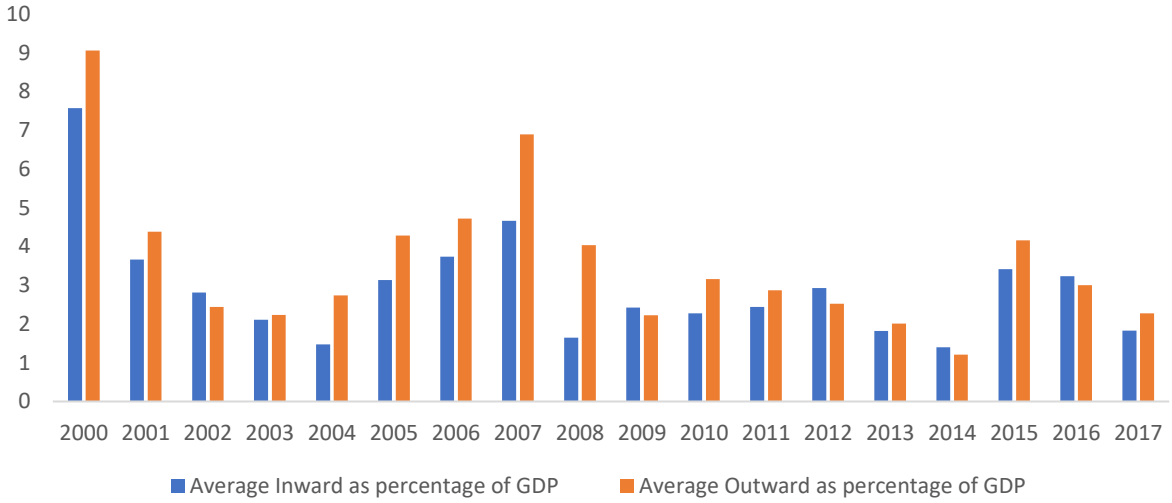
Figure 2 - Average FDI stocks as percentage of GDP for EU 28 countries




Source: United Nations Conference on Trade and Development (UNCTAD)

It should be mentioned that most figures presented in this chapter take into consideration FDI stocks, and not flows. A detailed explanation on the two different type of measures is provided in the following chapters, but in this case, we will also analyse the average FDI flows as percentage of GDP for the EU 28 countries (figure 3). A complementary analysis can be provided by the flows which represent the changes of the FDI stocks. The annual changes were minor and presented decreases even when the FDI stocks were increasing, as in 2017. This means that since 2008, the average FDI inward as percentage of GDP, has increased but the annual increase has not been stable.

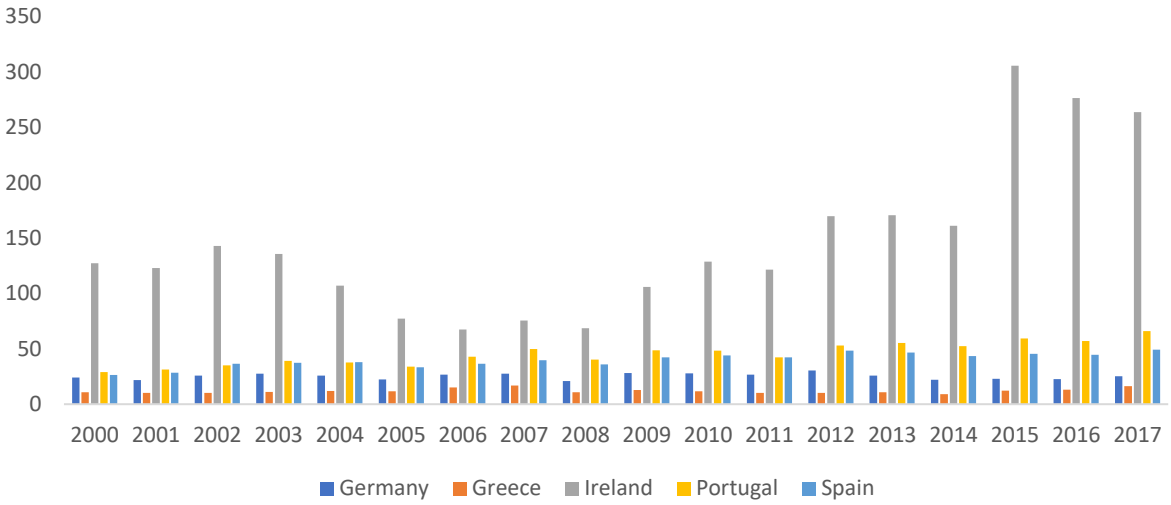
Figure 3 - Average FDI flows as percentage of GDP for EU 28 countries




Source: United Nations Conference on Trade and Development (UNCTAD)

In figure 4 a comparison among five countries is performed. Inward FDI stocks are represented for the four countries that received external financial aid during the most recent economic and financial crisis, Spain, Greece, Ireland and Portugal. In addition, FDI data is represented for the Deutsche economy, used as benchmark reference.

Figure 4 - Inward FDI stocks for Germany, Greece, Ireland, Portugal and Spain as percentage of their GDP




Source: United Nations Conference on Trade and Development (UNCTAD)

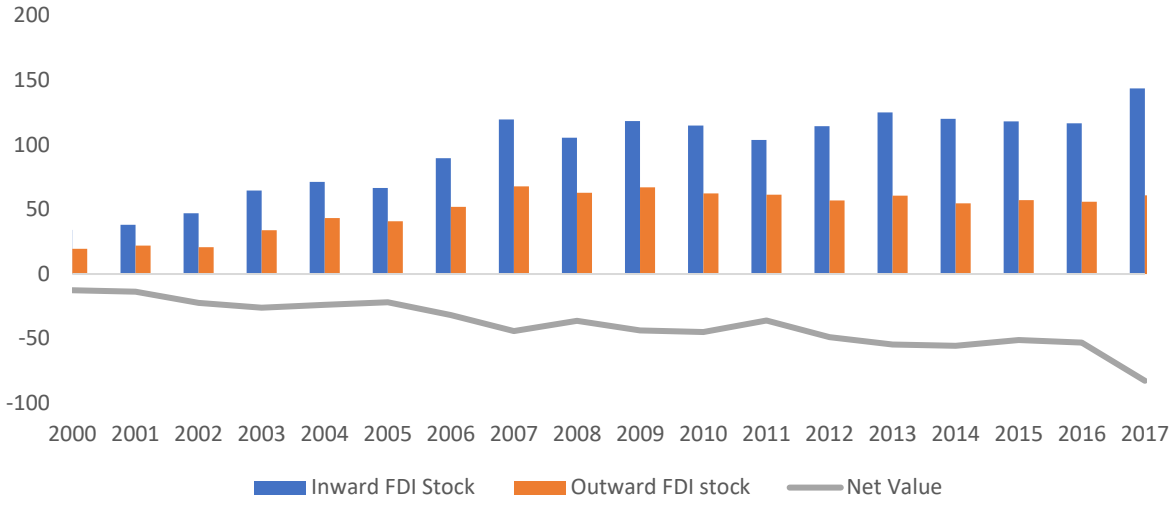
According to figure 4 Ireland was the country with the higher FDI inward increase. Spain FDI inward as percentage of its GDP increased from 26% in 2000 to 49% in 2017.

On the other hand, the Greek economy captured only a small amount of inward FDI, and in 2017 it was only 16% of its GDP. Finally, the Portuguese economy finished 2017 with FDI inward at 66% of its GDP, higher then the value of 28% registered in 2000. The benchmark economy, Germany, kept the inward FDI value stable at 25% during the entire period.

Portuguese data can be analysed in more detail in figure 5 for inward stocks, outward stocks and net value, between 2000 and 2017.

It shows an increase both on the inward and on the outward stocks since 2000. In 2017 the inward stock was 71% higher then in 2000, and the outward stock increased by 65% comparing to 2000. This trend follows the same observed for the 28 EU countries. However the Portuguese net value is negative, which means that the inward stocks have been higher than the outward stocks, concluding that Portugal receives more investment from abroad then it invests.

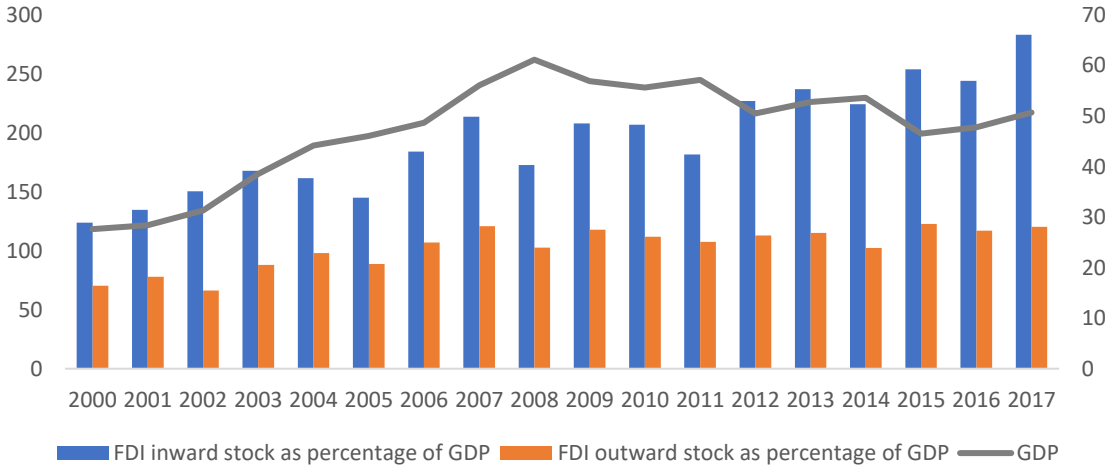
Figure 5 - Inward and Outward FDI stock for Portugal ($10^9$ of USD)




Source: United Nations Conference on Trade and Development (UNCTAD)

Figure 6 shows the Portuguese FDI stocks as a percentage of the Portuguese GDP. The inward FDI contribution to the GDP has registered an increase, from 28% in 2000 to 66% in 2017. The outward FDI contribution increased from 16% in 2000 to 28% in 2017.

Figure 6 - FDI as percentage of the Portuguese GDP ($10^9$ of USD)

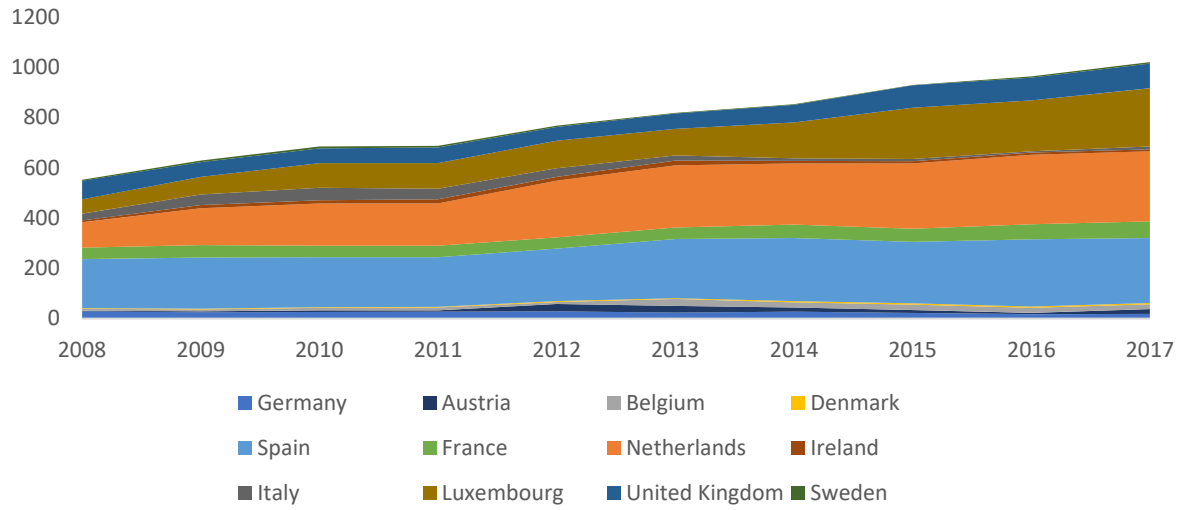



Source: United Nations Conference on Trade and Development (UNCTAD)

When analysing the FDI data for large number of countries, it may be difficult to understand the results and the detailed information, as seen in figure 7, where it is represented the Portuguese FDI inward stocks from the main EU investors.

Understanding who are the biggest contributors is a simple process, however, if we aim to determine the amount of smaller investments made and how they changed over the time, it may be more changeling. In simple two-dimensional graph it is difficult to analyse with detail small changes in columns, especially if we take into consideration many countries.

Figure 7 – Portuguese inward FDI stocks - Main EU Investors ($10^6$ of euros)




Source: Banco de Portugal (BdP)

Since we want to analyse the FDI relations for the European countries and specifically the Portuguese economy, we need to use a methodology that will present the characteristics and patterns that define the European Union network of FDI. The methodology should also be capable to present the results in a detailed and clear way.

We chose network analysis tools as our main methodology, due to its many capabilities. According to Amador and Cabral (2016), the use of network analysis to study economic relations is due to the ability of this methodology to identify the full structure of interactions between multiple agents. The study of networks focuses on the entire structure of connections, instead of focusing only on the characteristics that are limited to one or two elements.

Other advantage on using this methodology is the visualisation capability. By using graphs with a set of nodes (representing the countries) linked by edges (representing the FDI relations), we provide a visual tool that allows the study of

the relationship structure between multiple agents but with simple and clear graphical representations.

# 3. Problem statement

Despite the existence of many papers studying the behaviour of FDI and its contribution to different economies, most of the studies rely on econometric models to establish a link between FDI and other economic variables, to identify a causality relationship between them. In Annex A1 a summary table of the main studies is presented. The main articles that were analysed are identified in chapter 6. However, to better identify our problem we need to look at economic literature. Most articles presented in Annex A1 use econometric models, such as Bayesian random effects model or dynamic panel data, to understand the behaviour of FDI or its contribution to different economies. This means that the analysis is dependent on variables other than FDI to establish a correlation and reach some conclusion. Another limitation presented resulting from this methodology is the data presentation. Most of the economic articles use simple tables or two-dimensional graphs to show their conclusions, which have the limitations previously identified.

It should be mentioned that the use of network analysis as a methodology to analyse a complex structure of relationship between different agents is not new. As described in chapter 6, there were different studies which covered this issue. Some studies rely on FDI behaviour and with the use of network analysis tools, but most of them do not study specific relations between countries, but instead they provide a global framework of the FDI behaviour.

# 4. Objectives

We will construct a representation of the European Union Network of FDI, identifying patterns, establishing trends and describing the relations between different countries over time. We will also assess the position of Portugal in this network.

To achieve this goal, we will take the following steps:

I. Define the main variable, FDI, its characteristics and specificities;
II. Collect data for the 28 EU countries from 2000 to 2017, and compare it with different sources;
III. To describe the methodology that will be used;
IV. Define the network structure to represent the European investment relations and the correspondent metrics that will be used to define its characteristics and patterns;
V. Present and analyse the position of Portugal in the context of the FDI European Union network;
VI. Define the Portuguese FDI network, its main investors, and trend over the last years;
VII. Propose some conclusions related to the results obtained.

# 5. Relevance

This paper aims to contribute to the FDI research by applying a methodology that exploits the interlinkages between the EU economies. The results of this study could be compared with other economic studies, which aim to analyse economic variables with many different agents involved, creating a network and interpreting its characteristics.

Taking this into consideration, in this study we intend to cover the following issues:

I. To improve the understanding of network analysis methodologies and its great utility to economic research. As already mentioned, many studies regarding FDI and its impact on different economies rely on methodologies that use different variables to establish the impact of FDI, not always having into consideration the different characteristics of each country and the relations built with each other. Network analysis methodology allows the study and presentation of a complex network, which refers to the use of a large data set, including more countries and more periods, but also does not imply the study of other variables, relying only on the main variable data to establish its characteristics and behaviour;
II. To build a research database, including different data from different sources;
III. To identify economic trends during the 2008 financial crisis;
IV. To define the main investment sources in Europe, studying the statistical connections between the European countries;
V. To present clearly the results applying some visualisation tools.

# 6. Literature review

This chapter reviews the theoretical literature considered relevant for this study. It is divided into three sections. The first part presents some previous studies on FDI and what results have already been obtained by various authors. The second part covers the methodologies that have been followed, their main advantages and results. Lastly it covers the methodology that we apply in this network analysis, its advantages and motivations for using it.

## 6.1. Studies on foreign direct investment

In the last years FDI has increased its role as a crucial and permanent part of the global economy (Rózanski, 2014). FDI provides a way to transfer tangible assets, such as capital (Hermes & Lensik, 2010), but also intangible assets like technology, innovative product designs and new production skills or techniques (Simionescu, 2016).

The existence of two different FDI dimensions must be addressed: Inflows, when a country is the host of an investment; outflows, when a country is the source of an investment in other economy. When analysing these two different investments it should be highlighted that the destination of an investment is not always known, i.e. the final investors are not usually the primary direct investors.

The existence of a final investor requires that the original investment may have been made through a different country or company and has been channelled through, perhaps, a subsidiary in another country that offers better conditions for the operation. This means that the final investor may not be the original one (Silva, 2015). On the other hand, the direct investor defines the investment origin. This is the country where the decision is made, and this investor must own at least 10% of the voting rights after performing the investment (BMP6 and OECD Explanatory notes).

In the literature the contribution of FDI to economic growth has generated a significant debate (Hermes & Lensink, 2010). It has been focused on how FDI

may help to increase the economic growth of recipient countries (Hermes & Lensink, 2010). Under a neo-classical approach, FDI has a big contribution to the output level, but does not impact the long-term growth rate. On the other hand, the approaches based on the new growth theory consider that FDI influences the economy growth through research development and human capital. According to Simionescu (2016), the spillovers from the technology affected by the FDI ensure the long-term economic growth.

The importance of the FDI inflows and outflows to determine the potential investment of a country must also be noticed (Rózanski, 2014). Some authors, such as Maria Carkovic and Ross Levine (2002) consider that hosting FDI may boost the country economy by transferring the technological and business know-how. The spillover effect will help to improve firms not necessarily only the one receiving the investment (Rappaport, 2001). As Ungureanu and Baldan (2017) argued, the hosting country will receive positive effects in the commercial trade balance, an internal investment stimulation and it will help increasing the country's overall budget.

These authors recognize the main benefits that a country can achieve from foreign investment. However, these benefits do not always exist since endogenous and exogenous variable have also to be considered. Different methodologies were used in order to measure the main benefits from FDI.

## 6.2. Methodologies used to analyse FDI

According to the different perspectives and the economic literature, there is a methodology commonly used - Bayesian random effects model - an econometric tool that depends on a set of panel data (Guris, Sacildi and Genc (2015); Simionescu (2016); Luiz and Mello (1997); Carkovic and Levine (2002)). The main advantage of this model is, "the fact that they could be used on a short data set" (Simionescu, 2016). In this respect, many studies are based on a low time-span, usually under 10 years, and as such the Bayesian regression is a recommended tool.

The econometric models are commonly used to achieve robustness and accurate results on the correlation between two variables, in most cases, FDI and GDP growth. These methodologies allow the authors to establish a simple relation between the two variables, mainly using the Granger Causality method. They conclude on the positive or negative relation between FDI and GDP for the correspondent country and use this relation to explain the behaviour of FDI. Therefore, these methodologies imply the use of other variables to analyse the behaviour and characteristics of a main variable, FDI (in annex A1 a set of different methodologies are identified)

## 6.3. Network Analysis for the FDI comprehension

To avoid the limitations previously mentioned, we will use network analysis tools and apply them to the foreign investment relations within the European Union. In the last decade there has been an increase of network analysis in both social and natural sciences, due to its ability to reconstruct the links and the connections between different individuals or agents (Marvasi, et al., 2013). In this case, the set of tools provided allows the identification of the full structure of interactions between many countries without any limitation on using longer time frames. According to Newman (2010) there is a set of measures to examine analytically the large-scale properties that are subject to a complex network system. This means that we can integrate the data in one single structure and analyse it according to different measures which define the properties of this structure.

In addition, the network tools provide a set of visual aid for the structure representation. It uses graphs with notes that contain nodes linked by edges to support a better understanding of the relationships between each country, represented by a node. This node indicates the closeness between each country in the same group (Marvasi, et al., 2013).

The use of the network analysis in economics can improve the understanding of economic systems, where firms or individuals interact between each other. It also explains stylized facts and complex relationships structures, with simple models (Marvasi, et al., 2013).

According to Amador and Cabral (2016) many articles use the complex network perspective to achieve an empirical analysis of international trade interactions. One of the examples that these authors mentioned as common application of this perspective is the World Trade WEB (WTW). In this case each country is defined as a node and the bilateral interaction between them is defined as an edge. Many studies already focus on this interaction, either on an undirected way (when the interaction is from both countries) or directed way (just from one to the other), as Kali and Reyes (2007), Fagiolo et al. (2009) and Garlaschelli and Loffredo (2005).

The use of network analysis can also determine the existence of a high level of clustering between two or more countries (Amador and Cabral 2016), which may indicate common characteristics between the different countries.

In the recent years, network analysis has been used for different purposes. Amighini and Gorgoni (2014) analysed the patterns of trade in auto parts and components and found out that the rise of emerging economies as suppliers forced a change in the international market structure. On the other hand, Akerman and Seim (2014) analysed the global arms trade network and the results showed that over the years the network became more clustered and decentralised. More recently Amador and Cabral (2016) analysed the global value added in the trade flows to understand the structure of global value chains (GVC), using a complex network analysis to represent the value that each country added to the GVC.

However, there are only few studies researching FDI networks. One exception is the one by Li, et al. (2018), on the FDI evolution on the global network, from 2003-2012. The authors used network analysis tools to present and analyse the global FDI, using some metrics to define the global characteristics of the network. The authors recognized the value added from using the methodology. Furthermore, they used network analysis customization and presentation tools, such as changing the size or the colour of nodes in order to present their importance in the network. And they also presented two network metrics, the degree and the average path length, to better define the characteristics and the relations inside the network.

# 7. Data source characteristics and variables

In this chapter, we describe the different data sources that will be used and their characteristics together with the characteristics of the variable in study.

## 7.1. Variable characteristics

FDI first concern should be the direction of the investment, which can be either an inflow or an outflow. In the case of the Portuguese economy we say it is an inflow if the investment is being made by a foreign country to the Portuguese economy. On the same view, an outflow is to be considered when a Portuguese investment is made to another country. This is referred as the directional principle presented in the 5th edition of the Manual of the Balance of Payments and International Investment Position. According to the 6th edition of the Manual of the Balance of Payments and International Investment Position (BPM6), the directional principle was replaced to the assets/liability's principle, in which the data is presented from an asset creation perspective or liabilities in relation to the exterior.

Both presentations are complementary, but in net terms both perspectives are the same (which means that the assets deducted of the liabilities are equal to the outflows deducted from the inflows), each perspective serves two different purposes:

- International direct investment statistics presented under the assets / liability's principle make it easier to compare between different statistics (inflows and outflows) because they follow the same logic as the other functional categories of international investment in the context of balance of payments and international investment position statistics, as well as national accounts;
- International direct investment statistics presented according to directional principle are more suitable for the analysis of the motivations of the direct investment, since they are usually disaggregated by country (or group of countries) of the non-resident entity and by sector of economic activity of

the resident entity, these statistics allow to identify the countries that are investing in Portugal or in which Portugal is investing, as well as economic activities that are attracting foreign investment or are investing abroad.

It should also be mentioned that although the presentation based on asset/liability principle could be appropriated for macroeconomic analysis, the presentation on directional principal is more recommended to assist policymakers and government official statistics to formulate investment policies, according to the Methodological Note of the World Investment Report (2016). With this in consideration in this article the main principle used will be the directional principle.

The possible existence of a reverse investment should also be refereed. Under the directional principle, a company that received the direct investment can also invest/lend to its original investor. According to BPM6 “reverse investment arises when a direct investment enterprise lends funds to or acquires equity in its immediate or indirect direct investor, provided it does not own equity comprising 10 per cent or more of the voting power in that direct investor” (page 126). In terms of data presentation and according to the direction principle the final inward value of FDI may be negative, due to the difference between the original direct investment and the transaction made to the investor.

FDI data can be disaggregated by stocks and flows. According to BPM6 “flows refer to economic actions and effects of events within an accounting period, and positions refer to a level of assets or liabilities at a point in time” (p. 29). Foreign direct investment, such as any other data presented in the Balance of Payments can be presented in stocks, with its evolution being explained by the flows. Data presented under the stock format represents the data at one specific time, and it is also represents a quantity existing at that point in time, which may have accumulated in the past. A data presented in the flow format is measured over an interval of time, usually a month or a year. In this article the use of each one of these formats will depend on the data in question and of the results that we aim to achieve.

## 7.2. Data sources

One of the biggest challenges when analysing FDI is the different data sources. Four main data sources can be considered to obtain FDI data for the EU countries: the European Central Bank (ECB), the Organisation for Economic Co-operation and Development (OECD), the International Monetary Fund (IMF), and the United Nations Conference on Trade and Development (UNCTAD). Considering that most data sources have many possible customizable settings to filter the data available, first we should select the appropriate settings that we want to use. Regarding the reporting country we selected the 28 European Union Countries. In the level of counterpart we chose the "immediate counterpart", also known as direct investor, and we chose the Euro as the currency reference. The measurement principle is inward stocks, for all resident unites. Finally, the period from 2000 to 2017 was selected.

Having defined our preferable settings, it was required to construct our own database, regarding data from various sources. This is due to gaps in different data sources. For example, when analysing the period from 2000 to 2017 the more detailed and completed data is only available in the IMF repository, however it only counts from 2009 until 2017. The remaining data must be obtained from the OECD data source, with, however, more gaps, mainly in terms of a lower coverage of countries.

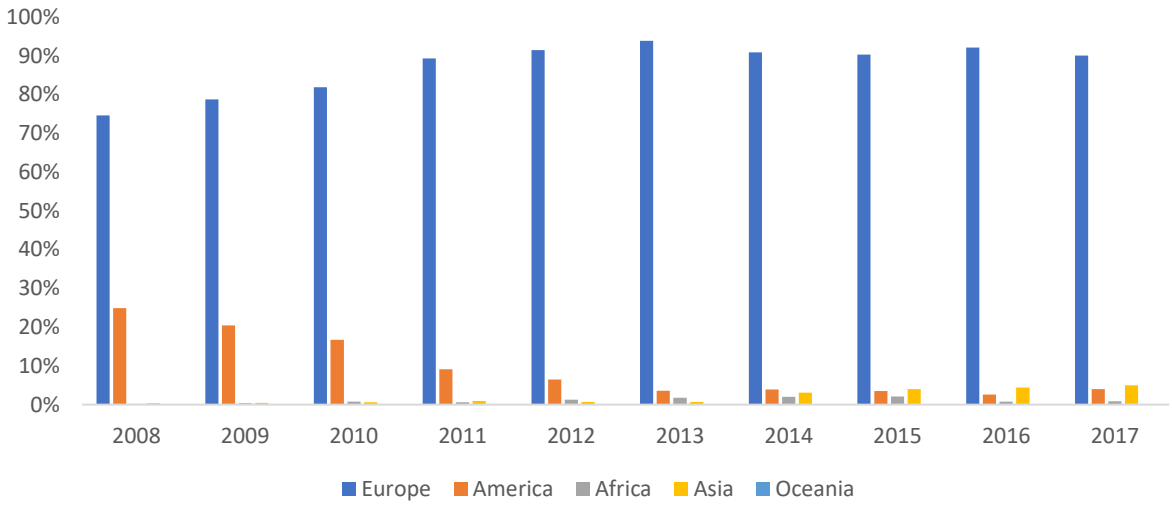
For most cases it will be mainly used data regarding the period from 2009 until 2017. The reason of this choice becomes from the results of the 4$^{th}$ edition of the benchmark definition of FDI made by OECD (BMD4) and completed in 2008, that, between other aspects, created a new way to interpret, analyse and treat FDI data. On some cases we will use specific years before 2009 (the year in which most agencies that treat FDI adopted the BMD4) when the use of such years (and the previous BMD3) data seems to be consisted.

This analysis is performed to the 28 countries members of the European Union[2]. We chose to analyse the European Union countries, not only because of the lack

[2] The 28 EU countries in study are: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom.

of studies focusing the European Union network of investment but also given the importance of the EU FDI in the Portuguese economy, the main economy in study. As it is represented in figure 8, EU countries are responsible for an average of 90% of the total FDI received by Portugal since 2008, with American countries, being responsible for only 5%.

Figure 8 – World regions inward FDI to the Portuguese economy ($10^9$ of USD)




Source: United Nations Conference on Trade and Development (UNCTAD)

# 8. Methodology approach

In the following sections motivations for applying network analysis to FDI will be addressed. In addition the main concepts and description of this methodology will be identified.

## 8.1. Network Analysis

A network is composed by a set of nodes (or vertices) connected by edges (or links). In this case each single node represents individually each of the 28 European countries. The edges stand for the connections between each node, which provides a crucial information on the dependency and importance of a subset or the all set of nodes. The network is defined by the nodes, edges and its visualisation in a graph. It should be noticed that many characteristics can be associated to each node or edge. For example, for a node representing a person, its characteristics may include their age or gender.

An important issue of a network is the connection between the nodes – if they are directed, each node can be reached from every other node, by following directed links. Otherwise, if they are undirected, every node can be reached from every other node by following links in either direction. One example to illustrate an undirected network is by thinking on a subway system map. In a subway map two stations have an undirected connection, which means that the subway can have each one either as a point of origin or as a destination. Conversely, if the subway system was *directed* the subway could only go from one station to the other, not doing the same way back. In the network representation each edge that connects two nodes, must have at least one arrow, indicating the direction of the investment, i.e, the investment that is made by one economy (the investor) in the other economy (the host). If an edge has two arrows, each pointing towards a different country, then both countries made an investment to each other.

Although one of the main benefits of the network analysis is the capability to deal with a large and complex data set, normally a threshold is used to rank the data. A threshold will define the limits to include or not the data in the network.

However, it should be noticed that a threshold needs to be balanced with the loss of large amounts of data, which can bias the results.

The main benefits from the network analysis tools, is the ability to identify the full structure of interactions between each different agent. Networks take into consideration the interdependence of observations and study the entire pattern of connections, instead of just focusing on the isolated characteristics of each individual element. Overall network analysis helps in analysing: the importance of central nodes that provide the only connection between other nodes, the number of links, which may represent insufficient or excessive connections between each node and the average distance, the distance that separates the nodes.

The advantages defined above can be obtained by analysing a set of metrics that are defined in a network. These metrics may be defined for the entire group of nodes or just to a specific one, especially when the objective is to determine its position in the network. According to Jackson (2008) there are four metrics that analyse the essential properties of a network and its nodes:

- **Degree** – can indicate how exposed is the network to nodes that have higher importance. It defines how well connected a node is, what can be either an opportunity to influence or to be influenced directly. In a direct network there is also the **in degree** and the **out degree**, corresponding to the number of edges pointing inward and outward from a node;
- **Closeness** – defines how far a node is from all others, or how long it takes for whatever is flowing through the network to arrive;
- **Betweenness** – indicates how often a node lies along the shortest path between two other nodes. It may represent the power of influence from a certain node or the dependency that other nodes have;
- **Eigenvector** – represents how well connected a node is. A node that has a higher score is a central node that is connected with other nodes that are equally central nodes. It is an index or exposure and risk; this means that it is a very important metric since it can provide crucial information about the network dependency to one or a few central nodes. If a network

is highly centred, it is more susceptible to shocks because of its dependency to a small number of nodes that can fail.

Another important issue of the network analysis is the ability to define clusters. When taking into consideration many nodes (representing the countries) each one with different characteristics and with connections between them, it is important to understand how cohesive and centred the network is. The existence of clusters inside a network is usually measured using the clustering coefficient metric.

It should also be noticed that the benefits from the network analysis relies on its visualisation. Each country and the correspondent relations is represented by nodes and edges, providing a high customization possibility. Each node and edge contain those properties, such as their shape, size or colour, in a way that represents the node characteristics and improves the analyse of the network. Those properties are commonly linked to the node characteristics.

Two main algorithms are contained in the network presentation performed by NodeXL[3]. These algorithms define the layout of a network: the Fruchterman-Reingold which is a force-directed layout algorithm. This means that the layout takes into consideration the force between any two nodes, setting the positions in terms of the total force (or weight) of each node. The other option for a layout would be the Harel-Koren fast multi-scale layout. However this presentation methodology is most commonly used to represent large data sets, with thousands of samples, analysing specially the existence of clusters, not the connections between the nodes, or the weight of each one (Rodrigues, et al., 2011). We will use thus the Fruchterman-Reingold algorithm.

## 8.2. Defining the Networks

For the main objective of analysing the European Union network of FDI we will use a set of 28 nodes, representing the 28 countries in the analysis. The criterion for the existence of an edge (or a link) is set to reflect the importance of a country

[3] Template used to represent the network

according to its contribution to the total FDI in Europe. For the objective of defining what investments should be considered, a threshold was set. The choice of the threshold was made in a way that the resulting data is simple to interpret and visualise, while capturing the relevant relations between the nodes. The threshold was set at 0,5%, which means that in each country, only the investments superior to 0,5% of the total FDI for that country received in a year, will be taken into consideration. According to what was referred in chapter 7.1, we will use FDI stocks, since it provides a representation of the data at one specific time and also the accumulated value.

Other threshold percentages were tested however 0,5% is the percentage that seems to better represent the data, without largely influencing the results. A 1% and 0,1% threshold presented 288 and 458 edges, respectively, when a 0,5% threshold presents 356 edges while still allowing for clear visual analysis of the main relations between the countries. The network representation for the 1% and 0,1% threshold applied to the year of 2017 are presented in annex A.2 and A.3[4].

As defined in section 7.1. and according to BPM6 by IMF: "Reverse investment arises when a direct investment enterprise lends funds to or acquires equity in its immediate or indirect direct investor, provided it does not own equity comprising 10 percent or more of the voting power in that direct investor". If the amount of reverse investment is higher than the amount that was invested directly, the investment relation will be counted as negative.

In our case, since the main objective is to define the strength of the connection between the economies, and not to analyse the balance of investment, we will have to use the absolute values to include all the positive and negative values:

$$v_{x,y} = abs(FDI)_y^x$$
$$where\ x \neq y; x = 1, \dots, 28; y = 1, \dots, 28 \quad \textbf{(1)}$$

This means that FDI from country $x$ to country $y$ will be analysed in absolute terms. $v_{x,y}$ represents the value of investment from country $x$ to country $y$ and it's equal to the absolute value of FDI made from one country to another. We will

[4] Alternative threshold percentages were tested, and the main features of the network remained unchanged. All detailed results are available from the authors upon request.

analyse each of the 28 EU countries, so $x$ and $y$ are defined from 1 to 27, and if $x = y$ the value will not be determined.

$$V_x = \sum_{y=1}^{27} v_{x,y} \ \ where\ x = 1, \dots, 27 \quad \textbf{(2)}$$

In order to sum all the investment made on a specific country, $V_x$ represents the total FDI made on the country x from the 28 EU countries.

To conclude, we will determine what values are approved ($A$ ), which occurs if the FDI made from $y$ to $x$ country is superior to 0,5% of the total FDI received by $x$.

$$A = \begin{cases} \frac{v_{x,y}}{V_x}; & \frac{v_{x,y}}{Vx} \geq 0{,}005 \\ 0; & \frac{v_{x,y}}{V_x} < 0{,}005 \end{cases} \quad \textbf{(3)}$$

We can define this network as *directed* since there is a clear interpretation for the orientation of the edge. If a country has a direct investment on another country, then there is an edge with an arrow pointing to that country, which represents a one-way relationship. The existence of an edge connecting two nodes must, however, respect the threshold previously defined.

This network can also be defined as a weighted network, since all the edges connecting the nodes have specific weights assigned to each other. In this case, the strength of an edge corresponds to the total amount of investment made from one country to another. In this way we can define the counterpart country of an investment and in addition determine the detailed contribution amount from each country. If our goal was to determine what are the counterpart countries of each investment, a binary approach would be used. Usually this map is known as *unweighted network*, representing a country that invests on another one with a one and a country that does not invest as a zero.

# 9. FDI network in the European Union

The first network we will analyse is a network for FDI considering the 28 countries in the EU.

## 9.1. Network representation

In the following section we will represent graphically the network. The data treatment will be mainly done with Microsoft Excel and the network representation and analysis will be make with NodeXL and Gephi, mainly due to their customizable and presentation capabilities which go according to our objectives.

Each country is represented by a circle or a square (both represent nodes) with links (also known as edges) between them. In all graphs the size of each node is proportional to its contribution to the foreign direct investment, in absolute value, between all the European Union countries for a specific year.

$$S_x = \frac{\sum_{y=1}^{27} abs(FDI)_{x,y}}{abs(FDI)_{TE}} \quad \textbf{(4)}$$

Where $S$ means the size of the node for the country $x$, $FDI_y$ means the total FDI made to country $Y$ and $FDI_{TE}$ means the total ($T$) European ($E$) $FDI$ made in that year, in all the 28 European countries.

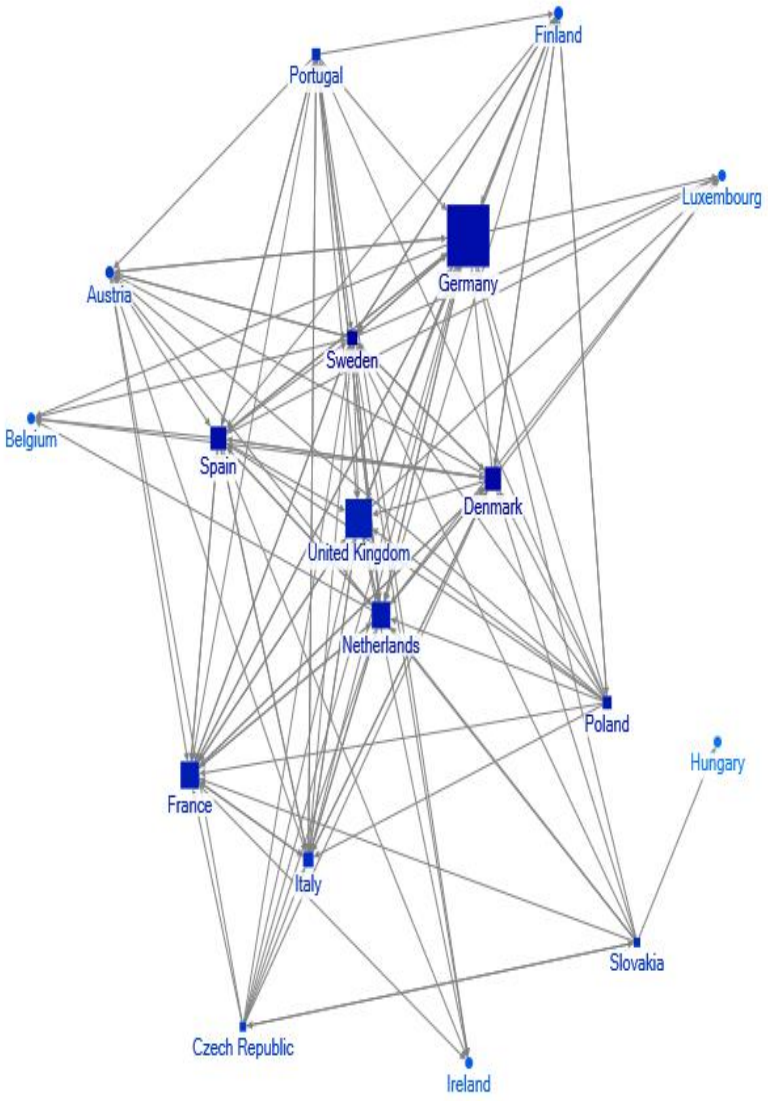
The colour of the node is mapped to its degree, darker blue nodes indicate a higher degree where light blue nodes indicate lower degree. On NodeXL we defined that the lowest degree value should have the lighter blue and the highest degree value should have the darkest blue colour. The colour choice for each node was then automatically applied according to the proximity of each value to the lowest or highest degree[5]. The shape of the vertices is related to its eigenvector centrality, countries with a metric higher than the metric global average are represented as a square, the remaining take the shape of a sphere.

[5] The option of ignoring outliers was chosen in order to avoid skewing the results, by some small or large values, or outliers.

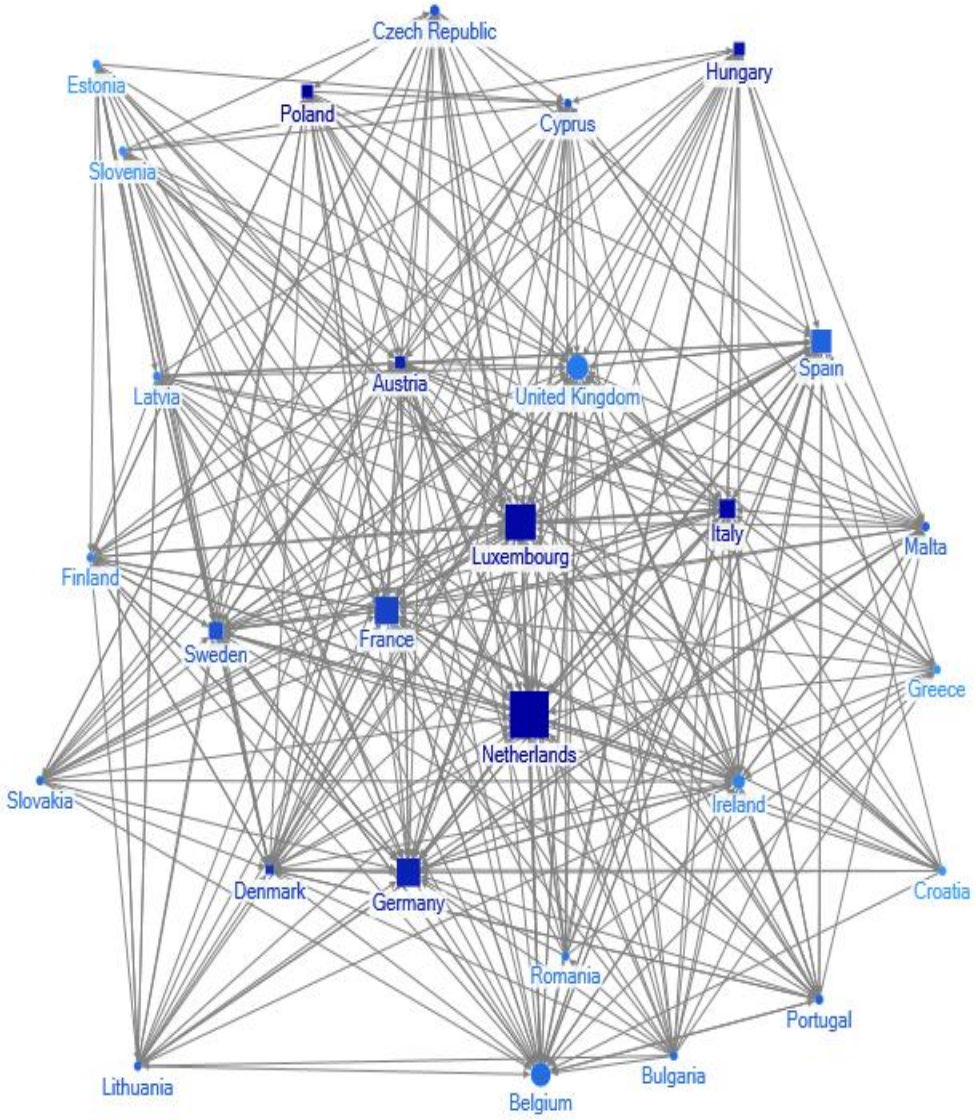
The network representation followed the Fruchterman-Reingold algorithm which means that the layout takes into consideration the force between any two nodes, setting the positions in terms of the total force (or weight) of each node. This means that the position of each node is dependent on its weight, that in this case is represented by the total foreign investment received (inflows) As we will see nodes with a more centred position in the network, tend to represent countries that are geographically central in the EU area, with the peripheric nodes mainly representing peripherical countries.

Figure 9 - Network graphs of total foreign direct investment – 2000, 2009, 2014 and 2017

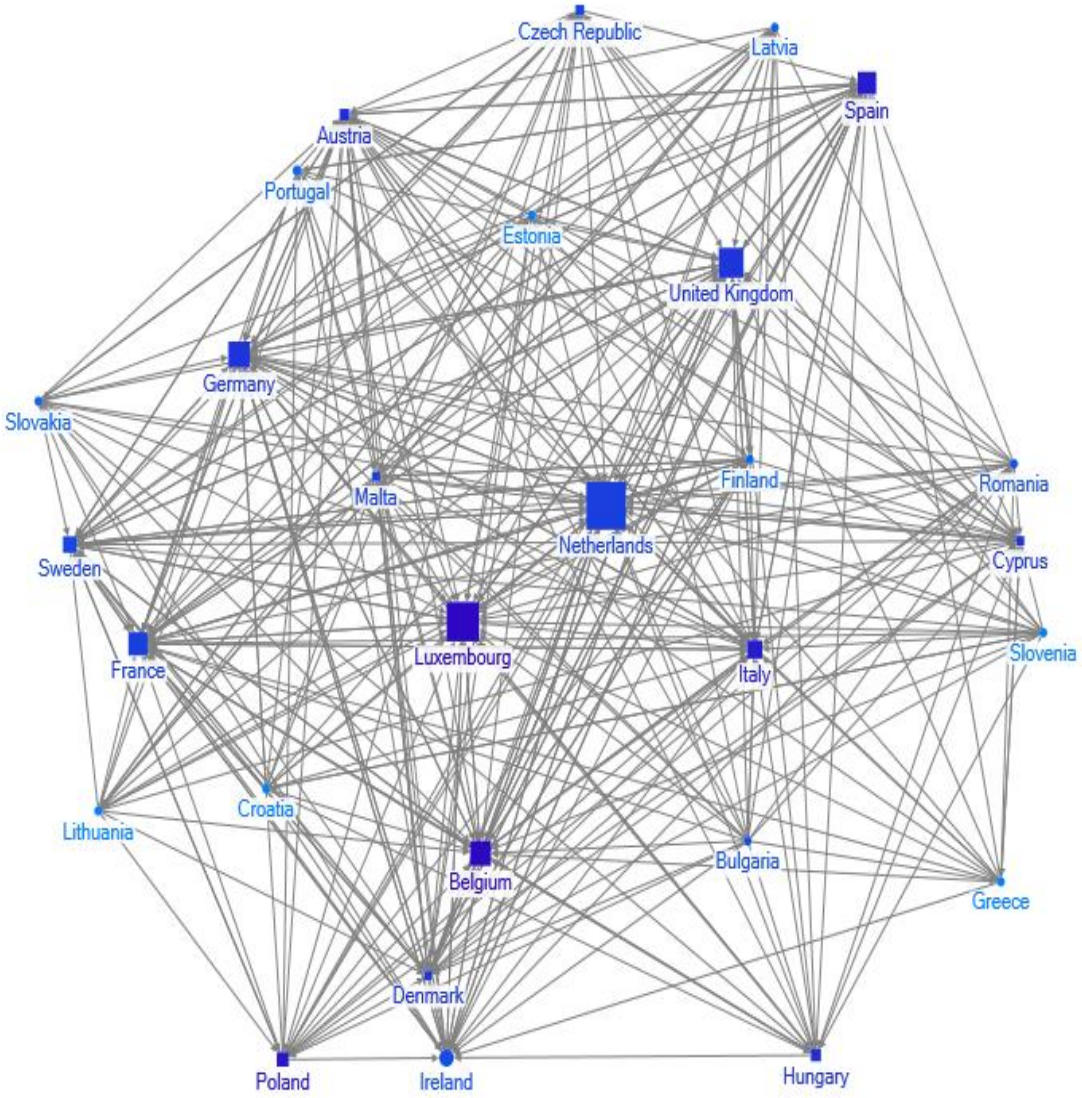
(a) 2000



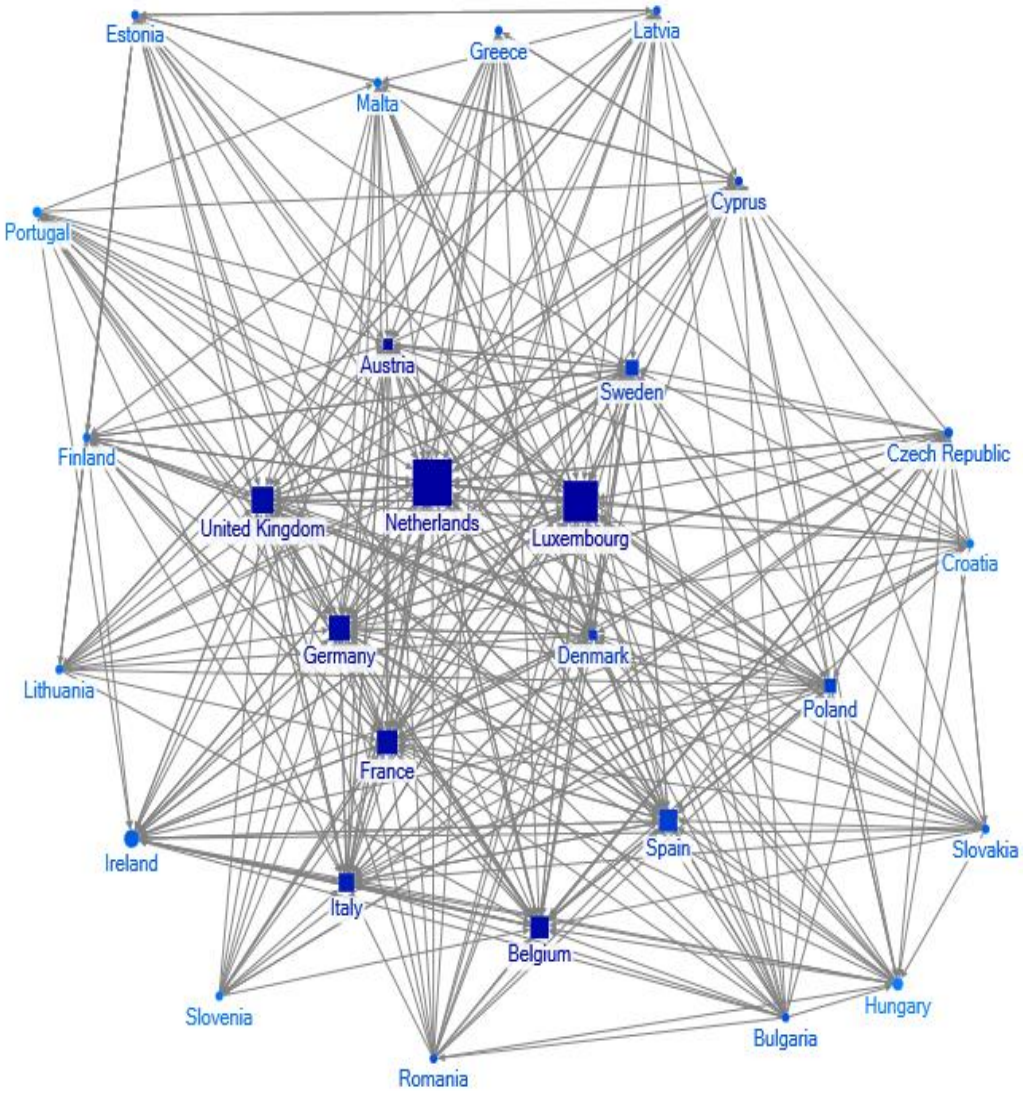
(b) 2009


Czech Republic
Estonia
Poland
Cyprus
Hungary
Slovenia
Latvia
Austria
United Kingdom
Spain
Luxembourg
Italy
Malta
Finland
Sweden
France
Greece
Netherlands
Slovakia
Ireland
Denmark
Germany
Croatia
Romania
Portugal
Lithuania
Belgium
Bulgaria

(c) 2014

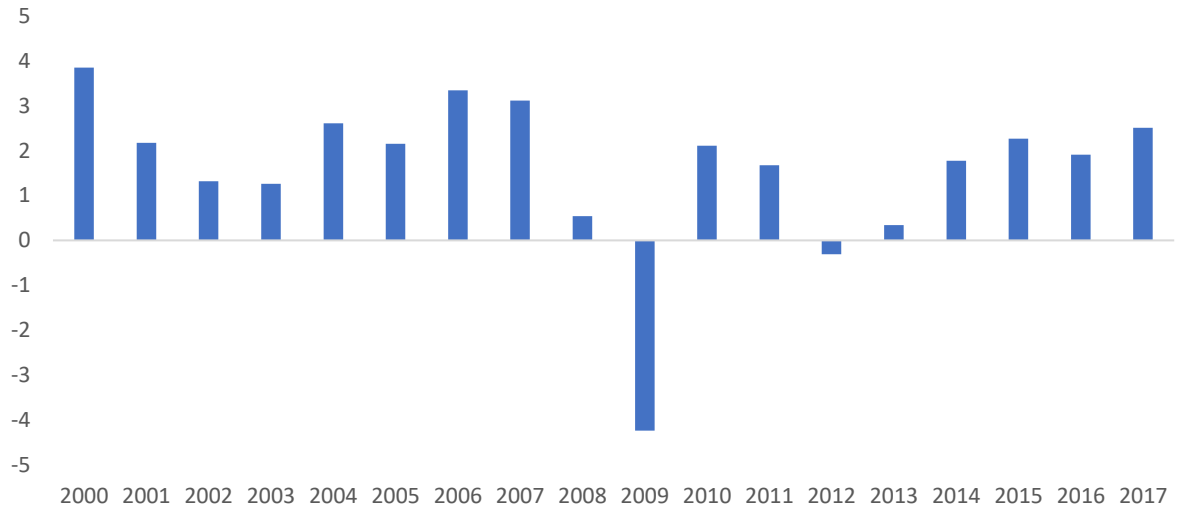

Czech Republic
Latvia
Spain
Austria
Portugal
Estonia
United Kingdom
Germany
Slovakia
Malta
Finland
Romania
Netherlands
Sweden
Cyprus
Luxembourg
France
Italy
Slovenia
Croatia
Lithuania
Belgium
Bulgaria
Greece
Denmark
Poland
Ireland
Hungary

(d) 2017




In figure 9 it is presented the network of foreign direct investment for the European countries. The beginning of the 21th century was considered and four different years were selected. EU annual GDP average growth rate was the criteria to choose 2009, 2014 and 2017. According to figure 10, 2009 is confirmed as the peak of the international trade and financial crisis, 2014 was the reverse for most economies and lastly 2017 was chosen as the last period available.

Figure 10 - EU annual GDP average growth rate




Source: United Nations Conference on Trade and Development (UNCTAD)

In general there are some conclusions that can be reached with a simple visualisation analysis of the network generated by the algorithm chosen. In terms of the number of connections, the year 2000 is highlighted by presenting the smaller number of edges. This is mainly due to the fact that there is no available information in IMF for 2000 and consequently only 18 EU countries can be obtained by OECD data base, as explained in 7.2. Both 2009 and 2014 present similar level of relations, with a high density of edges easily seen. Although there exists a high amount of edges in 2017, the network density seems to be lower than in the previous years in analysis. Some conclusions can also be reached with the help of the customizable colours and figures chosen for this network. In all the years in analysis, the countries with a darker blue colour, which represent the country degree (or connections), appear mainly in the centre of the network, with the countries that have a smaller degree occupying the peripherical positions. The same conclusion can be reached for the shapes of the nodes. Countries represented by squares, that represents an eigenvector higher then average, are placed in the middle of the network, while countries with an eigenvector lower then average, and so presented with a sphere, are placed in the border of the network. The main FDI network characteristics are presented in table 1.

Table 1 - FDI network's main characteristics.

| | 2000 | 2009 | 2014 | 2017 |
|---|---|---|---|---|
| Number of edges | 123 | 349 | 351 | 356 |
| Number of nodes | 18 | 28 | 28 | 28 |
| Nodes with darkest blue colour | 11 | 8 | 2 | 10 |
| Nodes with lighter blue colour | 7 | 20 | 26 | 18 |
| Nodes with a square shape | 12 | 11 | 16 | 12 |
| Nodes with a sphere shape | 6 | 17 | 12 | 16 |

In order to perform a more detailed analysis of the network, the **degree** and **eigenvector** will be used.

In the beginning of the century, in the year 2000, which is represented in panel figure 9 panel (a), the average degree was set at 10. This means that on average, each EU country represented in the network, had a direct investment relation in other 10 EU countries. In the network represented there are 11 countries with a darker blue node, they represent the 11 countries that have a higher degree, while the remaining 7 countries with a light blue have a lower degree. The country with a higher degree was Sweden, with 16 investment relations. On the other hand, the country with the lowest degree was Hungary, obtaining investment from only one other EU country and not making any meaningful investment in return, considering the threshold we defined.

Panel (b) in 2009, after the financial crisis that started in 2007, shows that the average degree was set at 18, superior to the 2000's values. Only 7 countries presented a darker node, with more countries, like France and Spain, presenting an intermediate blue, not dark but also not light. This also proves the increase on the average degree, with more countries registering a higher degree then before. The highest degree was achieved by the Netherlands with 25 investment relations, and the lowest degree was obtained by Slovenia, with only 8 investment relations.

The panel (c), representing 2014, the year in which the EU average GDP growth rate achieved positive values, the average degree was higher then when the financial crisis had begun, with each EU country making 19 direct investments in

another EU member. Following the 2009 trend, in 2014 there were less countries represented with the darkest blue node, only 4 presented a far superior degree, with more countries presenting an intermediate blue. The countries with a higher degree were the Luxembourg and Belgium, both had a total of 27 direct investments in other EU countries. On the other hand, the countries with a lower degree were Greece, Estonia and Croatia, all with 12 direct investment relations, which was still superior to the average values of 2000.

Finally, for the panel (d) in 2017, the trend of increasing degree for the EU countries was kept, achieving the average value of 20 direct investments for the EU countries. However, it should be noted that the countries presented by the darkest blue node, increased to 7 with less countries occupying the intermediate position. The countries that obtained the higher degree were the United Kingdom, the Netherlands and Luxembourg, each accomplishing 27 investment relations. The country achieving the lowest degree was Greece, only achieving a total of 12 investment relations.

The second metric analysed was the eigenvector centrality. It defines how a network is centred around one or more important nodes, providing that way the information about the network dependency to one or a few central nodes. The nodes presented with the shape of a square, have an eigenvector higher then the average, exercising a more important role in the network. Sometimes eigenvector centrality may be an extension of the degree centrality (Newman, 2010), since a higher eigenvector may be a sign of high degree, as countries with a higher amount of relations may have more importance then countries with less relations.

In 2000 the average eigenvector was set at 0,056. Of the 18 countries in analyse, Sweden was the one with a higher eigenvector of 0,079. This means that the country that had a higher amount of investment relations in that year, was also the country with a most important role in the network. Similarly, the country with a lowest degree, Hungary, was also the country with a lower eigenvector of only 0,004.

In 2009 the average eigenvector was lower then in 2000, achieving the value of 0,036, which means that on average, the influence of the nodes in the EU network was lower. This time however, the country with a higher degree (that in 2009 was

the Netherlands) is not the country with a most important position in the network. That place was taken by Germany, Luxembourg and the United Kingdom, all achieving an eigenvector centrality of 0,046. The lowest value of 0,024 was obtained by Croatia.

Following the average values of 2009, 2014 also kept an average eigenvector of 0,036. In terms of higher values, Austria, Luxembourg, Netherlands and the United Kingdom all obtained an eigenvector centrality of 0,046, even though some of them, as Austria and the United Kingdom were far from achieving the highest degree value. Estonia was the country with the lowest value, of 0,024.

Finally, in 2017 the eigenvector centrality was kept at the same value of 0,036, with the countries of Germany, Luxembourg, Netherlands and United Kingdom obtaining the highest value of 0,046. This time the lowest value was obtained by Slovenia, achieving an eigenvector of 0,024.

Eigenvector centrality defines how a network is centred around one or more important nodes, providing that way the information about the network dependency to one or a few central nodes. In the start of the century, this variable presented the value of 0,0556, however after 2009 the value was already lower, at 0,037. During the period that followed, until 2016, the metric did not change much, achieving the final value of 0,0357 in 2016.

The two previous metrics explain the colour and the shape of the nodes, however the size of each node is explained by its proportional contribution to the total foreign direct investment between all the European Union countries for a specific year. This is only possible because we are working with a weighted network, and so the relations between each country take into consideration the total investment made from one to another. So, nodes with a higher size, represent the countries whose total amount of investment received was higher.

In 2000, there was only one country responsible for the majority of the EU FDI, Germany, with an average of 42% of the total investment received in the EU.

Analysing panel (b) we can conclude that in 2009 the country with more FDI received was the Netherlands, obtaining the 24% of the total EU FDI, far superior from the average of each country that was only 1,28%.

In 2014 the average FDI received by each country was kept at 1,21% of the total FDI flows in the EU, with the Netherlands keeping the highest value of 25%.

More recently, in 2017 the average value increased to 1,32%, with the Netherlands still taking the lead as the main receiver of FDI, with 24% of the total.

It is important to mention that both Netherlands and Luxembourg are countries known by the presence of subsidiaries of companies from outside the EU. These countries policies, mainly the fiscal policies, attract large multi-national companies and serve as a point of origin for their investments in other EU countries (Sara Morais, 2011).

## 9.1. Network metrics

Having analysed the network for specific years, we will now do an analysis for a larger period, so that we can detect changes and trends on the network characteristics. We will also analyse metrics that were previously defined, such as the average geodesic distance, the average betweenness centrality, average clustering coefficient and the average out degree.

In figure 11 we can analyse some of these metrics regarding the entire period from 2009 until 2017. Since our objective was to study a larger time period, and not to skew any of the results, we chose the data regarding this period obtained from the IMF, that originally is limited to these years. The usage of other years from another data source added to the ones already in use could provide wrong or incomplete results. The complete values of these measures for all the networks and all the countries are available on annex A.3.

The first two measures that we will analyse are the macro metrics. On figure 11 panel (a) the metric presented is the **average degree** of the network, which measures its average connectivity, as previously defined. From 2009 until 2017, there was an increase of 2% on the average degree, however the increase was not stable. On average, from 2009 until 2011 each EU country increased their connections from 18 to 20. However, that value was reduced in 2012 to 18. Since

2013 the value kept an increasing rate, being stable in the last years with an average of 20 connections.

The second metric, in panel (b), represents the **average geodesic distance**. This metric can show the economic position of each country, since that nodes that have a low average geodesic distance are close to each other, which means that their economic relation is strong and possibly do not depend on other countries to establish a link between them. The average geodesic distance represented in panel (b) is 1,22 and there is no visible trend. The highest geodesic distance, for all the years is 2. On the years that followed the financial crisis the values were lower, at 1,21, and after 2014, with the economy recovery of most of the EU countries, that value went up to 1,24. We can conclude that over the years the average economic position of each country has remained stable and lower than the highest distance registered.

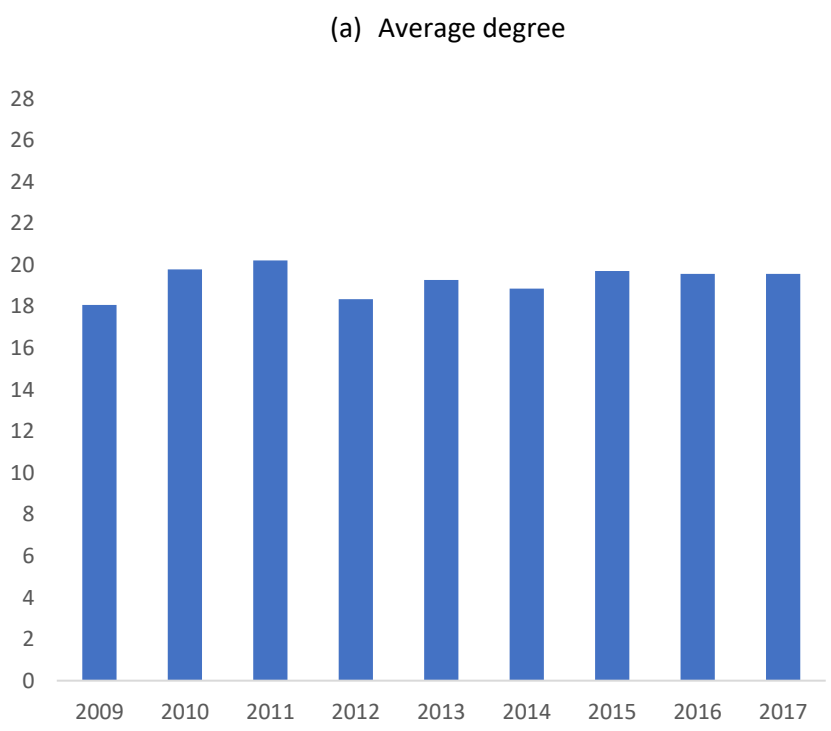
In panel (c) it is presented the **average out degree**, meaning the average number of edges that point outward from a node. The average out degree for the entire period is 13, which is also the value achieved in 2017, superior to the initial value of 12, registered in 2009. This means that in the period in analysis there was a slight increase, although it was not substantial, on the average outward investment in the EU network. The **average in degree** values are presented in panel (d) and they show that each country has kept an average in degree of 12. The analysis of this two metrics help us to conclude that in 2017, on average, each EU country had FDI outwards towards 13 countries while receiving FDI investments from 12 countries.

The **average betweenness centrality** is represented in panel (e). This metric measures the extent to which a node lies on a path between other nodes. The highest value this metric may have is 26, which means that to reach from one node or country to the other it is necessary to pass on all the remaining 26 nodes/countries. In our case this measure analysis the importance of a country as an intermediary between the relations of two other countries. A high betweenness may indicate that a network is highly influenced by a set of nodes/countries. Panel (d) shows that there is not any clear pattern over the years. In average the betweenness centrality was set at 7,3, achieving in 2011 the lowest value of the period in analyse of 6.8. In overall we can conclude that

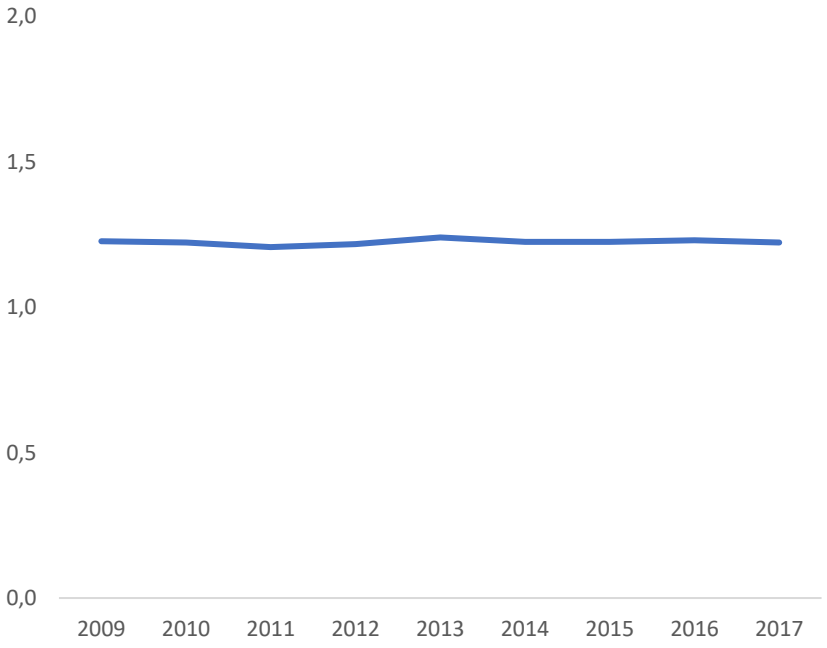
the in the EU investment network the importance of each country as intermediary between two other countries has remained steady, existing on average 7 countries whose importance to establish connections is still high.

Other important network characteristic is how tightly clustered the nodes are, analysed by the **clustering coefficient**. The existence of clusters may indicate the existence of common characteristics between the different countries and the high density of ties. If every node in the network is connected to every other node, then the cluster coefficient is 1. If no nodes in the network are connected, then the clustering coefficient will be 0. The results of panel (f) show that the average clustering coefficient since 2009 has remained at 0,56 which indicates a trend for half of the countries to remain together.

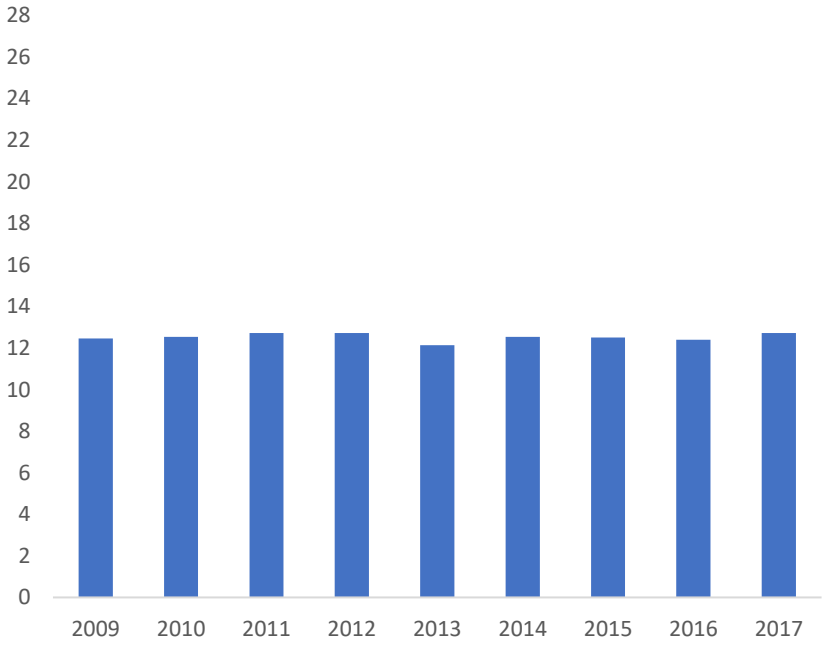
Figure 11 – European aggregate network metrics over time



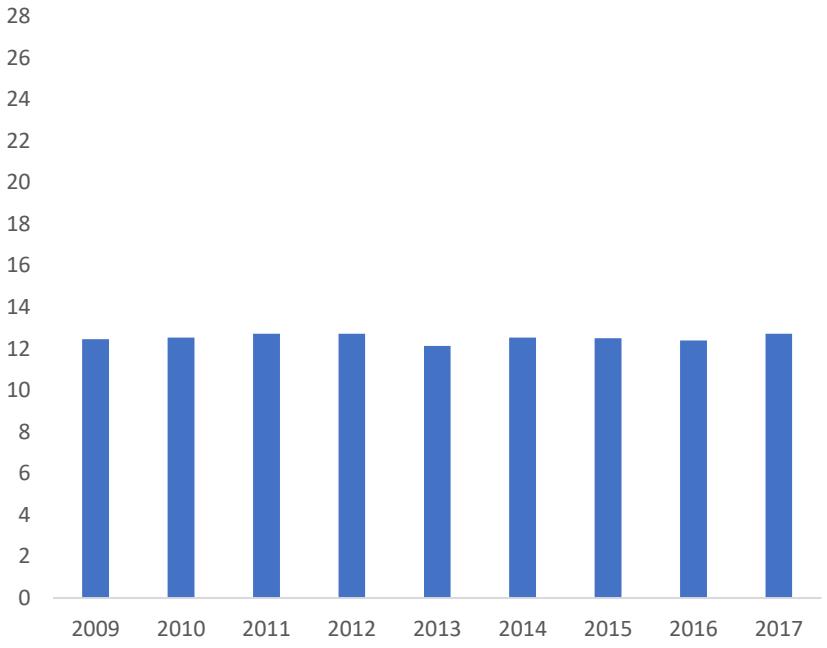
(b) Average geodesic distance



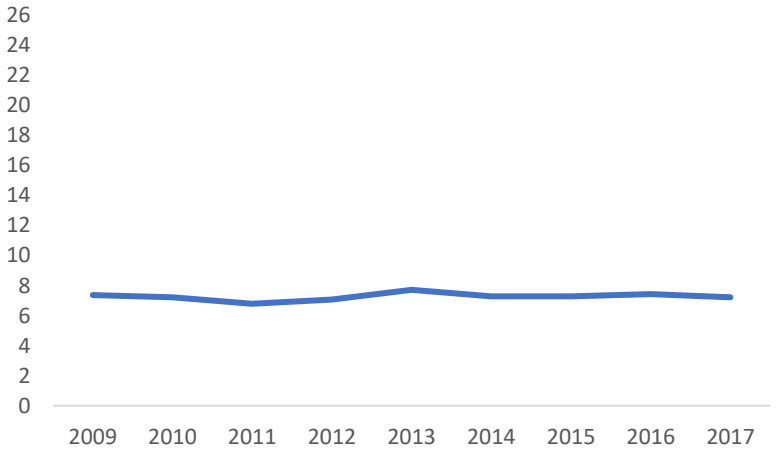

(c) Average out degree



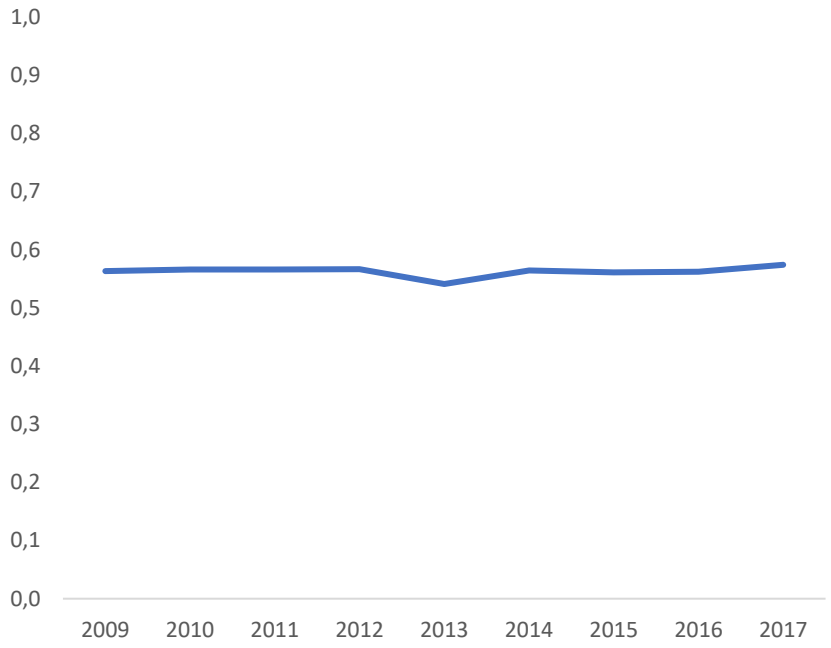
(d) Average in degree




(e) Average betweenness centrality



(f) Average clustering coefficient




Note: Network metrics were computed using Microsoft Excel and NodeXL.

# 10. The position of Portugal in the European Union network of FDI

In the previous section we have analysed the European Union network of FDI and its main characteristics and trends. Now we will focus on the position of Portugal in this network.

## 10.1. Network metrics

In order to assess the position of Portugal in the EU network of FDI we compute the specific metrics associated with FDI inflows to PT from 2009 to 2017. In figure 12 we can analyse some of these metrics. The complete values of these measures for all the networks and all the countries are available in annex A.4.

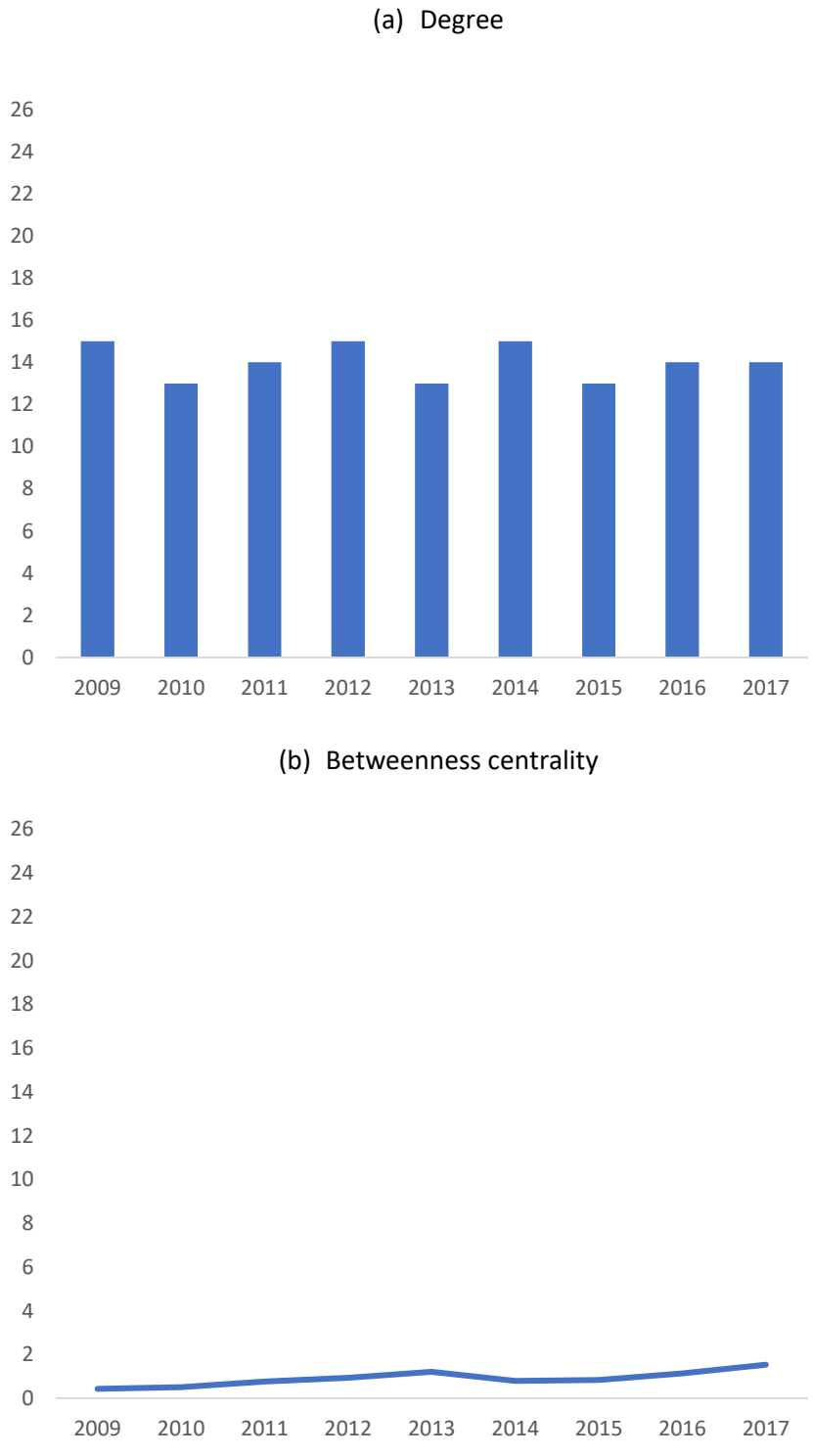
The first measure presented on panel (a) is the **degree**. In our case the degree measures the number of countries that have made direct investments in Portugal. In 2009, there were 15 countries with direct investment relations with the Portuguese economy (inward and outward). In the end of the period in analysis, 2017 that value was reduced to 14.

The next metric presented in panel (b) is the **betweenness centrality**. This metric measures the extent to which a node lies on a path between other nodes. In our case the betweenness measures the extent to which the node that represents Portugal lies on a path between other nodes. By looking at the metric representation in panel (b) there is a trend that points to the increase of this metric over the period in analysis. In 2009 the value of betweenness was set at 0,433 and by the end of 2017 that value was already at 1,534.

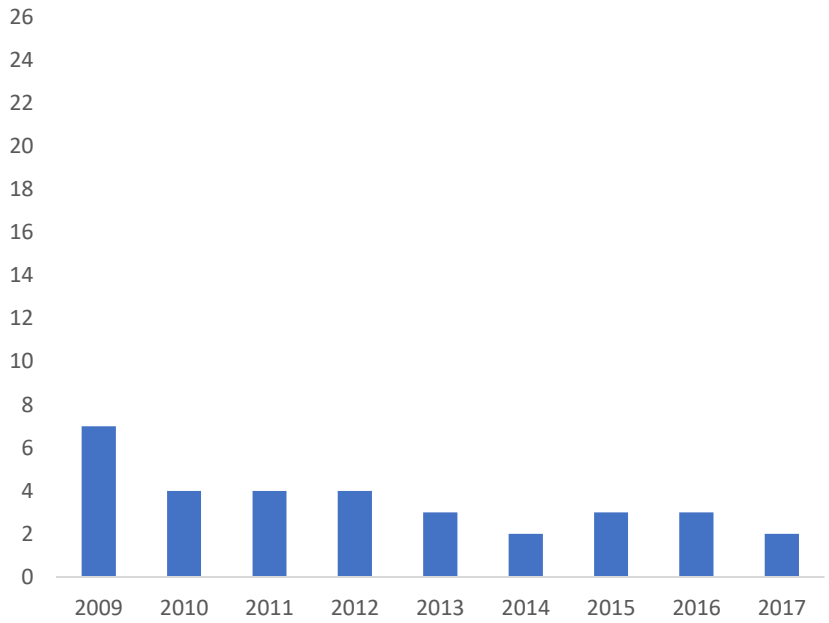
Finally we need to analyse panel (c) and (d), representing the **in degree** and the **out degree**, respectively. The in degree, has not kept the same trend as the degree, and in its turn, it has been lowering since 2009, where it was set at 7 countries that invested in Portugal to only 2 in 2017. The out degree did not change much over the time, it was set at 13 in 2009 and by the end of 2017 it was 14. We conclude that in 2017 and according to the threshold defined,

Portugal had FDI with 14 other countries, while Portugal received investment from only two countries, while it invested in 14 other EU countries.

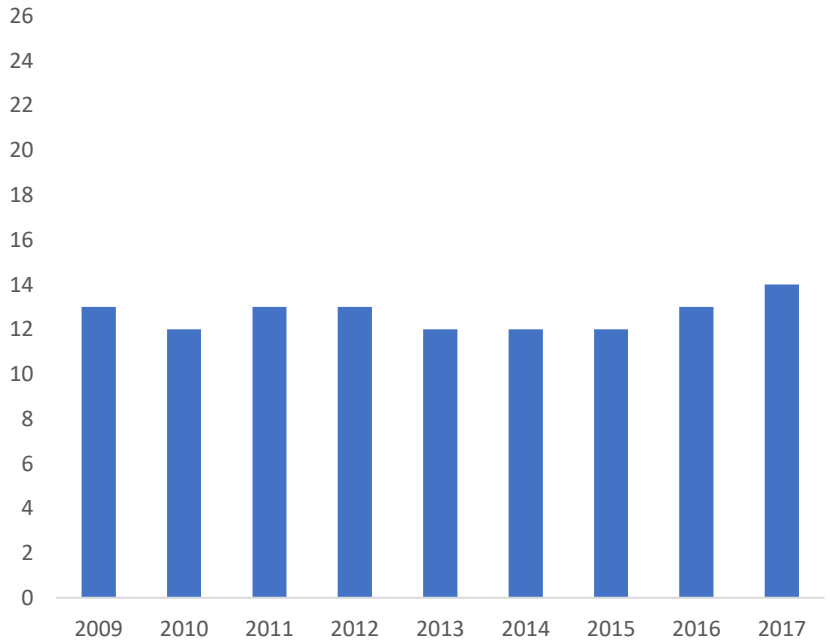
Figure 12 - Portuguese aggregate network metrics over time



(c) In degree




(d) Out degree




Note: Network metrics were computed using Microsoft Excel and NodeXL.

# 11. Portuguese network of investment

In the previous section we have described the main metrics that define the Portuguese network of foreign direct investment. In this section we will graphically represent the network to achieve the goal of determining which countries have a bigger impact on the Portuguese economy in terms of FDI, how has that impact change over the years (and specially during the crisis period) and how dependent is Portugal from these countries.

Since, in this case, we are analysing a network in which the centred node is Portugal and the rest of the nodes only establish links with the main node, most graph characteristics are unique, so metrics that we used before, such as degree or eigenvector, will not be useful here, since we are not presenting the relations between the other countries, but only the relation of each country with the Portuguese economy. This way the colour and shape of the nodes do not matter in this analyse.

However, this network is still weighted therefore, in all the graphs, the size of each node is proportional to its contribution to the total FDI between all the European countries for a specific year (respecting the 0,5% threshold previously defined).

To achieve the goals we will focus on the years 2009, 2014 and 2016 for the reasons mentioned before. The year 2000 previously analysed won't be considered, mainly due to the lack of detailed data regarding the FDI investors in the Portuguese economy for this year.

## 11.1. Main investors

When referring to the main investors on the Portuguese economy the first question should be who invests in Portugal, taking into consideration the threshold previously defined. In order to answer this question, we created a simplify representation of an investment network for the Portuguese economy, with Portugal taking the central role, as the only destination of investment. The

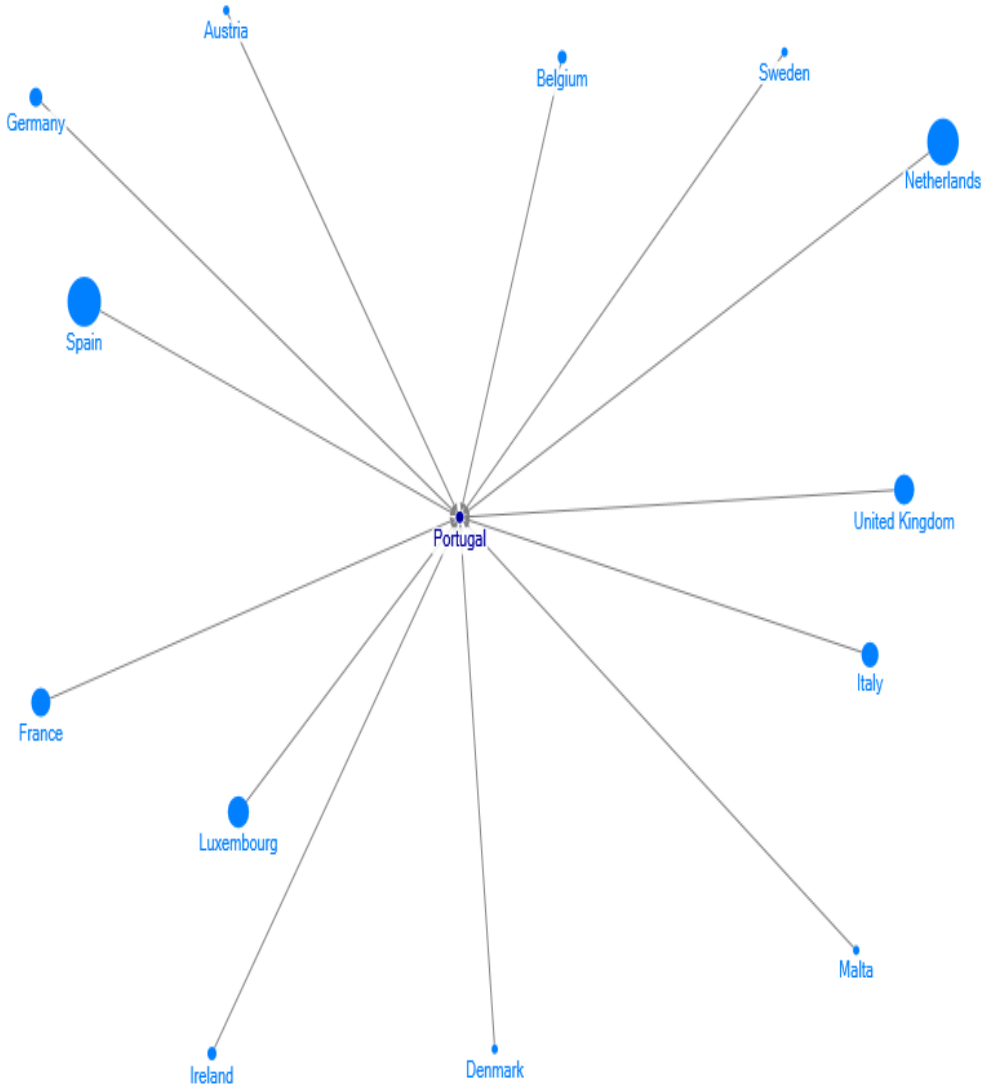
remaining countries presented different size depending on their total investment to Portugal, as the following expression explains:

$$S_{PT} = \frac{\sum_{y=1}^{27} abs(FDI)_{y,PT}}{abs(FDI)_{PT}} \quad \textbf{(5)}$$

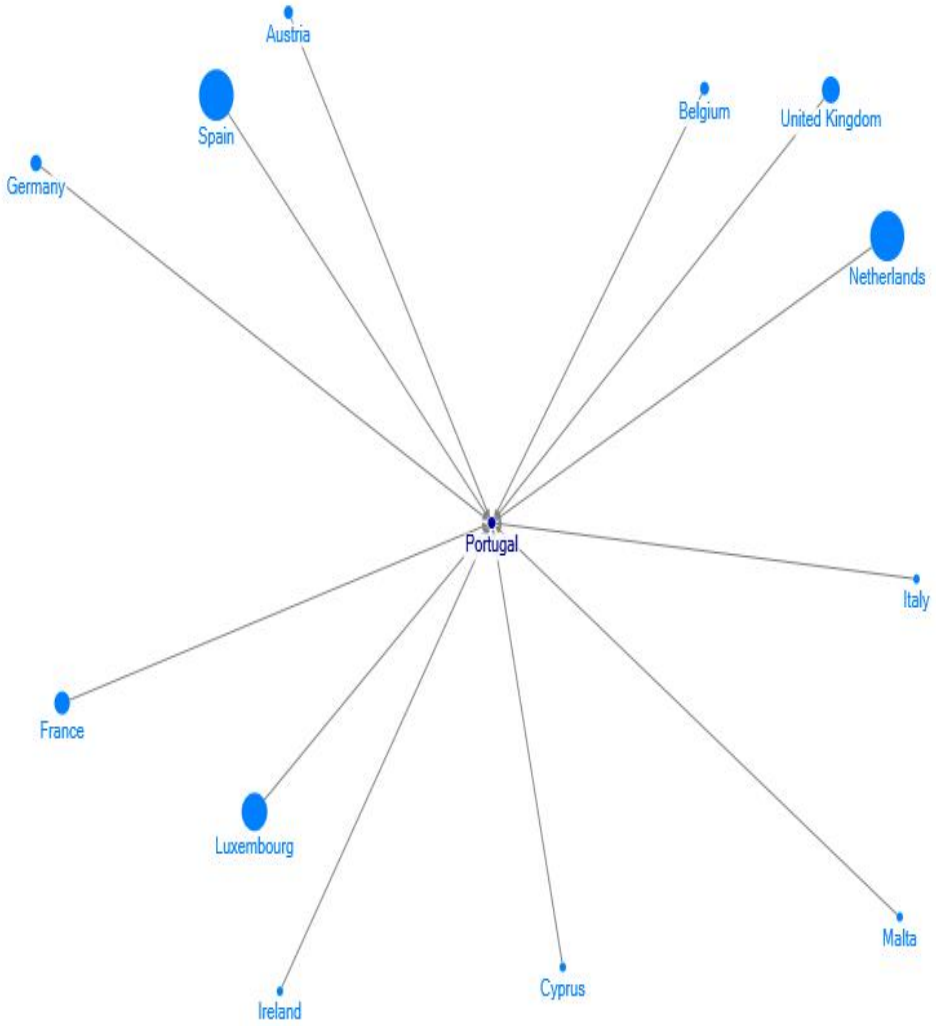
Where $S$ means the size of the Portuguese node, $FDI_y$ means the total FDI made from country $Y$ to Portugal ($PT$) and $FDI_{PT}$ means the total European $FDI$ made in that year to Portugal ($PT$) , from all the 28 EU countries.

Figure 13 - Network graphs of total foreign direct investment in Portugal - 2009, 2014 and 2017

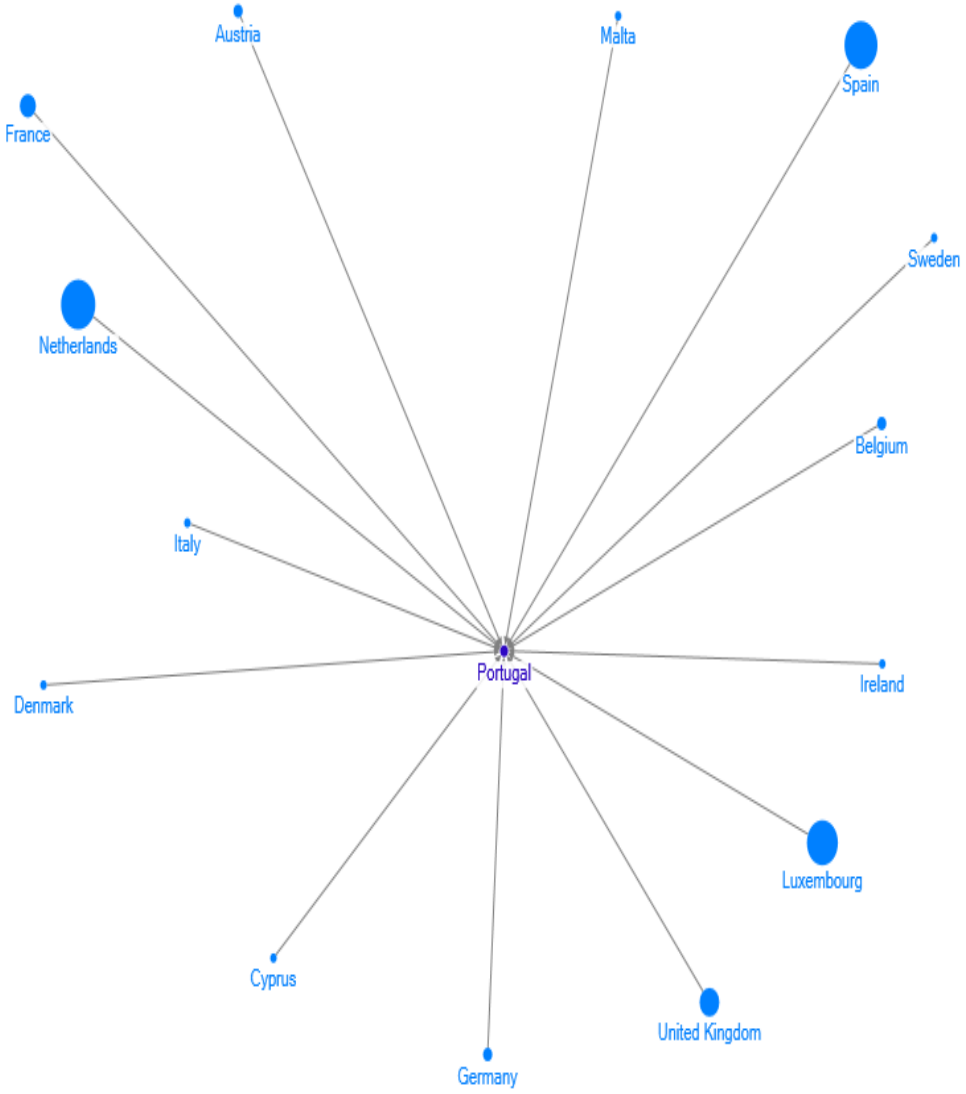
(a) 2009



(b) 2014


Austria
Spain
Belgium
United Kingdom
Germany
Netherlands
Portugal
Italy
France
Luxembourg
Malta
Ireland
Cyprus

(c) 2017



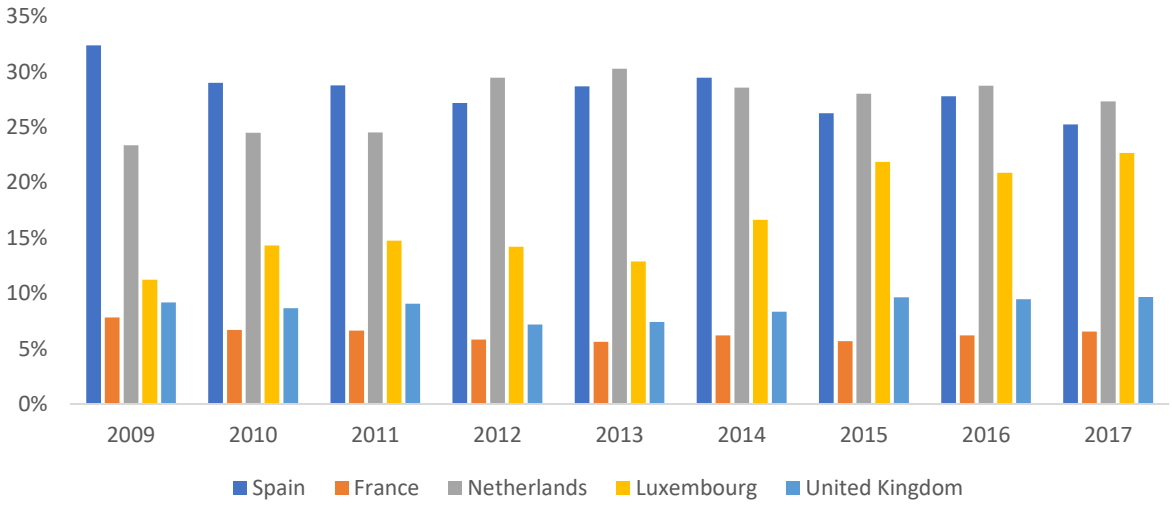

When looking at figure 13 we can see that in 2009 there were 13 countries that invested directly in the Portuguese economy. In 2014 that number was reduced to only 12 countries, and in 2017 that number increased to 14 direct investors.

When analysing the size of the investments there are some conclusions that can also be reached. In 2009 the main contributors to the Portuguese economy were Spain (32%) and the Netherlands (23%). In 2014 the Netherlands and Spain investment were the same, each originated 28% of the total investment in

Portugal. In 2017, the Netherlands was the main investor (27%), with Spain (25%) and Luxembourg (23%) following as main investors.

Before reaching more conclusions about the percentual contribution of each European country to the total investment received from Portugal, we must analyse the actual values of the investment, mainly to determine if the changes on the percentual contribution are due to a decrease of investment from a certain country or an increase on investment from another country, that will reduce the significance of other investments. To obtain those details we must analyse figure 14, that presents the five main investors in the Portuguese economy, as previously seen, with the corresponding investments in millions of euros.

Figure 14 - Main EU investors in the Portuguese economy in percentage of total EU inward FDI




Source: Banco de Portugal (BdP)

Some conclusions can be reached. For the entire period in analysis Spain and the Netherlands have been the main investors in the Portuguese economy. Although the Spanish investment has declined over the years, the Dutch investment has mostly increased, specially in the period that follow the financial crisis. Foreign direct investment obtained from the Luxembourg has also increased over the years, specially from 2015 to 2017. Other two main investors in the Portuguese economy were the United Kingdom and France. However the amount of investment has been kept low and stable during the years. It should be noticed that although the negative impact that the financial crisis had on the Portuguese economy, its main investors have kept their positions, and some of

them have even increased their investments in the last years, what may be a result of the better performance of the Portuguese economy.

# 12. Limitations and recommendations for future work

Despite the attempt to use the full potential of network analysis, there were some limitations to take full advantage of its capabilities, namely the following:

- The data was spread between different data sources and, despite the common characteristics between them, there were still some disparities in the values;
- We were limited to use a single data source, the IMF, since it provided data with good quality, updated and detailed. However, it was limited to the 2009 to 2017 period, reducing the scope of the analysis;
- Our analysis took into consideration the direct investors, or direct counterpart, which has limited our scope of analysis. We did not capture the perspective of the final investor, which can be from outside Europe.

Despite these limitations, the FDI data remains one of the most useful sources to understand the international relations between different countries and how it is evolves overtime. Some suggestions for subsequent development phases, which were covered in this work, include the following:

- Aim to analyse a larger time period, that allows to better understand the behaviour of FDI and its main trends, not being limited to a period of financial crisis;
- Increase the scope of the analysis, using information from other countries from outside the EU, providing useful information about the behaviour of FDI at a global scale;
- Analyse the global main investors on the Portuguese economy, with a special look at the main world economies, like China and the United States of America, and also with a focus on historical economic partners, like Brazil and Angola;
- Do an in-depth analysis on the difference between direct and indirect investors, identifying who are the main indirect investors on the EU;
- Perform a more detailed and completed cluster analysis for the EU network of direct investment. Identifying groups of countries that have closer relations or common characteristics, will help to understand what

motivates different countries to establish investment relations between them. Identifying main factors, such as proximity, language or culture;

- Create a network analysis with only transactional data, instead of stocks. It could provide more information regarding the FDI behaviour, especially on a year to year analysis, helping to explain the different trends that can be registered and how they are affected by endogenous or exogenous situations;
- Analyse the impact that FDI has on the different economical sectors. Define what are the main targets of foreign investment, how have they changed over time and what is their impact for the economy.

From the above aspects, it is clear that a useful extension of this study can be conducted.

# 13. Conclusions

The final chapter attempts to draw conclusions and give recommendations based on the results obtained in the previous chapters. The aim of this work was to improve the understanding of FDI behaviour in the European Union context and especially in the Portuguese case. We aimed to construct a representation of the European Union network of FDI, identifying patterns, establishing trends and understanding the relations between the different countries have changed over time. We used data from different data sources and applied it to a period marked by generalized financial crisis.

The analysis started with an introduction to the main variable, FDI. We describe its importance for the world economy and more specifically to the EU. We defined what data was available and its characteristics and after it we chose a methodology that would serve our purpose, by not only providing us the results but also the visualisation tools to understand them.

After choosing network analysis as the best methodology, we defined what were the main metrics that would allow us to analyse the behaviour of our main variable and more specifically, how the different countries were related to each other. Before constructing the network, we chose the threshold of 0,5% of the total FDI received by each country in a year, that would allow us to filter the existing data obtaining only the most meaningful part. We defined the mathematical process that would allow us to obtain all the data and the characteristics of the network.

After constructing the EU network we concluded that over the period from 2000 until 2017, the EU countries have increased their relations with each other's, with countries like the Netherlands, Luxembourg, Germany, United Kingdom and Belgium registering the higher number of investments with other EU countries. We also concluded about the importance of some countries in the network, identifying Germany, Netherlands, Luxembourg and the United Kingdom as countries with important roles on the network structure, mainly due to their connections. In terms of metrics that defined the centrality of the countries, such as geodesic distance, betweenness and clustering coefficient, the results were not significant enough to obtain sustainable conclusions.

We also made a in-depth analyses to the Portuguese economy position in the EU network of FDI. We concluded that since 2009 the FDI relations have decreased but its investments to or from countries with an important role on the network have increased. We also created the Portuguese network of investment and concluded that its main investors did not change much since 2009, with Spain, Netherlands and Luxembourg occupying the highlighted positions.

From the results obtained it is clear that network analysis tools present many advantages on the study of economic variables, especially when studying a larger data period with many agents. We've highlighted not only the visualisation capabilities of this methodology, but also its ability to apply metrics that provide useful information about economic relations. Therefore, in order to ensure the most efficient use of existing large data sets, without using other variables, network analysis presents itself as a tool to analyse, describe and present the results.

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# 15. Annex

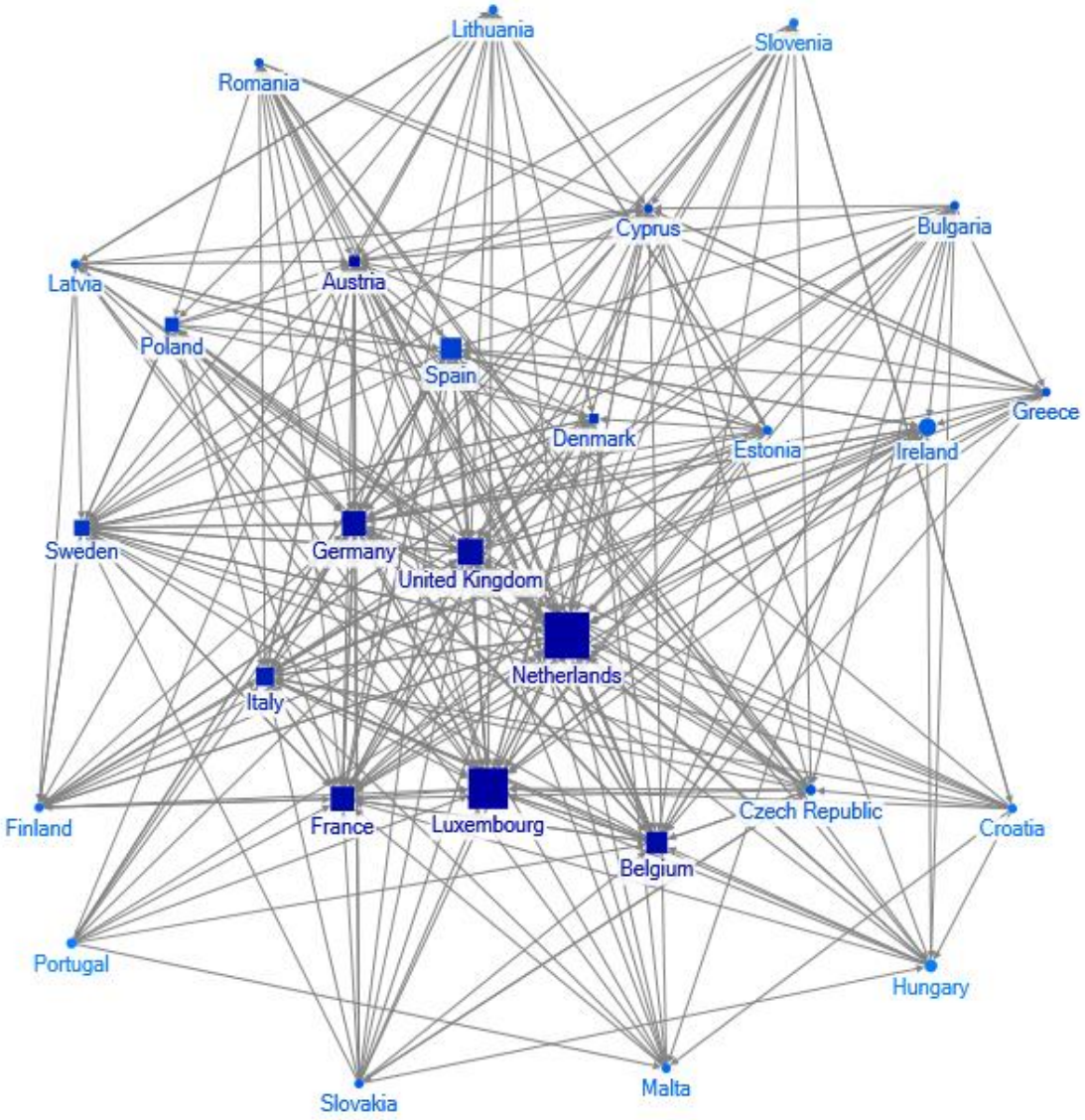
## A.1. List of articles with the theme of FDI (Author | Period | Countries | Variables | Methodology)

| Author | Period | Countries | Variables | Methodology |
|---|---|---|---|---|
| Akinlo (2004) | 1980-2012 | Nigeria | Private capital, education level, efficiency of production, externalities caused by FDI. | System equation method; vector error correction |
| Alaya (2006) | 1990-2008 | Morocco, Turkey and Tunisia | Exports, domestic growth. | Autoregressive-Distributed Lag models |
| Anwara and Nguyen (2010) | 1996-2005 | Vietnam | Exports, human capital, macroeconomic stability, public investment, level of financial development | Simultaneous equations model |
| Asheghian (2004) | 1970-2010 | U.S.A. | GDP, stock of capital. | Beach Mackinnon technique |
| Balasubramanyam et al. (1996) | 1994-2004 | 17 developing countries | Exports, GDP, capital stock | Simultaneous equations model |
| Carkovic and Levine (2002) | 1960-1995 | 72 countries | Average years of schooling, inflation, government size as share of GDP, openness to trade as exports plus imports relative to GDP. | Dynamic Panel Data; Generalized-Method-of-Moments |
| Chowdhury and Mavrotas (2006) | 1969-2000 | Asia | GDP | Toda-Yamamoto test for causality |
| Hsiao T. and Hsiao M. (2006) | 1986-2004 | China, Korea, Taiwan, Hong | GDP, exports. | VAR, VECM and Granger causal relations |

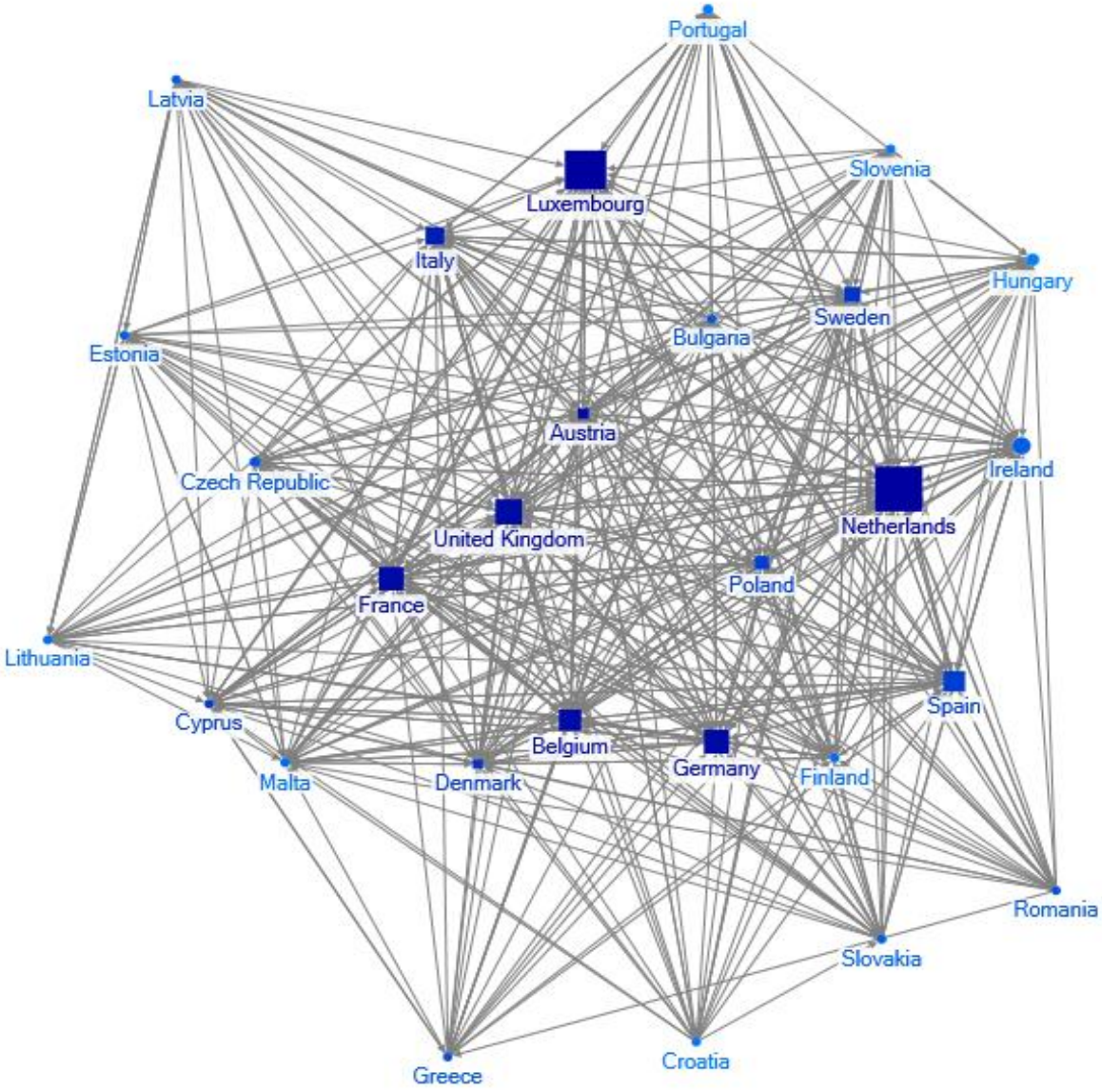
| | | | | |
|---|---|---|---|---|
| | | Kong, Malaysia | | |
| International Monetary Fund (2009) | n/a | n/a | n/a | n/a |
| Li, B., Liao, Z., Sun, L. (2018) | 2003-2012 | Global | FDI | Network Analysis |
| Simionescu (2016) | 2008-2014 | EU-28 | GDP growth rate | Bayesian random effects models; Bayesian linear regression models; Panel vector-autoregressive models (panel VAR models) |
| Zhang (2001) | 1984-1998 | China | GDP, stock of domestic capital and total productivity of factors | Growth model and dynamic panel data |

Source: Author

A.2. Network graphs of total foreign direct investment 2017 – 1% threshold



A.3. Network graphs of total foreign direct investment 2017 – 0,1% threshold



## A.4. European aggregate network metrics over time (2009 – 2017)

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|
| **Average Degree** | 18 | 20 | 20 | 18 | 19 | 19 | 20 | 20 | 20 |
| **Average Betweenness Centrality** | 7,4 | 7,2 | 6,8 | 7,1 | 7,7 | 7,3 | 7,4 | 7,4 | 7,2 |
| **Average Clustering Coefficient** | 0,56 | 0,57 | 0,57 | 0,57 | 0,54 | 0,56 | 0,56 | 0,56 | 0,57 |
| **Average Geodesic Distance** | 1,23 | 1,22 | 1,21 | 1,22 | 1,24 | 1,22 | 1,22 | 1,23 | 1,22 |
| **Average Out degree** | 12 | 13 | 13 | 13 | 12 | 13 | 13 | 12 | 13 |
| **Average In degree** | 12,464 | 12,536 | 12,714 | 12,714 | 12,143 | 12,536 | 12,5 | 12,393 | 12,714 |

## A.5. Portuguese aggregate network metrics over time (2009 – 2017)

| | Degree | Eigenvector centrality | Betweenness centrality | In degree | Out degree |
|---|---|---|---|---|---|
| **2009** | 15 | 0.028 | 0.433 | 7 | 13 |
| **2010** | 13 | 0.026 | 0.514 | 4 | 12 |
| **2011** | 14 | 0.027 | 0.764 | 4 | 13 |
| **2012** | 15 | 0.027 | 0.938 | 4 | 13 |
| **2013** | 13 | 0.026 | 1.217 | 3 | 13 |
| **2014** | 15 | 0.026 | 0.789 | 2 | 12 |
| **2015** | 13 | 0.026 | 0.841 | 3 | 12 |
| **2016** | 14 | 0.028 | 1.138 | 3 | 13 |
| **2017** | 14 | 0.029 | 1.534 | 2 | 14 |