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# Ranking the socioeconomic and environmental framework of European Union farms: A network analysis

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## Abstract

The context of European Union farms is markedly diverse. This is verified when, for example, several dimensions of the agricultural sector are analyzed, considering variables related with economic, social, or environmental dynamics. Indeed, frequently the farms in EU countries present relevant differences inside economic, social, or environmental dimensions. To better understand the interrelationships inside the economic, social, and environmental framework of European Union farms, this work analyzes the networks among these fields by considering rankings in decreasing order (with the statistical information of the representative farms of each European country) for variables like farming output, current subsidies, total inputs, gross investments, subsidies on investments, fertilizer and crop protection consumption, farming labor, and wages paid. Data was gathered from the Farm Accountancy Data Network, across the European Union member-states and over the period 2012-2014. This statistical information was analyzed through network analysis, exploring edgelists among the several variables considered and the network bridges between European countries. The results show that, in fact, there are significant differences in the scores found for European countries inside economic, social, and environmental dimensions, which was highlighted by the network analysis. However, the European Union farms are, in general, networked in the rankings for the variables considered.

**Keywords:** European farm context; Edgelists and network bridges; Farm Accountancy Data Network; Benchmarking.

**Jel codes:** C45; D01.

## 1. Introduction

The multiplicities of characteristics in European Union farms are good in terms of diversity, although this can bring several difficulties when common management plans or common strategies are implemented. In fact, a variety of agricultural realities occur among countries, inside regions, and between and inside socioeconomic and environmental dimensions. Some farms have, for example, good performance in some economic variables, but lower dynamics in other dimensions.

It is important to better understand these frameworks and identify the European Union countries where farm variables related with socioeconomic and environmental fields present the same or different performances. For that, this work considered network analysis, ranking in decreasing order and across the European Union member-states, variables related with the economic dimension (farming output, current subsidies, farming inputs, gross investment, and subsidies on investment), social fields (farming labor and wages paid), and environmental impacts (fertilizers and crop protection consumption).

Data at the farm level was considered and retrieved from the Farm Accountancy Data Network (FADN 2017) across European Union countries over the period 2012-2014. The FADN database has the advantage of provide microeconomic statistical information at farm level. The statistical information was worked in average over this period of three years. Considering a period of three years allowed capturing the effects of any annual fluctuation in the variables. In the consideration of this period, 2012-2014, there was the intention of take into account a balance between to have recent years a avoid to have the new CAP policies from the 2013 reform (for 2014-2020) totally implemented. The year of 2014 is, indeed, inside of the period for the new partnership agreement, however we consider that this is not a problem, because the first years of the community support frameworks, and other policies implementation, are usually periods of adjustments for the new strategies.

The network analysis was implemented following Stata (2017) procedures and NWCommands (2017) developments. With the network analysis, pairs of variables (chosen taking into account the statistical information available in the database considered) were compared inside each dimension (economic, social, and environmental), using for each variable the list of European Union countries and their respective values in decreasing order. In this case, for each variable the European member-states were considered ranked in decreasing order.

The network analysis allows exploration for each pair of farm variables, in the ranking, the

edgelists (connections between different values of different variables in the same level of score in the ranking) and the network bridges (a tie from any node  $i$  to  $j$ ), showing the countries with variables that have the same score and those with different levels. This is an interesting analysis, because it clearly highlights the countries in which the performance of some variables needs to improve to achieve the ranking of others. In turn, it is possible to identify different countries with the same score for different variables, allowing for future benchmarking among different farms. In any case, the techniques and the statistics behind these methodologies are well developed by works as Grund (2015).

## **2. Literature analysis**

The network analysis considered, with different approaches, for several researches related with diverse economic sectors and in various fields of the society dimensions, such as health contexts (Paredes-Esquivel et al. 2009), genetic studies (Gao et al. 2011), interrelations analysis among and inside species (Trainor et al. 2013), road linkages (Pacina, Popelka, and Novak 2015), spatial analysis (Sousa and Small 2016), and economic dimensions. Environmental contexts were also looked at, sometimes with a sustainable development perspective.

In fact, no one and nothing works alone; understanding of the respective networks is crucial for effective and adjusted planning and management. In turn, network analysis and similar approaches are more proper methodologies for research intended to explore relationships among variables in the presence of multidimensional characteristics (Fabbrizzi et al. 2015).

Specifically concerning agriculture, network analysis may bring several interesting contributions to sector understanding, namely in the relationships with balanced rural development (Boron et al. 2016). Understanding the agricultural sector is fundamental considering the diversity of particularities that characterize farms around the world, particularly in the European Union, where agriculture is regulated in many fields by common strategies in the Common Agricultural Policy (CAP) framework.

Questions about agricultural networks and their relationship with other sectors, such as biodiversity and the environment, assume special importance in less favorable regions, such as mountain zones (Tzanopoulos et al. 2011). In these zones, the farming sector has an important contribution for sustainable development and CAP instruments play a crucial role in these contexts. Network analysis may be an interesting approach that supports national and European institutions in the design of adjusted policies.

A good assessment of potential scenarios before agricultural policies are implemented is determinant to achieve the objectives intended with their design, namely in zones with more susceptibility to changes in strategies and where the consequences may be more dramatic, not only economically, but principally at social or environmental levels (Hirschi et al. 2013). In fact, the farmers' presence in the mountains or less favored zones avoids desertification and prevents wildfires.

Another question concerns the understanding of the several networks, formal or informal, created between the farmers and among the farmers and the organizations, namely for the exchange of information (Isaac 2012). Information flows are determined in the farming sector, which considers its particularities, specifically with access to the technical information that supports adjusted decisions. In addition, questions related to information networks in the farming sector assume a special importance in zones where there is frequently a migration of farmers, with several impacts in the destination regions (Isaac et al. 2014).

Related, yet, to the agricultural sector, the network analysis may give determinant support in participatory processes for the implementation of new technologies, innovations, or agronomic practices (Lamb et al. 2016). The introduction of innovation in the farming sector is not easy and petitions for participation processes involving the farmers to help design appropriate approaches for implementation. In fact, these participatory processes are fundamental for successfully adopting new technologies and should be well planned to better understand the farmers' perspectives, identifying potentialities and constraints in the implementation strategy. Listening to farmers and other agricultural operators is crucial to understanding their conceptual structures about several dimensions interrelated with their farms; for example, efficiency or sustainability (Hoffman, Lubell, and Hillis 2014).

Another aspect is the management of the scarce resources of the farms and municipalities that are sometimes shared by different farmers or by other diverse operators or entities, like water. Understanding the network dynamics may improve this management and contribute to using resources more efficiently (Rathwell and Peterson 2012).

The scarcity of water and its interrelationships with national and international networks is a concern for many policymakers and authors (Yang et al. 2012). Indeed, water quality and its availability are and will be determinant questions, namely because of climate change and for the performance of several sectors in society, specifically for farming. Network analysis methodologies may have important contributions, namely finding links that facilitate adaptation processes (Varela-Ortega et al. 2016).

Agriculture dynamics depend on several production factors, each important in farming performance. One such factor is soil, which has a crucial contribution. Understanding soil characteristics is very important to farming planning and management, and is a field in which network analysis may also be an interesting approach (Navarrete et al. 2015).

### **3. Network analysis**

Following Stata (2017) procedures, Grund (2015) proposals and NWCommands (2017) developments, edgelist and network bridges between European Union countries for agricultural variables related to economic, social, and environmental dimensions were explored. Data from the FADN (2017) was considered, which provides statistical information at the average farm level (an average farm per European country). For each variable the countries were ordered in decreasing value (creating rankings), considering the respective values provided by the database. Of stressing that, the analysis here realized is about the network between rankings of the different variables, not about absolute values behind. The results for the network analysis are presented in figures 1-6 and tables 1-6.

#### **3.1. Economic dimensions**

Figure 1 and table 1 - the network analysis among the farming output and current subsidies (excluding the investment subsidies) - shows that countries like Slovakia, Romania, Poland, and Hungary present the same level in the ranking for network relationships among the two variables considered. This reveals that in these countries the current subsidies seem to be strongly linked with output. Slovakia has the highest level and Romania the lowest. Slovenia and Cyprus are reciprocally interrelated because the farming output in Cyprus is at the same level of the current subsidies in the ranking (position 23), and the farming output in Slovenia is at the same level of the current subsidies in Cyprus (position 26). The remaining countries, including the European Union as a whole, are interrelated in a network that begins, for example, in Luxembourg and finalizes in the Czech Republic. (The farming output in Luxembourg is at the same level of the current subsidies in France, and the output in France is at the same level of the current subsidies in Estonia, and so on). This means that in the network analysis between farming output and current subsidies, countries across the European Union are divided into three groups: countries with the same level among the two

variables; countries that are reciprocally networked alone; and countries that are networked together, including the European Union as a whole.

[Insert figure 1]

[Insert table 1]

The networks among the farming output and input (figure 2 and table 2) stress the presence of three main groups: a set of countries where the two variables present the same level in the ranking (Slovakia, Romania, Poland, Netherlands, Luxembourg, Ireland, Germany, France, Denmark, Czech Republic, Cyprus, and Austria); three countries networked together (Sweden, Belgium, and United Kingdom); and two countries networked together (for example, Portugal and Slovenia). The high number of countries with the same level for the two variables and very close positions for the other countries shows that European Union farms with high output have great level inputs as well.

[Insert figure 2]

[Insert table 2]

Figure 3 and table 3 show that farming output and gross investment have the same ranking level in Romania, Finland, Bulgaria, and Austria (stressing the lower levels of farming output and gross investment in Romania). In turn, Malta and Portugal are reciprocally networked, and the same happens with France and Estonia. The remaining countries are networked in two groups: one starting with Italy, for example, and going until Lithuania, and the other starting with the United Kingdom and going until Sweden.

[Insert figure 3]

[Insert table 3]

Figure 4 and table 4 show the gross investment and subsidies on investment. This data shows that the United Kingdom and Finland are reciprocally networked; Slovakia, Luxembourg, and Poland have the same level for the two variables; Spain, Italy, Croatia, and Cyprus seem to be networked together; and the remaining countries are interrelated between each other. In stressing the different positions in the ranking for the two variables across the European countries, this was expected to be correlated.

[Insert figure 4]

[Insert table 4]

### **3.2. Environmental fields**

Concerning fertilizers and crop protection consumption in European Union farms (table 5 and figure 5), the following countries have the same level of utilization: Slovakia, Romania, Luxembourg, Latvia, Greece, France, Czech Republic, and Cyprus (with Slovakia having the biggest level of consumption and Romania the lowest). These countries have the same environmental impact with fertilizer consumption and crop protection utilization. In turn, Slovenia and Malta, as well the United Kingdom and Germany, are reciprocally networked. The remaining countries are networked together.

[Insert figure 5]

[Insert table 5]

### **3.3. Social dimensions**

Figure 6 and table 6 present the ranking network for farming labor and wages paid. From this it is possible to identify three main groups: countries with the same level for labor and wages paid (Slovakia, Netherlands, Germany, the European Union as a whole, Estonia, and Czech Republic); countries with Lithuania, Portugal, Denmark, the United Kingdom, and Belgium networked in the rankings; and a big group for the other countries. Of importance is that Slovakia (position 1 in the ranking), Czech Republic (position 2), and Netherlands (position 3) present the highest level of labor input, but also have the greatest level of wages paid.



[Insert figure 6]

[Insert table 6]

#### **4. Conclusions**

This work explores the networks inside the economic, social, and environmental dimensions of farms across European Union countries, considering data at the farm level from the Farm Accountancy Data network, as an average over the period 2012-2014. (A period of three years was considered to capture any annual fluctuation in the statistical information).

For the economic dimensions, variables such as farming output, current subsidies, farming input, gross investment, and subsidies on the investment were taken into account. For social dimensions, variables such as labor input and the wages paid were considered, whereas for the environmental context it was fertilizers and crop protection consumption.

A methodological approach was used for the network analysis, using Stata software. Mainly edgelists and the bridge networks were explored for each pair of variables between the European Union countries in decreasing order, taking into account the respective values for each variable.

The network analysis for the pairs of variables (farming output-current subsidies, farming output-farming input, farming output-gross investment, gross investment-subsidies on investment, fertilizers-crop protection, and labor input-wages paid) shows that, in general, European Union countries have different levels for different variables; only a small number of member-states have the same levels. The pair of variables with the most countries with the same ranking level is farming output-farming input; that with the fewest countries matching is gross investment-subsidies on investment. Network rankings for the output-input reveal that farms that produce more also use more resources and have more costs, and vice-versa. In turn, the network rankings for the investment-subsidies pair on investment show that countries with a great level of gross investment are not the same as those that receive a high level of subsidies on investment. This conclusion needs a deeper analyses in future researches, because these findings may be a consequence of the subsidies on investment have been targeted for countries with more structural weakness in the farms (and this is good, because is

the objective of the structural funds for the agricultural sector), or may be because some problems in the implementation of these subsidies.

In general, the majority of European Union farms are networked in the rankings for the variables considered, except for the pairs farming output-farming input and farming output-gross investment. In the first case, this is because there is a large number of countries with the same level for the two variables; in the second case this is because the majority of the countries are networked in two main groups.

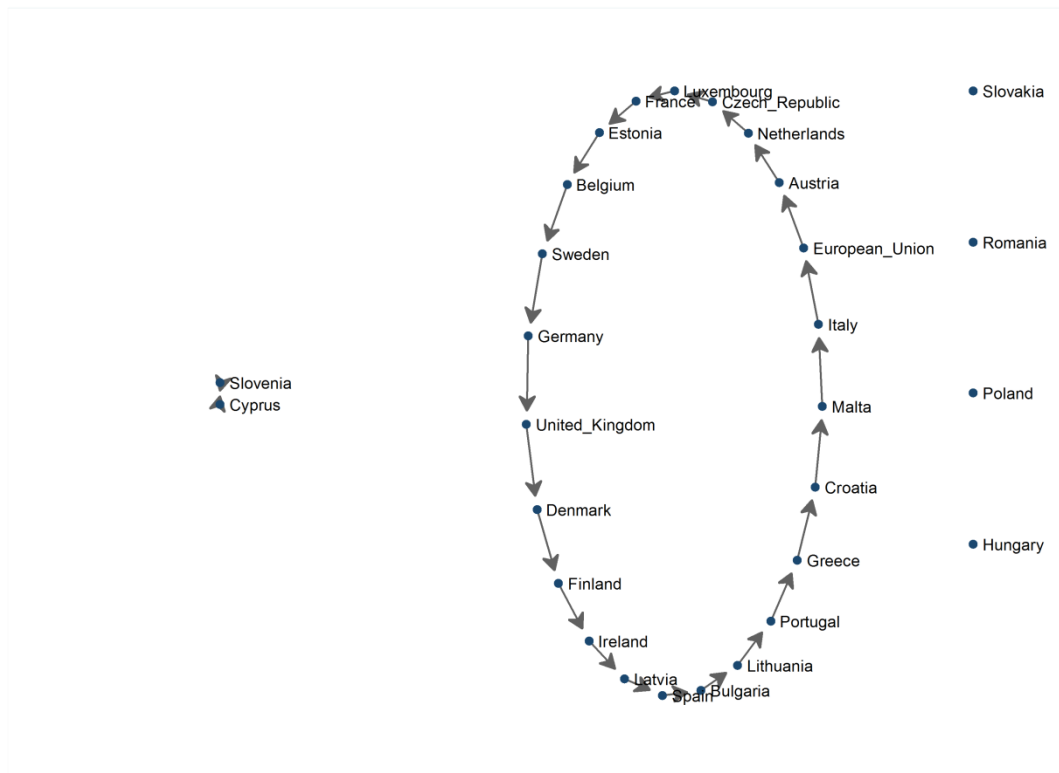
This means that in the majority of the situations inside the economic, social, and environmental farm dimensions there are relevant differences in the relative levels of several variables across European Union countries. These findings could be considered for future works with the perspectives of benchmarking, taking advantage of best practices to improve the less interesting contexts, and exploring these networks for new policy implementation. In fact, it was possible to identify the countries with more social and environmental problems, namely in terms of wages paid and fertilizers and crop protection consumption. On the other hand, it will be important design future policies to improve the efficiency in the European Union farms, because the countries with more output are the same with more resources consumption.

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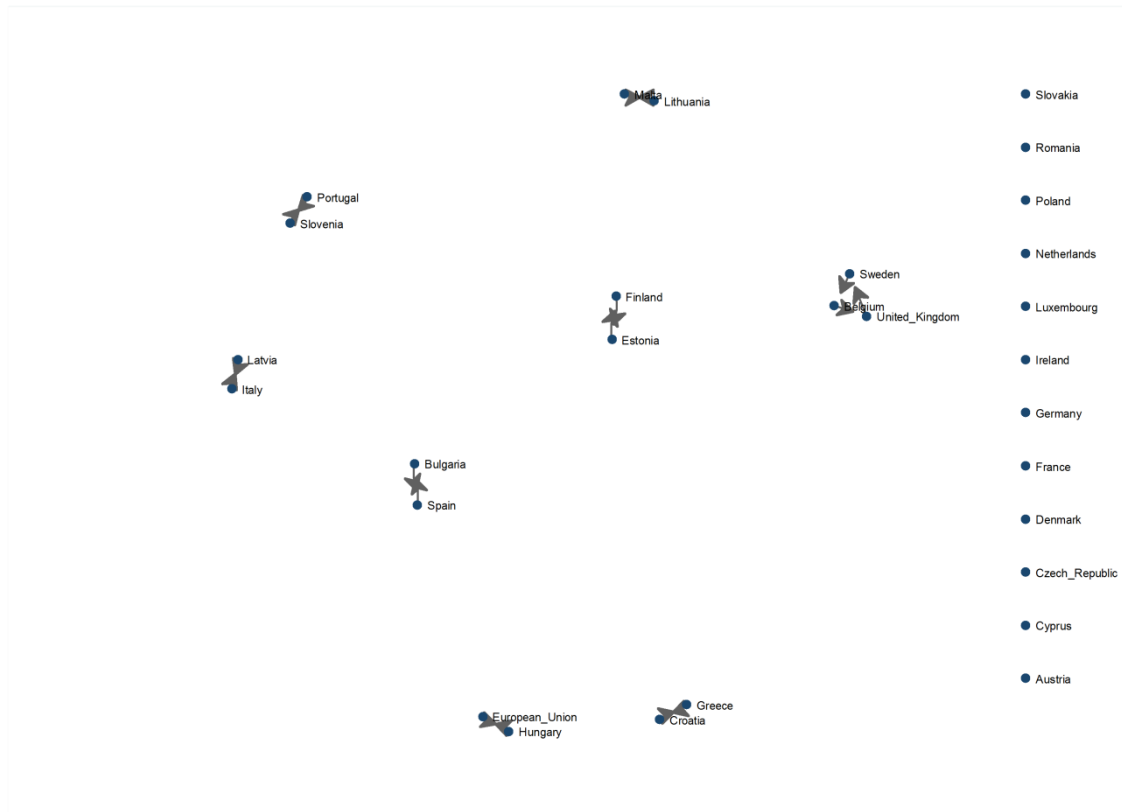
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**Figure 1.** Network analysis among total farming output (euros) and total current subsidies (euros) across European Union countries over the period 2012-2014

**Table 1.** Ranking in decreasing order for total farming output (euros) and total current subsidies (euros) across European Union countries over the period 2012-2014

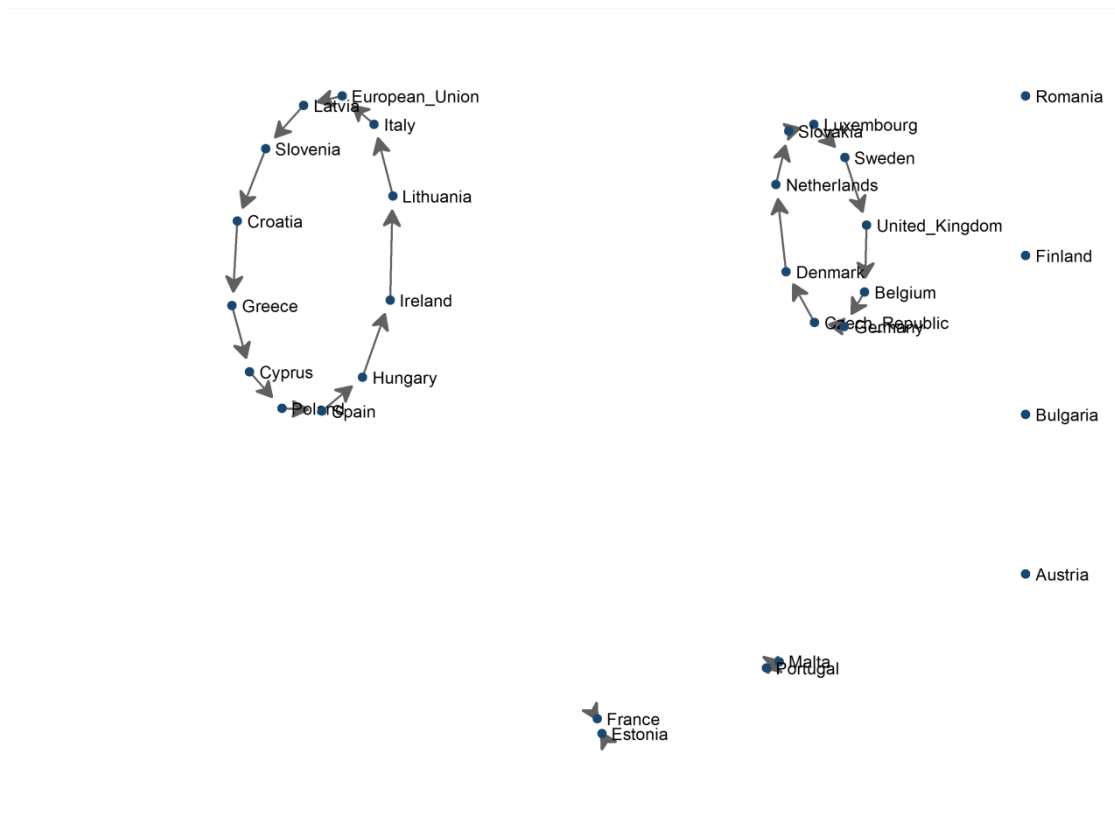
Ranking in decreasing order	Total output	Total current subsidies
1	Slovakia	Slovakia
2	Netherlands	Czech Republic
3	Denmark	Finland
4	Czech Republic	Luxembourg
5	Germany	United Kingdom
6	Belgium	Sweden
7	United Kingdom	Denmark
8	Sweden	Germany
9	Luxembourg	France
10	France	Estonia
11	Estonia	Belgium
12	Finland	Ireland
13	Austria	Netherlands
14	European Union	Austria
15	Hungary	Hungary
16	Ireland	Latvia
17	Italy	European Union
18	Latvia	Spain
19	Spain	Bulgaria
20	Bulgaria	Lithuania
21	Malta	Italy
22	Lithuania	Portugal
23	Cyprus	Slovenia
24	Portugal	Greece
25	Poland	Poland
26	Slovenia	Cyprus
27	Greece	Croatia
28	Croatia	Malta
29	Romania	Romania



**Figure 2.** Network analysis among total farming output (euros) and total inputs (euros) across European Union countries over the period 2012-2014

**Table 2.** Ranking in decreasing order for total farming output (euros) and total inputs (euros) across European Union countries over the period 2012-2014

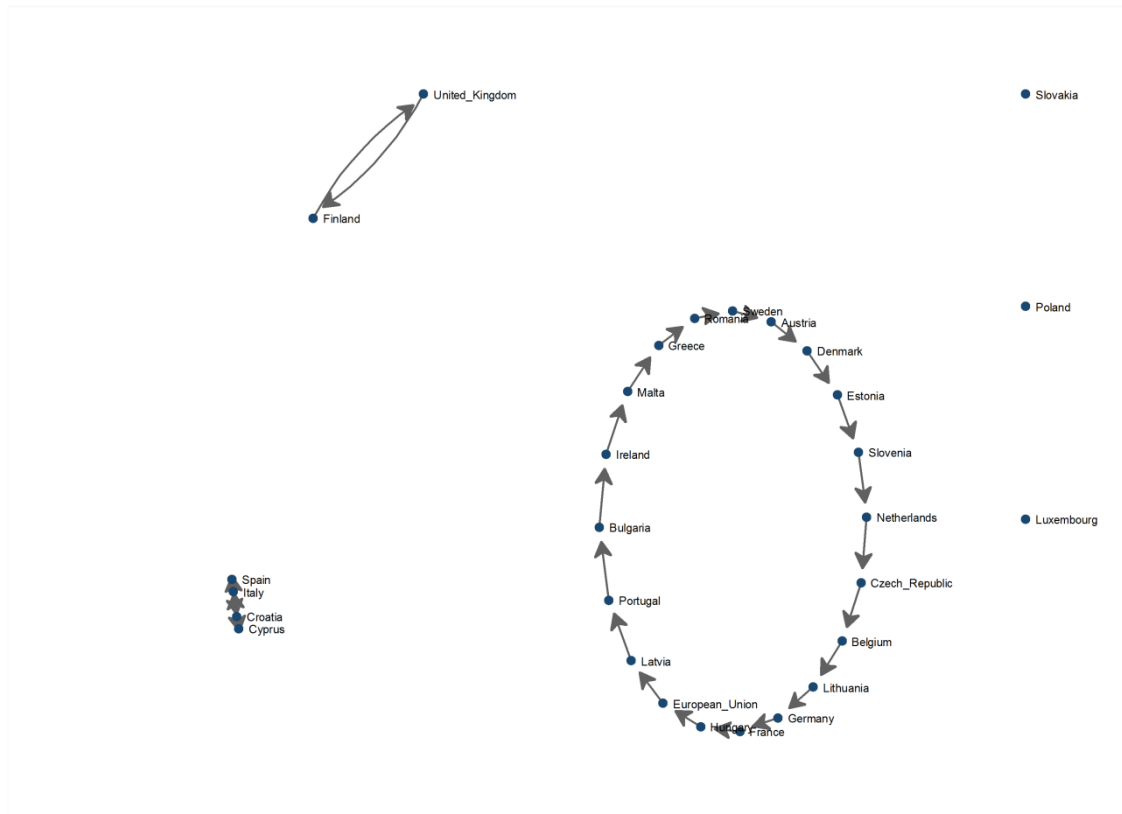
Ranking in decreasing order	Total output	Total Inputs
1	Slovakia	Slovakia
2	Netherlands	Netherlands
3	Denmark	Denmark
4	Czech Republic	Czech Republic
5	Germany	Germany
6	Belgium	United Kingdom
7	United Kingdom	Sweden
8	Sweden	Belgium
9	Luxembourg	Luxembourg
10	France	France
11	Estonia	Finland
12	Finland	Estonia
13	Austria	Austria
14	European Union	Hungary
15	Hungary	European Union
16	Ireland	Ireland
17	Italy	Latvia
18	Latvia	Italy
19	Spain	Bulgaria
20	Bulgaria	Spain
21	Malta	Lithuania
22	Lithuania	Malta
23	Cyprus	Cyprus
24	Portugal	Slovenia
25	Poland	Poland
26	Slovenia	Portugal
27	Greece	Croatia
28	Croatia	Greece
29	Romania	Romania



**Figure 3.** Network analysis among total farming output (euros) and gross investment (euros), across European Union countries over the period 2012-2014

**Table 3.** Ranking in decreasing order for total farming output (euros) and gross investment (euros) across European Union countries over the period 2012-2014

Ranking in decreasing order	Total output	Gross Investment
1	Slovakia	Luxembourg
2	Netherlands	Slovakia
3	Denmark	Netherlands
4	Czech Republic	Denmark
5	Germany	Czech Republic
6	Belgium	Germany
7	United Kingdom	Belgium
8	Sweden	United Kingdom
9	Luxembourg	Sweden
10	France	Estonia
11	Estonia	France
12	Finland	Finland
13	Austria	Austria
14	European Union	Latvia
15	Hungary	Ireland
16	Ireland	Lithuania
17	Italy	European Union
18	Latvia	Slovenia
19	Spain	Hungary
20	Bulgaria	Bulgaria
21	Malta	Portugal
22	Lithuania	Italy
23	Cyprus	Poland
24	Portugal	Malta
25	Poland	Spain
26	Slovenia	Croatia
27	Greece	Cyprus
28	Croatia	Greece
29	Romania	Romania

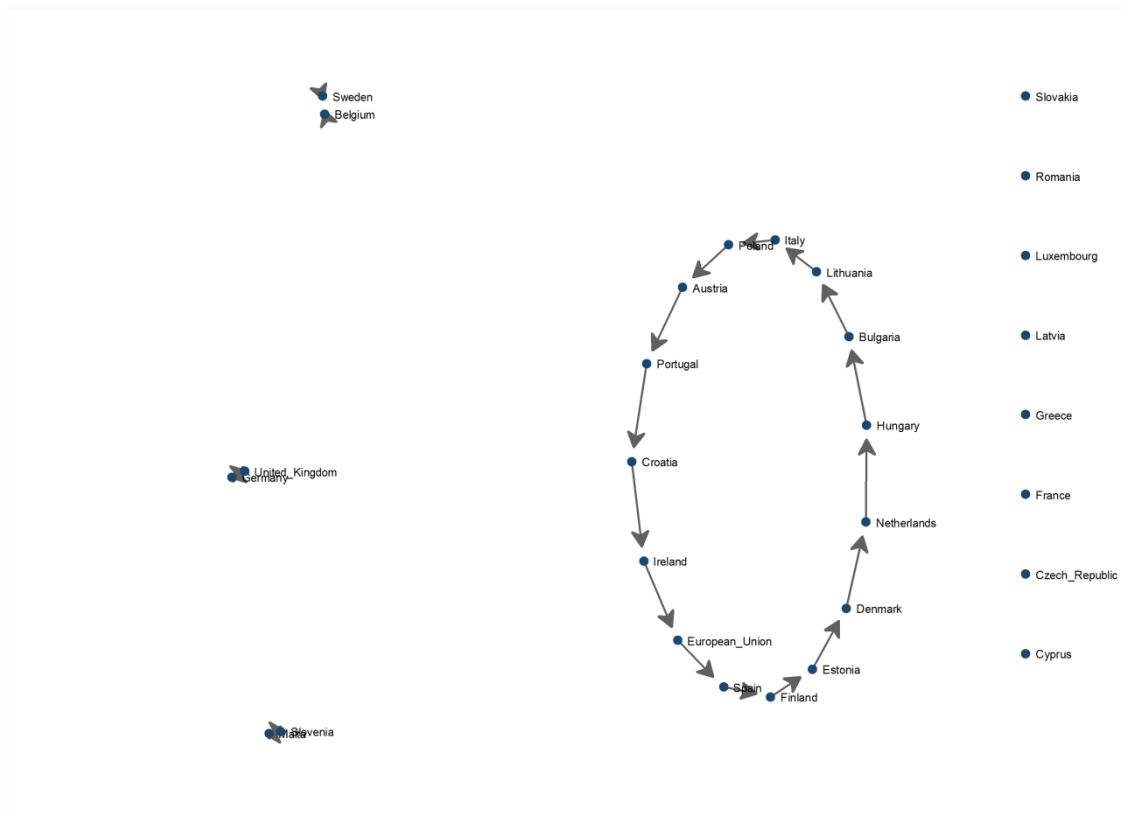


**Figure 4.** Network analysis among gross investment (euros) and subsidies on investment (euros) across European Union countries over the period 2012-2014

**Table 4.** Ranking in decreasing order for gross investment (euros) and subsidies on investment (euros) across European Union countries over the period 2012-2014

Ranking in decreasing order	Gross Investment	Subsidies on investments
1	Luxembourg	Luxembourg
2	Slovakia	Slovakia
3	Netherlands	Czech Republic
4	Denmark	Estonia
5	Czech Republic	Belgium
6	Germany	France
7	Belgium	Lithuania
8	United Kingdom	Finland
9	Sweden	Austria
10	Estonia	Slovenia
11	France	Hungary
12	Finland	United Kingdom
13	Austria	Denmark
14	Latvia	Portugal
15	Ireland	Malta
16	Lithuania	Germany
17	European Union	Latvia
18	Slovenia	Netherlands
19	Hungary	European Union
20	Bulgaria	Ireland
21	Portugal	Bulgaria
22	Italy	Cyprus
23	Poland	Poland
24	Malta	Greece
25	Spain	Italy
26	Croatia	Spain
27	Cyprus	Croatia
28	Greece	Romania
29	Romania	Sweden

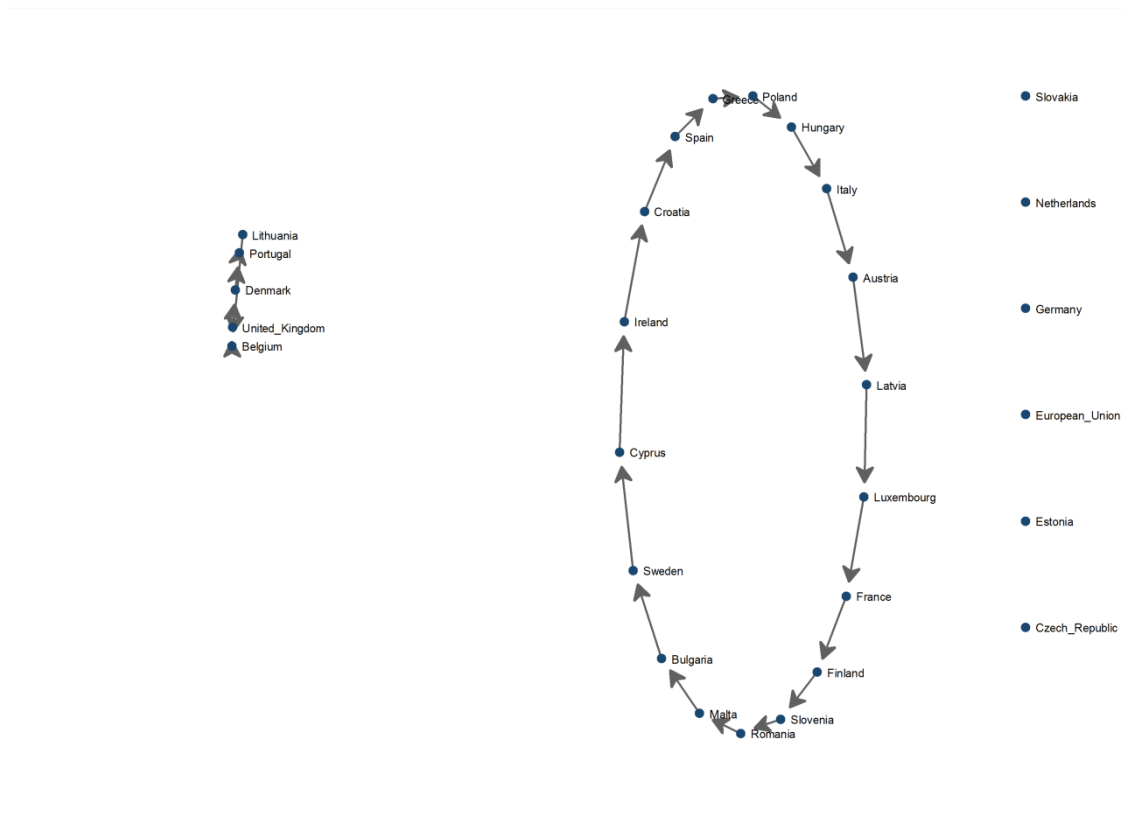




**Figure 5.** Network analysis among fertilizers (euros) and crop protection (euros) across European Union countries over the period 2012-201

**Table 5.** Ranking in decreasing order for fertilizers (euros) and crop protection (euros) across European Union countries over the period 2012-2014

Ranking in decreasing order	Fertilisers	Crop protection
1	Slovakia	Slovakia
2	Czech Republic	Czech Republic
3	United Kingdom	Germany
4	France	France
5	Germany	United Kingdom
6	Denmark	Netherlands
7	Estonia	Denmark
8	Sweden	Belgium
9	Luxembourg	Luxembourg
10	Belgium	Sweden
11	Netherlands	Hungary
12	Finland	Estonia
13	Ireland	European Union
14	Latvia	Latvia
15	Hungary	Bulgaria
16	Lithuania	Italy
17	European Union	Spain
18	Bulgaria	Lithuania
19	Spain	Finland
20	Poland	Austria
21	Italy	Poland
22	Austria	Portugal
23	Croatia	Ireland
24	Cyprus	Cyprus
25	Portugal	Croatia
26	Greece	Greece
27	Slovenia	Malta
28	Malta	Slovenia
29	Romania	Romania



**Figure 6.** Network analysis among labor input (hours) and wages paid (euros) across European Union countries over the period 2012-2014

**Table 6.** Ranking in decreasing order for labor input (hours) and wages paid (euros) across European Union countries over the period 2012-2014

Ranking in decreasing order	Labour input	Wages paid
1	Slovakia	Slovakia
2	Czech Republic	Czech Republic
3	Netherlands	Netherlands
4	United Kingdom	Denmark
5	Germany	Germany
6	Belgium	United Kingdom
7	Bulgaria	Sweden
8	Estonia	Estonia
9	Luxembourg	France
10	Latvia	Luxembourg
11	Lithuania	Belgium
12	Poland	Hungary
13	France	Finland
14	Hungary	Italy
15	European Union	European Union
16	Austria	Latvia
17	Croatia	Spain
18	Malta	Bulgaria
19	Denmark	Portugal
20	Sweden	Cyprus
21	Portugal	Lithuania
22	Romania	Malta
23	Italy	Austria
24	Cyprus	Ireland
25	Spain	Greece
26	Greece	Poland
27	Ireland	Croatia
28	Slovenia	Romania
29	Finland	Slovenia