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EMBODIED TECHNOLOGY FLOW: INVESTIGATION OF A MISSING LINK

Doktora Tezi

Cemil Faruk DURMAZ

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Keywords: Teknoloji Transferi, Bilgi Üretimi, Eşzamanlı Denklemler

Abstract

This thesis examines embodied technology flows through intermediate good transactions between industries in various economies and focuses on the ambiguity about their link to innovation. We use input-output tables as a proximity mechanism for research capital and utilize production function approach. The empirical model consists of two equations measuring labor productivity and knowledge production, and the latter is measured as the explanatory variable of productivity. We compare direct effect of embodied research transfer on labor productivity through intermediate good transactions between industries and its indirect effect via knowledge creation. We observe that labor productivity soars with direct and indirect utilization of technology transfer via knowledge production. GMM results support the system we introduce, indicating that both channels of embodied technology spillovers are significant. We also analyse technology transfer networks in terms of their structures for each economy in the sample. Service industries have prominent role as supplier and customer technology. High and medium-high technology industries come forward as central suppliers of research.

Keywords: Technology Transfer, Knowledge Production, Simultaneous Equations

GENEL BİLGİLER

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Bilim Dalı: İktisat (İng.)

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Anahtar Kelimeler: Teknoloji Transferi, Bilgi Üretimi, Eşzamanlı Denklemler

Özet

Bu tez, çeşitli ekonomilerdeki endüstriler arasındaki ara mal işlemleri yoluyla somutlaştırılmış teknoloji akışlarını incelemekte ve bunların inovasyonla olan bağlantılarına ilişkin belirsizliğe odaklanmaktadır. Araştırma sermayesi için bir yakınlık mekanizması olarak girdi-çıktı tablolarını kullanıyoruz ve üretim fonksiyonu yaklaşımını kullanıyoruz. Ampirik model, emek verimliliği ve bilgi üretimini ölçen iki denklemden oluşur ve ikincisi, verimliliğin açıklayıcı değişkeni olarak ölçülür. Somutlaştırılmış araştırma transferinin, endüstriler arasındaki ara mal işlemleri yoluyla emek verimliliği üzerindeki doğrudan etkisi ile bilgi yaratma yoluyla dolaylı etkisini karşılaştırıyoruz. Bilgi üretimi yoluyla teknoloji transferinin doğrudan ve dolaylı kullanımıyla emek verimliliğinin arttığını gözlemliyoruz. GMM sonuçları, sunduğumuz sistemi desteklemektedir, bu da somutlaştırılmış teknoloji yayılmalarının her iki kanalının da önemli olduğunu göstermektedir. Ayrıca örneklemdeki her bir ekonomi için teknoloji transfer ağlarını yapıları açısından analiz ediyoruz. Hizmet endüstrileri, teknoloji tedarikçisi ve alıcısı olarak önemli bir role sahiptir. Yüksek ve orta-yüksek teknoloji endüstrileri, teknoloji tedarikçileri olarak merkezilikleriyle öne çıkıyor.

to

my mother

and

my father

Acknowledgements

First and foremost, I would like to express my gratitude to my thesis supervisor Dr. Burcu Düzgün Öncel for all her guidance, invaluable advice, and never-ending support.

I would also like to thank Dr. M. Nedim Sualp for sharing his knowledge, experience and support.

I also express my special thanks to Dr. Yasemin Özerkek, Dr. B. Can Karahasan, Dr. Tolga Aksoy and Prof. Dr. Mahmut Tekçe as my dissertation committee members for their comments and advice.

I extend my thanks to Dr. Umurcan Polat and Dr. H. Kutay Bolkol and all members of Faculty of Economics in Marmara University for all their help.

I would also like to acknowledge the help and valuable opinions of Dr. Moritz Mueller of Strasbourg University.

I am also grateful to all members of Faculty of Business and Management Sciences in İstanbul Sabahattin Zaim University for the work environment they provide with understanding and sympathy.

Finally, I would like to thank TUBİTAK for funding a part of my research in Strasbourg University with International Research Fellowship Programme for PhD Students.

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USPTO (United States Patent Office)

EPO (European Patent Office)

FDI (Foreign Direct Investment)

R&D (Research and Development)

NACE (North Atlantic and Central European)

WIOD (World Input Output Database)

OECD (Organisation for Economic Co-operation and Development)

WIPO (World International Patent Office)

IPC (International Patent Classification)

VIF (Variance inflation factors)

GMM-3SLS (Generalized Method of Moments-3 Stages Least Squares)

FIVE (Full-Information Instrumental Variables Efficient)

ANND (average nearest neighbor degree)

CHAPTER 1: THE MISSING LINK

1. INTRODUCTION

Economic growth is based on many factors in an economy and the production process depends mainly on two inputs; capital and labor. A third factor, which is related to these, is the technology. It is a well-known fact that an invention or a series of innovations in a particular field leads to a greater productivity in the production process. A common example of general-purpose technology from the history is the steam engine. Invention of steam engines lead to a more efficient production process in many sectors and not just in manufacturing but also in transportation i.e. ships with steam engines. Innovation on the other hand is defined as an incremental improvement in a technology. It should be noted that innovation could be created mainly in two different ways in a manufacturing industry; product and process innovation. Product innovation is simply the introduction of an entirely new or improved product, which improves the revenue fraction of a firm's profit. Process innovation is the improvement in production process that targets a reduction in the cost i.e. labor-saving process.

Knowledge enters production process in the form of technological progress. Knowledge itself could be defined as a commodity. However, unlike normal goods knowledge is non-rival and partially excludable. First, more than one person can benefit knowledge even at the same time. Second, even though one can prevent others from using the knowledge he/she created, this is not entirely possible. These properties of knowledge differ technology from other factors of production. Another distinctive feature of technology is about the rule of diminishing returns. As we know, both labor and capital presents diminishing returns as their quantity increases. Even though an innovation can be outdated in time, it is related to obsolescence. It may become obsolete in the presence of other superior technologies. These features of knowledge lead economic growth literature from exogenous models i.e. (Solow, 1956) to endogenous growth ((Romer, 1990), (Grossman & Helpman, Quality Ladders in the Theory of Growth, 1991a)) where we can find increasing returns to scale and divergence. Knowledge generation is related to two factors and interaction of them; human capital and knowledge capital stock. Previously generated knowledge is examined and utilized by educated labor force. Output of generation is heavily indicated by innovation and inventions. Measurement of the knowledge output is a problematic issue in terms of value. The former can be measured with innovation surveys, the strongest indicator for an invention is a patent granted to inventor.

Especially, first two properties of knowledge opened the door for a field of research; knowledge spillovers. Since, the generated knowledge spills over to other agents in an economy, dynamics of this process have been also examined. In case of open innovation, it is assumed that the knowledge created by one agent cannot be contained hence the comparative advantage provided by the superior technology to that particular agent can be faded in time. This feature of knowledge, which is called the 'spillover effect', has three main dimensions. One of the early theoretical studies of international technology diffusion is by (Grossman & Helpman, Trade, knowledge spillovers, and growth*, 1991b). Later, (Coe & Helpman, 1995) look for international spillovers empirically. Their method is based on imports as a weighting scheme of knowledge capital, which is proxied, by R&D capital stock. It should be noted a FDI and intermediate (and capital) good imports are common transmission mechanisms of international technology transfer in the empirical literature. Other dimensions of knowledge diffusion are generated within an economy; intra and inter-sectoral spillovers. These could occur after the entrance of foreign technologies and their reverse engineering process or after the generation of a new technology with a country's own efforts. It is not plausible to say that these two are independent from each other. However, in our research we will focus heavily on within country inter-sectoral spillovers. It is possible to determine how much firms invest in R&D and whether they have succeeded on realized innovations. It is not clear whether the knowledge is totally generated within borders or not. This is not the main concern of our research. International transfer mechanisms have been deeply investigated in cross-country research. It does not allow much to examine individual characteristics of countries. We concern about how the knowledge generated in a country disseminates within. How the new technology is utilized and generate a multiplier effect throughout the sectors creates a non-negligible difference between economies.

1.1. Related Literature

Literature focuses on mainly these two types of technology flows; knowledge embedded in patent and intermediate goods. Following paragraphs present a review of related literature in order to lay the groundwork and explain the contribution and possible inefficiencies of the model proposed in this paper. (Jaffe, 1986) is a pioneer work on spillovers via patents which it constructs a technological proximity matrix between firms via technology fields of patent applications. As two firms' share of patents' technology fields approximates to each other, the transfer between them intensifies according to the vector built by Jaffe.

(Bloom, Schankerman, & van Reenen, 2013) improved this methodology. He augments technological proximity measure with a probability matrix and uses researchers in the same field rather than the patent applications. (Oikawa, 2017) states that Bloom's approach enables us to see the proximity not just a statistical relation between technology vectors but rather as a knowledge transmission mechanism. (Aldieri, Knowledge technological proximity: evidence from US and European patents, 2013) shows that Jaffe's method is also suitable for macro-economic measures where he compares proximity between US and European firms' patent applications. Hu and (Hu & Jaffe, 2003) studied Korea and Taiwan in case of knowledge flows from US and Japan. Their methodology was based on patent citations and examination was about how these countries tuned into innovators from imitators.

(Scherer, 1982) adopts a similar approach previously by defining the origin and using industry of innovations. With the emergence of technology flow matrix' based on Scherer's work, (Vespagen, 1997) uses three different methods to measure flows between sectors via patent documents. First two of them based on supplementary documents of patent applications to USPTO (United States Patent Office) and EPO (European Patent Office) databases where the information indicates a spillover to other industries. Second main approach is constructed on patent citations. When an applied patent cites another one that is granted to an agent in another sector it indicates that there is a pure knowledge transfer from latter to previous one. (Los & Vespagen, 2000) compares rent and pure knowledge spillovers. When they define transfer via a transmission mechanism (intermediate goods or patents) as indirect R&D spillovers, Jaffe's methodology is considered as a pure transfer.

They use EPO database based on the methods in their previous work with supplementary documents of patent applications. When the main document gives the information about the firm's operating industry, additional information in supplementary documents consisted with the information of the by-products of the patent that shows the contribution to other industries. They simply aggregate the IPC codes of the patents with correspondence to ISIC (rev 2). In the following paragraphs, place of intermediate goods is discussed. (Malerba, Mancusi, & Montobbio, 2013) presents a comprehensive study for inter-sectoral and intra-sectoral knowledge spillovers for both national and international level. They modify patent applications and citations measurement from firm-industry to industry-county level. Results indicate that national R&D spillovers are stronger than the international ones that emphasize the importance of within boundary knowledge flow.

Intermediate goods and their relationship with technology generation have an important place in various endogenous growth models such as (Romer, 1990) and (Grossman & Helpman, Quality Ladders in the Theory of Growth, 1991a). In Romer's endogenous growth model, labor is distributed between manufacturing and R&D. However, manufacturing sectors are also divided into two, intermediate good and final output producers. Notion of value added can be simply defined as the subtraction of the value of intermediate goods (along with subsidies and taxes) from final output. It is assumed that knowledge is embodied in intermediate goods, which is transferred from R&D producing side of the economy.

Grossman and Helpman evaluates intermediate goods with the same understanding in the quality ladder approach. They also suggest that knowledge is embodied by showing that quality of a final good is a function of intermediate goods used in production where w stands for input.

Empirical literature adopts this approach and uses intermediate good transactions as a weighting scheme. (Coe & Helpman, 1995) heavily rely on this methodology to measure international knowledge transfer. Use of Input-Output matrix enables to use intermediate good flows between sectors to estimate inter-sectoral knowledge flows. However, this should not be understood as the equivalent of the 'pure knowledge flows' explained above. One of the earliest suggestions of input output matrix as a weighting scheme is introduced by (Terleckyj, 1980). (Keller, 1997) compares import related technology transfer with unweighted R&D spillovers and shows that trade and knowledge flows between countries have no strong correlation. He also suggests that unweighted sum of R&D capital stock of a country's partners is more effective. However, these two different variables are not estimated simultaneously. Keller uses Yale Technology flow matrix along with the IO weighting scheme. He also simulates (Monte Carlo) a random weighting matrix for the sample of 13 industries. However, he concludes that technology flow measures also need improvements and specification compared to random weights. (Madsen, 2007) tests different calculations for research intensity and weight these variables with intermediate good transactions. He suggests that spillover variable is significant regardless it is measured by R&D expenditure or patent data. He concludes that international knowledge spillover via intermediate goods is an indicator of technology transfer.

(Aldieri, Sena, & Vinci, 2018) is one of the examples in recent literature that compares pure and rent knowledge spillovers. They also use Jaffe's methodology to define pure and IO matrix to construct rent spillovers. First, he shows that knowledge transfer via patents is stronger between agents close to technology frontier with same absorptive capacity. Second, it is estimated that firms, which are further to the firms with high R&D intensity, receives knowledge transfer mostly from rent spillovers. Even though, literature is heavily based on developed countries, emerging economies are recently a topic of interest. Researchers test the hypotheses proved for developed world for the developing countries. (Gonçalves & B. Ferreira Neto, Intersectoral flows of technological knowledge in emerging countries: An input-output analysis, 2016) classifies sectors in correspondence to Pavitt taxonomy and use input-output matrix to examine inter-sectoral transfer. Their sample consists of BRIC economies and they argue that when the knowledge spillovers are stronger for science-based industries in developed world, medium level sectors are also important technology producers for developing countries. The results are very similar to the Aldieri's work and emphasize the significance of rent spillovers for emerging economies. (Gonçalves, Perobelli, & Araújo, 2017), focuses on Brazil and draw a similar conclusion that medium technology sectors are significant for knowledge flows via intermediate goods. (Domingo & Borrás, 2017) present another work for comparison between direct and indirect knowledge flow. They also focus on sector heterogeneity and classify sectors according to their research intensity. Their results indicate that direct spillovers are stronger for low technology manufacturing sectors.

The reasoning behind the significance of knowledge flows via intermediate goods for developing economies could be that they are not fully innovators as the developed world. They are more efficient in reaping technology from goods embedded with it. Literature indicates that argument would be valid for within country spillovers.

Theoretical background before endogenous growth theories is established by Grilliches's production function with externalities in a compact way. (Grilliches, Issues in Assessing the Contribution of Research and Development to Productivity Growth, 1976) defines the spillovers arise from good purchases from one firm (industry) to another, as so-called 'rent spillovers'. He suggests that when an intermediate good with a new and more efficient technology is produced in one sector and purchased by another, decline in prices could be related to quality-price mismatch. The higher quality of the produced intermediate good might not be entirely captured by its price that is reflected to the purchaser's final output as a lower price. Process, ends up with a final good in the purchaser's sector however there is ambiguity about the occurrence of knowledge transfer. (Link, 1983) is one of the first studies that emphasizes the importance of external knowledge acquired by firms. He uses a Cobb-Douglas production function similar to the one introduced by Grilliches in his work in 1979 and asserts the importance of inter-firm technology purchases however, he does not distinguish between pure and rent spillovers. (Grilliches, 1992) continues to claim that positive externalities still exist and the social return of knowledge creation is higher than its private return. His literature review of different weighting schemes including IO matrix and patents enforces the main argument.

1.2. Main Proposition

In this subsection, we explain two main purposes of this chapter. First, we would create 'a link' from knowledge production to final product. We observe that empirical literature tends to regress direct or indirect knowledge externality directly to physical good productivity. Thus, we propose that research embodied technology spillover works through knowledge production function in order to obtain a new patent then the new idea is utilized in good or service production. Our first hypothesis is as follows;

Hypothesis 1: Embodied technology transfer might have an effect on a final good through knowledge production.

As an example, we assume that firm i operating in machinery sector producing hydraulic press buys a newly innovated metal component from firm j, which is operating in fabricated metals industry. The new component could be embodied with greater research intensity and enables firm i to produce with greater productivity. However, it does not necessarily mean that with influx of external technology firm i also achieves innovation. We do not argue that so called "direct effect" does not necessarily increase productivity of firm i's hydraulic press. However, we cannot simply conclude that R&D capital transfer which is weighted by transactions between industries causes an increase in firm i's productivity through its innovative performance. Griliches emphasizes a similar issue with a perspective in failure in price discrimination of firm j. We do not argue that 'blue arrows' in figure 1 do not cause an increase in productivity of receiving industry. Higher research intensity could result as an enhancement of the labor productivity. We aim to isolate direct and indirect effects of externality on labor productivity. We summarize our second hypothesis below:

Hypothesis 2: Embodied technology transfer might have a direct effect on a final good.

This chapter is composed as follows; section two describes the empirical model; section three presents descriptive statistics for the sample and section four explains the methodology and empirical results.

2. MODEL

Main purpose of chapter 1 is to examine inter-sectoral externalities and propose a new approach to indirect knowledge transfer. In empirical literature, an intermediate good is treated as carrier of technology between units in an economy. Grilliches (1976) proposes a production function with externality between firms as follows where the first term is the constant, Xi is the conventional production factors, Ki is the firm's own resources of research and the last term is the knowledge pool comes from all other firms in a sector.

$$Y_i = BX_i^{1-\gamma} K_i^{\gamma} K_{\alpha}^{\mu}$$

Grilliches defines externality as follows;

$$\sum_i K_i = K_{\alpha}$$

Therefore, he aggregates all firm production functions to observe overall elasticity of knowledge creation including the externalities;

$$\sum_i Y_i = \mathrm{B}(\sum_i X)^{1-\gamma} K_{\alpha}^{\gamma+\mu}$$

The last equation shows that coefficient of knowledge capital is greater than the individual production function in aggregated form. Based on Grilliches' function, we propose variations in twofolds. First, we use sector production functions and secondly we treat each sector as producer of final output and knowledge.

This section draws a two-equation model for inter-sectoral knowledge spillovers considering indirect channel for knowledge transfer. In endogenous growth theory, role of intermediate goods as a technology carrier is considered as apriority by empirical literature. Knowledge flows through intermediate goods as presented in Figure 1. Although intermediate goods is utilized as a proximity method between sectors, it is also possible to argue that these goods may cause ambiguity in two ways. First question we address is that; whether transmission of R&D intensity via intermediate goods directly affects final good production or it affects R&D development process of receiver and results in enhancement of its innovation capacity. Finally, the effect goes through internal knowledge production of receiver. Second, whether intermediate good transactions cause two different effects on receiving industry. First one, is the indirect technology transfer we have mentioned in first question and second is a direct impact on final good similar to literature. It is possible that a sector buys intermediate goods from another and directly utilizes the R&D in its own final good production. We would like to examine the effect of direct use of research on final good production. The model consists of two endogenous equations. One is for the knowledge and the other is for the final good production.

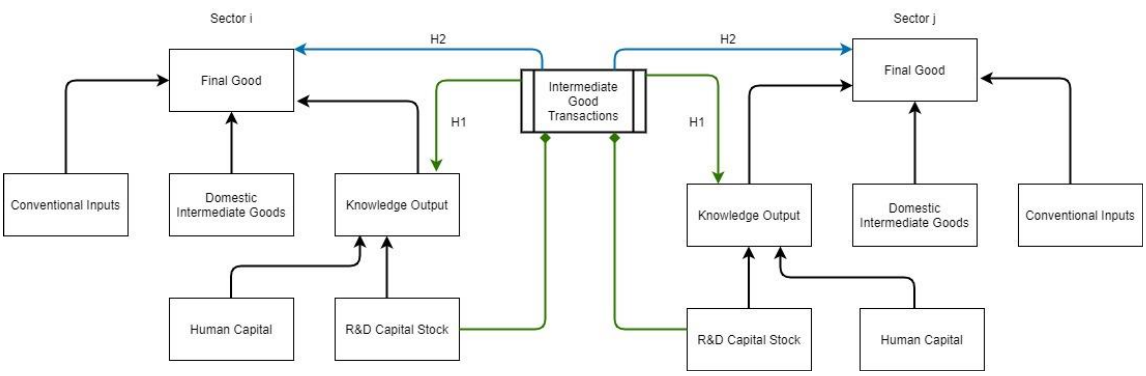


Figure 2. Inter-sectoral Knowledge Transfer

Figure 1, represents our model with black, blue and green arrows where black is the direct domestic flows, blue is the direct external effects and green is indirect flows[1]. Green arrows from R&D Capital Stock of Sector i to sector j is weighted by expenditures between sectors which is represented by the (black) box in the middle of the figure. Intermediate goods work their way into final good production in two different ways. First, one is the indirect transfer. R&D capital stock from sector i goes into R&D department of the firms in sector j via intermediate goods. The green arrow between sectors shows that destination of this transfer may lead to production of new knowledge. On the other hand, sectors have transactions of intermediate goods and R&D produced in one sector enhances the others' productivity directly. We show this effect with blue arrows from the black box to final good in each sector.

We present the relationship with two equations; Equation 1 shows the final good production function where Y is the value of final goods produced in sector i and country c, X is a vector of conventional inputs such as physical capital stock and domestic inputs for each sector and A is the internal knowledge input. We present knowledge production in equation 2 where R stands for the internal R&D efforts, H is human capital in sector i and T[2] is the knowledge spillover from other sectors. Unlike Grilliches' model, our spillover term is inserted into both equations to represent two channels of transfer.

$$Y_{ict} = X_{ict}^{\alpha_1} A_{ict}^{\alpha_2} T_{ict}^{\alpha_3} \tag{1}$$

$$A_{ict} = R_{ict}^{\beta_1} H_{ict}^{\beta_2} T_{ict}^{\beta_3} \tag{2}$$

We divide all variables to number of employees in each industry. Final good product turns into labor productivity and conventional sector inputs are fixed capital stock and inputs. Finally, all variables are transformed into logarithmic forms in differences with additional control variables[3]. We also utilize dummy for manufacturing industries in equation 3 and a dummy for high and medium-high technology level sectors in eq. 4 and 5 to control for sector heterogeneity.[4] We also consider backward link of spillovers in

[1] Diamond nods at the end of green curves show a transmission effect and the arrow heads are the final destination of the flow. Green lines are related to Hypothesis 1 and the blue lines stand for Hypothesis 2.
[2] T is the green arrow from R&D capital stock of each sector to other's knowledge input.
[3] From now on, small letters stand for first differenced-logarithmic per capita variables.
[4] First dummy variable takes the value of 1 if there is a manufacturing industries and 0 otherwise. Dummy variables in knowledge production function is constructed as follows; dummy for high-medium-high technology industries takes the value of 1 for Manufacture of chemicals and chemical products; computer, electronic and optical products, electrical equipment, machinery and equipment n.e.c., motor vehicles,

knowledge production where sectors adjust their innovative efforts in accordance with their buyers' research capital stocks in equation 5.

$$\triangle\, logY/L_{ict} = C_{ic} + \alpha_0 \triangle\, logK/L_{ict} + \alpha_1 \triangle\, logM/L_{ict} + \alpha_2 \triangle\, logA/L_{ict} + \alpha_3 \triangle\, logT_{ict} + \alpha_4 D_i^1 + \epsilon_t \quad (3)$$

$$\triangle\, logA/L_{ict} = C_{ic} + \beta_0 \triangle\, logR/L_{ic(t-1)} + \beta_1 \triangle\, logH/L_{ic(t-1)} + \beta_2 \triangle\, logT/L_{ic(t-1)} + \beta_3 D_i^2 + \epsilon_t \quad (4)$$

$$\triangle\, logA/L_{ict} = C_{ic} + \beta_0 \triangle\, logR/L_{ic(t-1)} + \beta_1 \triangle\, logH/L_{ic(t-1)} + \beta_2 \triangle\, logT/L_{ic(t-1)} + \beta_3 \triangle\, logB/L_{ic(t-1)} \beta_4 + D_i^2 + \epsilon_t \quad (5)$$

3. SAMPLE

We select the sample in accordance with available country-sector database. Main sources of database are WIOD (World Input Output Database) and OECD (Organisation for Economic Co-operation and Development) First, we match countries accessible in both sources and create clusters for the mean of labor productivity.[5] Clusters are presented in Table 1. It is also not possible to find R&D expenditure data for all sectors with two digit NACE Rev. 2 classification. List of sectors are presented in Appendix 1.[6] We consider cluster 1 in the rest of this chapter.

So that, service sectors are aggregated on higher levels. Time period is between 2009 and 2014 since R&D expenditure data causes missing observation problem before these dates. As a result, our sample is in panel data structure with two cross sections: 7 countries and 19 sectors. We have 798 observations in level data, and it reduces to 665 with first difference logarithmic form. Panel data is in accordance with nature of this study, because knowledge creation and its transfer become effective in time. Focus of this chapter is the first cluster with lowest productivity levels. Following statistics are based on cluster 1. Summarized descriptive statistics are presented in Table 2 with logarithmic

trailers and semi-trailers, other transport equipment, Information and communication (except Computer programming, consultancy and related activities) services, Computer programming, consultancy and related activities; information service activities.

[5] Countries and sectors with missing data are omitted.

[6] Service sectors are aggregated on higher levels because of missing observations. However, computer programming industry is excluded from sector J since it has a significantly high volume among information and communication technologies.

form.[7] Sample consists of multiple economies and sectors (manufacturing, service and construction) however we there are no cross-country variables.

Table 1
Mean Clusters (Labor Productivity)

Cluster 1 (Low)	Cluster 2 (Medium)	Cluster 3 (High)
Czechia	Australia	Austria
Lithuania	Canada	Belgium
Poland	Finland	Denmark
Portugal	Spain	France
Romania	United Kingdom	Germany
Slovenia		Ireland
Turkey		Netherlands
		Norway
		Sweden
		United States

Table 2
Descriptive Statistics

Variable		Mean	Std. Dev.	Min	Max	Observations	
y	overall	0.010028	0.149961	-0.6271	0.943263	N =	665
	between		0.070763	-0.21516	0.257038	n =	133
	within		0.132329	-0.63273	0.810311	T =	5
k	overall	0.002217	0.13666	-0.90569	0.634591	N =	665
	between		0.065521	-0.21802	0.18365	n =	133
	within		0.120037	-0.77012	0.631992	T =	5
m	overall	-0.06587	0.751549	-4.90745	3.550739	N =	665
	between		0.222068	-1.0899	0.58546	n =	133
	within		0.718198	-4.4169	3.493518	T =	5
a	overall	0.052897	0.236697	-1.45409	0.982915	N =	665
	between		0.102682	-0.51277	0.411917	n =	133
	within		0.213414	-0.88843	0.891063	T =	5
r	overall	0.374576	0.376164	-0.74728	4.08607	N =	665
	between		0.164647	-0.00432	1.0725	n =	133
	within		0.338459	-0.68654	3.480903	T =	5
h	overall	0.081257	0.509772	-2.40336	3.612784	N =	665
	between		0.1637	-0.51674	0.713787	n =	133

[7] Abbrevations for variables can be found in Table 3.

	within		0.48294	-2.23608	3.37252	T =	5
t	overall	0.347283	0.453349	-5.48036	2.606347	N =	665
	between		0.144444	-0.38604	0.599241	n =	133
	within		0.429868	-4.74703	3.093229	T =	5
b	overall	0.323911	0.670504	-5.03356	3.352848	N =	665
	between		0.188204	-0.43203	0.692523	n =	133
	within		0.643714	-4.30748	3.423846	T =	5

Figure 2.1, shows the qualitative relationship labor productivity and knowledge creation. We observe a possible positive relationship since new ideas and productivity. So that, patent grants would be utilized in good/service production. We also observe the relationship between final goods and external R&D capital stock as positive. In last two figures, comparison between external and internal R&D capital stock can be found. We expect contribution from both domestic and between industry R&D efforts to knowledge creation. In Figure 2.5. and 2.6., we present physical capital stock and backward embodied technology transfer. These two graphs indicate that they also have positive relationship between labor productivity and patent grants.

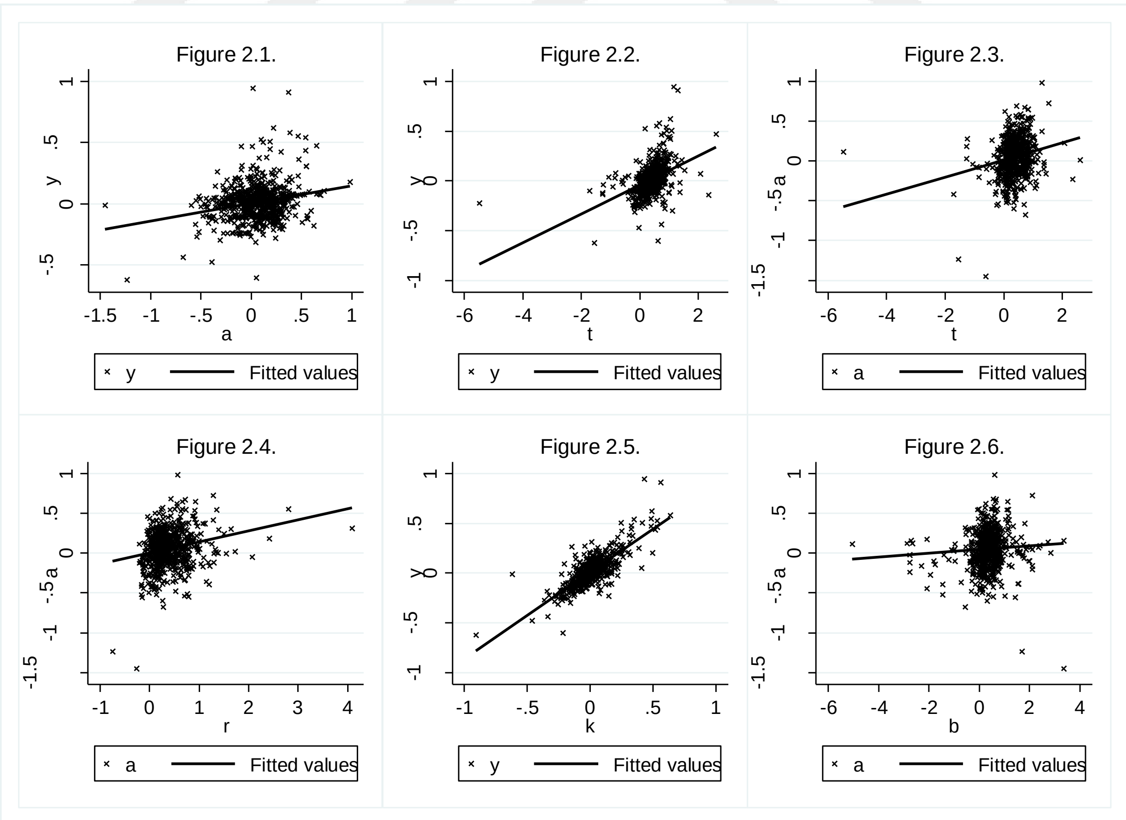


Figure 3. All Sample Scatter Plots

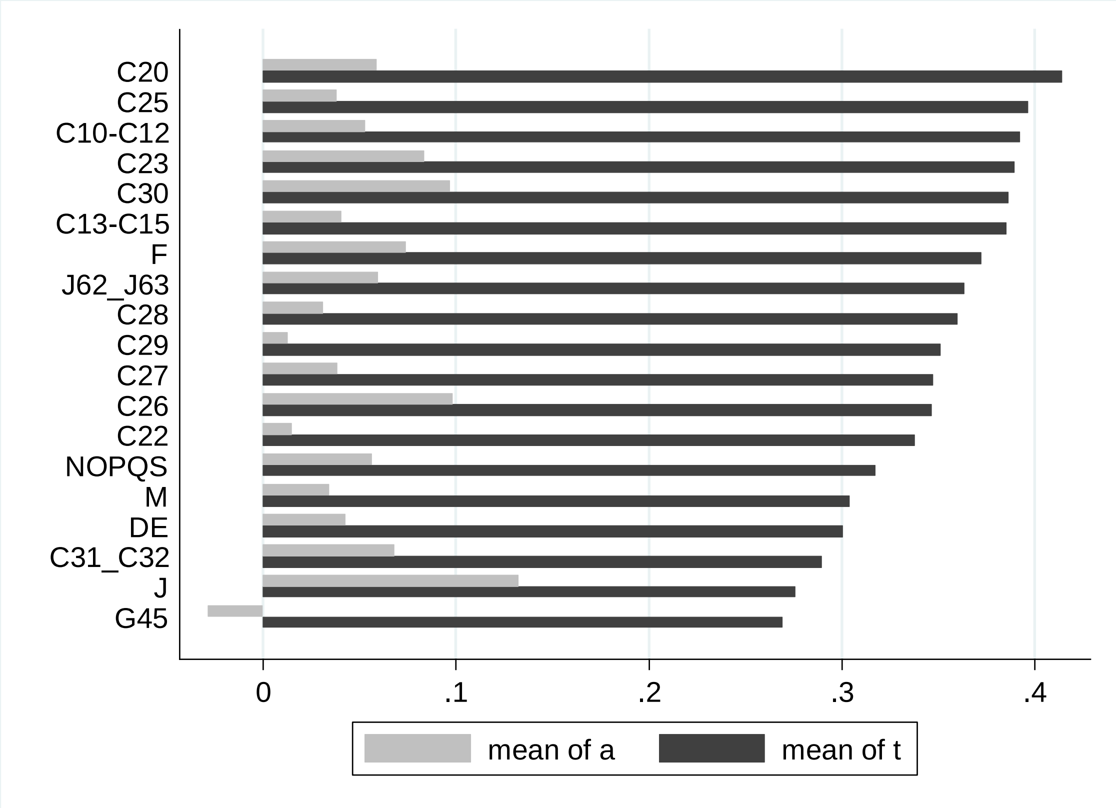


Figure 4. Knowledge Product and Spillover

We present mean of variable a and t for all countries and years in Figure 3. We observe that, magnitude of knowledge output and externality follow a similar pattern parallel to Figure 2.3. Manufacturing sectors receive considerably high amounts of R&D capital stock through intermediate goods imports, except high technology industries. Chemicals industry is an exception to this pattern. Construction also differentiates in non-manufacturing sectors with a higher value. Growth in patent grants is line with technology classification of industries where we observe high number of patent grants in medium-high and high technology sectors.

In Figure 4, labor productivity and spillover variable are compared. In general, it is plausible to say that service industries have negative values in terms of differences when the manufacturing sectors have a positive pattern.

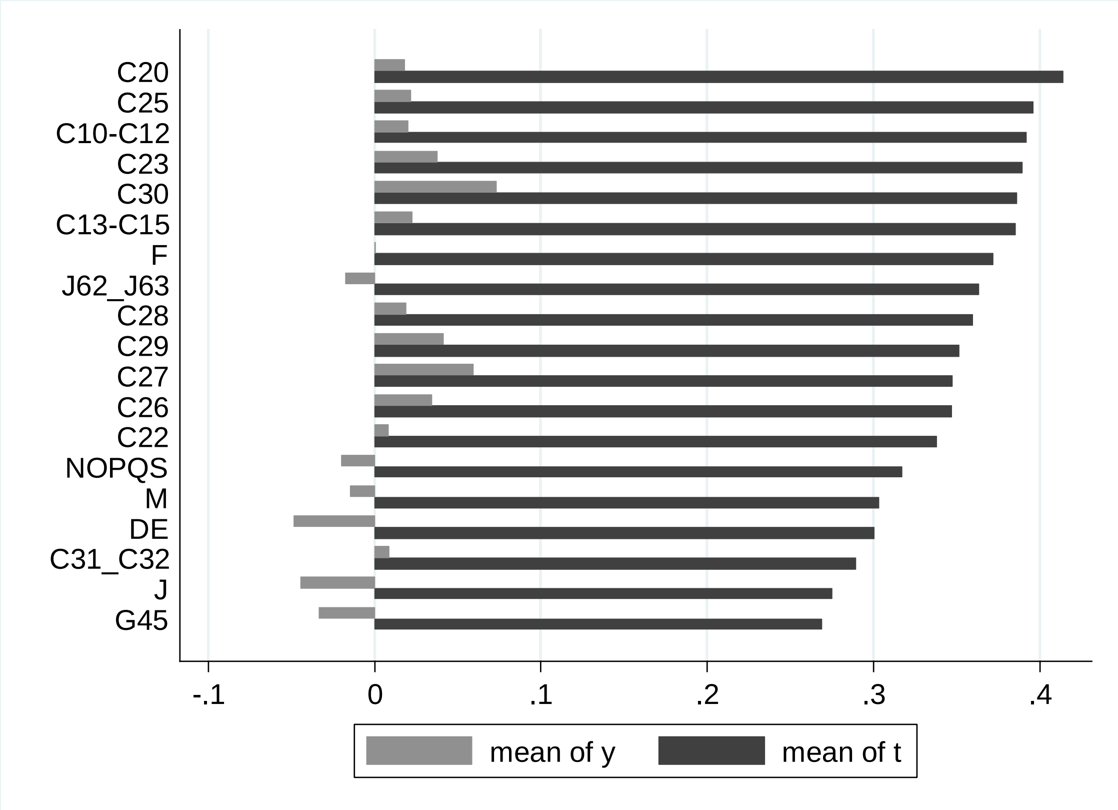


Figure 5. Labor Productivity and Knowledge Spillover

In Figure 5, we observe that labor productivity values are highest generally in medium-high technology sectors when it is extremely low for service sectors. Even though productivity is considerably high in computer manufacturing that is a high technology industry, growth of labor productivity is negative in ICT sectors except computer programming. Software industry has also very low growth value in productivity. We also observe that chemicals industry's patent grants are significantly high unlike its labor productivity.

Figure 6 shows the values for same variables for country means. We observe that highest differences in technology spillover belongs Poland, Slovenia and Lithuania. Although Turkey's change in patent grants is the third highest, she has negative values in productivity. Romania is the only economy with a negative value in patent grants. In overall, we observe that all countries have greater forward link values than the backward except Lithuania with a slightly larger change in the latter.

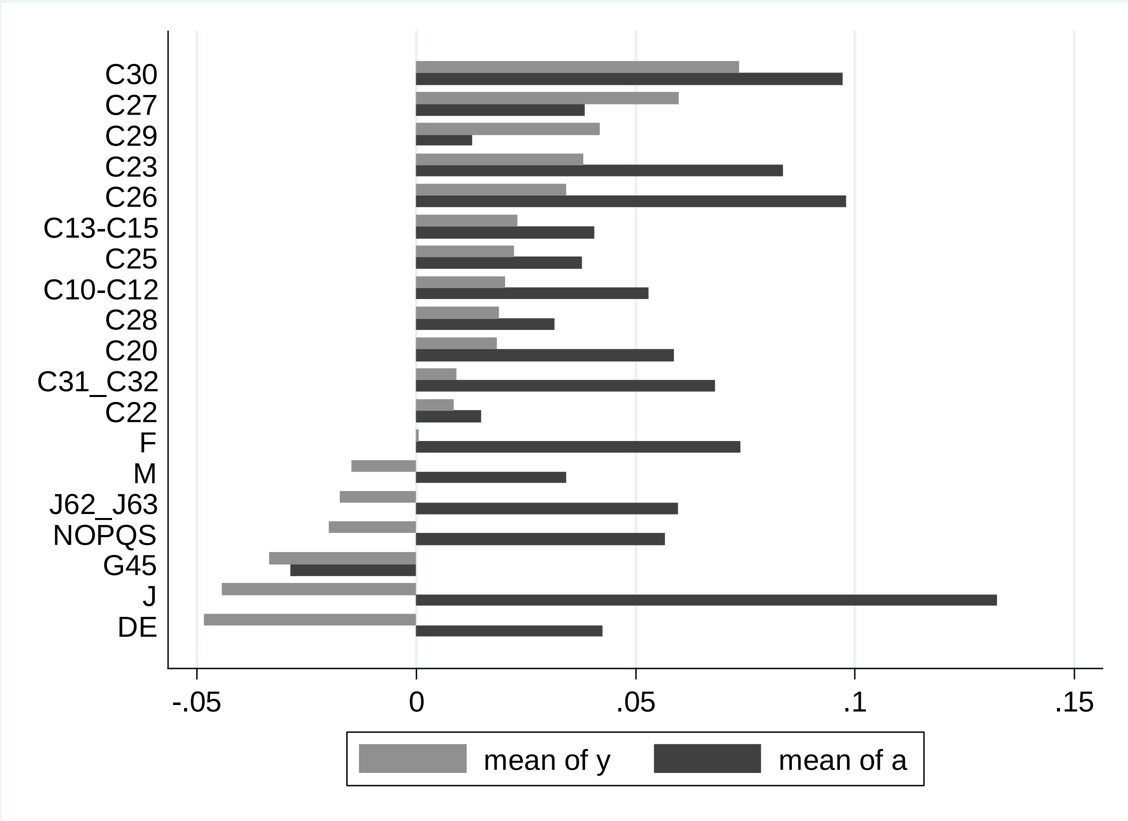


Figure 6. Labor Productivity and Knowledge

3.1. Inter-sectoral Input-Output Networks

We present, input-output matrix of each country to examine inter-sectoral linkages qualitatively. IO tables are used to weight our indirect technology spillover variable. We explain how the weighting scheme is constructed in next section. We use network graphs to observe the magnitude of relationship of industries.[8] We present the figures belong to this section in Appendix 2.

In almost all countries, We observe relatively strong transactions between manufacturing and service industries and also between service sectors. Especially infrastructure and construction sectors have strong ties with manufacturing. There are distinct examples of complementary triads in countries such as Czechia and Poland. There is a relatively strong triangular relationship between rubber and plastic, motor vehicles and wholesale of motor vehicles in Czechia. A similar triad can be observed in Poland replacing rubber and plastic industry with manufacturing of fabricated metal products.

[8] We calculate average of all years for each sector and exclude diagonals. Density of each link depends on the value. As one sector's transaction with others increases, the edge becomes more dense.

Infrastructure services stand out as a prominent partner for almost all manufacturing industries in Turkey. High technology industries such as computer and chemical products do not have distinctive links with other sectors except Romania where it has a relatively dense tie between computer industry and infrastructure services.

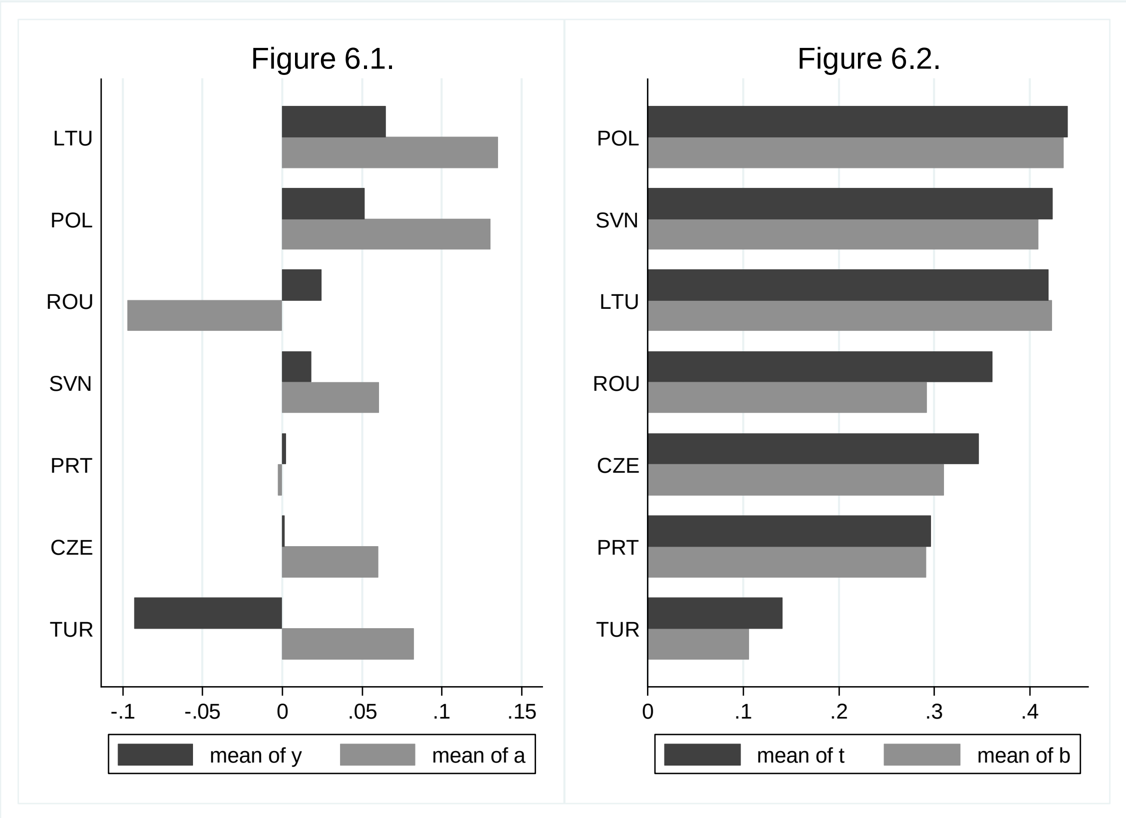


Figure 7. Values on Country Level

4. METHODOLOGY

The model consists of equation 3, 4 and 5. Explanation for variables are presented in table 3. Internal components of production function are calculated with conventional approach. Physical capital is nominal capital stock and number of employees in each sector stands for labor. Knowledge production function has three explanatory variables; R&D capital stock that is calculated via cumulative R&D expenditures with depreciation rate, human capital (number of researchers and R&D personnel), technology spillover.

All variables are transformed into real terms with price indices in WIOD database. Gross output and physical capital are deflated via Gross output prices when intermediate goods are deflated with intermediate goods price indices.[9] We use labor shares to overcome scale effects and estimate the system in differenced logarithmic forms. WIOD presents national input-output tables as a result of project which is funded by European Comission as described by Timmer, Dietzenbacher, Los, Stehrer and Vries (2015).

We use number of patents as a proxy for knowledge output. Data for patent grants are obtained from WIPO (World International Patent Office). Patent grants are classified under IPC (International Patent Classification) and even though they are aggregated in NACE Rev 2. codes, each IPC code does not belong to only one sector. A patent grant under a certain technology field could be categorized under more than one NACE sector with two digits. Since there are no patent grants in each technology field[10] for every year in our sample, the following method enables us to overcome missing data issue. We distribute each technology field code throughout the sectors with probabilistic concordance table presented by (Neuhäusler, Frietsch, & Kroll, 2019). They use patent data for approximately 150 million companies under IPC classification and aggregate them on industry to generate a "technology profile" for each sector. Their data consists of highly with European and North American countries. Coverage of dataset is suitable with our sample. Even though it is not, they explain that their concordance scheme works with on country level with small discrepancies.

Table 3
List of Variables

Abbreviation	Variable	Source
Y/L	Labor Productivity	WIOD-SEA
K/L	Phsyical Capital Stock per employee	WIOD-SEA
M/L	Within Sector Inputs per labor	WIOD-IO
A/L	# Patent Grants per labor	WIPO
H/L	Human Capital per labor	OECD-ANBERD

[9] Data collected from WIOD Socio Economic Accounts are transformed from national currency to dollar values by using exchange rates of countries presented by WIOD. Base year for price indices is 2010 and data for R&D expenditure is already in real terms from OECD database.
[10] A technology field is an aggregated title for IPC codes with more digits.

R/L	R&D Capital Stock per labor	OECD-ANBERD
T/L	Forward Indirect Knowledge Spillover per labor	Author`s calculation
B/L	Backward Indirect Knowledge Spillover per labor	Author’s calculation

Indirect technology transfer for each sector is calculated as sum of number of patents in other sectors weighted by bilateral intermediate good transactions matrix. Matrix is calculated from input-output tables of each country for 19 sectors. Wijc stands for IO table of each economy where i and j are sector indices and c is for the country. We measure expenditures between sectors by setting the diagonal of matrix W to zero. We name this matrix as WX_{ijc}.

$$WX_{ijc} = \begin{bmatrix} 0 & \cdots & n \\ \vdots & 0 & \vdots \\ n & \cdots & 0 \end{bmatrix} \quad (6)$$

Indirect technology spillover is calculated by multiplying WX_{ijc} by R&D intensity[11] of each sector in rows. So that, spillover value for each sector is the sum of products between R&D intensity and each IO column. We calculate the variable for every year in data in equation 7.

$$T_{ict} = \sum_{i=1}^{n} \frac{R_{jct}}{Y_{jct}} WX_{ijct} \quad (7)$$

We calculate backward linkage by simply transposing WX matrix in eq. 8.

$$B_{ict} = \sum_{i=1}^{n} \frac{R_{jct}}{Y_{jct}} \left(WX_{ijct}\right)^{T} \quad (8)$$

We also use domestic inputs of each sector as variable M. We obtain this variable by multiplying W with an identity matrix and extracting the diagonal.

$$WD_{ijc} = \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & 1 & \vdots \\ 0 & \cdots & 1 \end{bmatrix} W_{ijc} \quad (9)$$

4.1. Diagnostics

In this section, we present diagnostic test results for data. Table 4, shows variance inflation factors (VIF) for equation 3,4 and 5. It is plausible to say that there are no significant multi-correlation between our variables, since all VIF values are close to

[11] We calculate R&D intensity by dividing R&D capital stock to final output for each sector.

one. When all variables are tested jointly in all equations, VIF values are still close to one.

In Table 5, we present Breusch-Pagan / Cook-Weisberg test values and first order autocorrelation test results for the same equations. Null hypothesis for no heteroscedasticity is accepted by p values higher than 0.05 for all equations. Wooldridge test for autocorrelation indicates presence of first-order auto correlation in equation 3.

Table 4
VIF Values

Equation 3			Equation 4			Equation 5		
Variable	VIF	1/VIF	Variable	VIF	1/VIF	Variable	VIF	1/VIF
k_{ict}	1.2	0.834783	$r_{ic(t-1)}$	1.47	0.680747	$r_{ic(t-1)}$	1.53	0.655425
t_{ict}	1.17	0.856309	$h_{ic(t-1)}$	1.25	0.79763	$h_{ic(t-1)}$	1.27	0.790458
a_{ict}	1.09	0.916248	$t_{ic(t-1)}$	1.2	0.836301	$t_{ic(t-1)}$	1.24	0.807336
M_{ict}	1.02	0.980976	D^2	1	0.99787	$b_{ic(t-1)}$	1.13	0.88742
D^1	1.01	0.993258				D^2	1.01	0.99429
Mean VIF	1.1		Mean VIF	1.23		Mean VIF	1.23	

Table 5
Heteroscedasticity – First Order Autocorrelation Test Results

Equation 3	Equation 4	Equation 5
Breusch-Pagan / Cook-Weisberg test for heteroscedasticity		
Prob > chi2 = 0.1197	Prob > chi2 = 0.3474	Prob > chi2 = 0.0768
Wooldridge test for autocorrelation in panel data		
Prob > F = 0.0003	Prob > F = 0.0533	Prob > F = 0.0542

4.2. Estimation Method

Simultaneous equations models with panel data are suitable for our purpose. We estimate equations jointly via Generalized Method of Moments-3 Stages Least Squares (GMM-3SLS) method. A feature of 3 stages least squares is that it uses all exogenous determinants as instruments for all equations. On the other hand, 3 stages least squares estimator does not enable us to determine different instruments for each equation at first glance. However, (Hayashi, 2000) explains that Full-Information Instrumental Variables Efficient (FIVE) enables us to use instruments as it is described above. This special case is originated from GMM-3SLS estimator and even though (Schmidt, 1990) shows that traditional and GMM-3SLS are algebraically identical, (Wooldridge, 2002) states that since nature of simultaneous equations models might require different sets of instruments it is more preferable. GMM-3SLS definition[12] is consistent and asymptotically normal since traditional 3SLS uses different set of orthogonality conditions. We present three different estimation results for equation 3, 4 and 5.

Although we observe no significant heteroscedasticity and first order autocorrelation in most of the equations, we use a weight matrix up to two lags with Bartlett kernel. Band-with is determined as one addition to the lag structure used in variables. We also obtain robust clustered standard errors. Thus, we use twostep GMM estimator with a weight matrix that allows for heteroscedasticity and autocorrelation up to two lags.[13] Additionally we use an identity weight matrix for the first step parameter estimates.

We use instruments for all equations and the vectors of instrumental variables for all three equations are as follow.

$$Z^1_{ict} = f_{ict}\,(h_{ic(t-1)}, k_{ict}, m_{ict}, r_{ic(t-1)}, D^1_i, D^2_i, C_{ic}) \quad (10)$$

$$Z^2_{ict} = g_{ict}\,(h_{ic(t-1)}, k_{ict}, m_{ict}, r_{ic(t-1)}, t_{ic(t-1)}, t_{ict}\ D^1_i, D^2_i\ C_{ic}) \quad (11)$$

$$Z^3_{ict} = j_{ict}\,(h_{ic(t-1)}, k_{ict}, m_{ict}, r_{ic(t-1)}, t_{ic(t-1)}, t_{ict}, b_{ic(t-1)}, D^1_i, D^2_i, C_{ic}) \quad (12)$$

Set of instruments are used in three different system estimations in Table 6 in that order which shows that all variables for all equations are utilized in each equation.

5. EMPIRICAL RESULTS

Results of our estimations for equation 3, 4 and 5 are in table 6 where the first two columns include no spillover variables. Hansen's J test statistics which are developed

[12] It is given by Wooldridge (2002) in chapter 8, equation 8.36.
[13] Significance of our results do not vary depending on band-with used in weight matrix as the band-with increases. Related information can be found in Stata Manual for GMM.

by (Hansen, 1982) are also presented in table 6.[14] Hansen's J test statistics show that the system is over-identified. Thus, null hypothesis is accepted. We also present, correlation between predicted and observed values of both dependent variables estimated in equation 3 and 5 with 95% confidence interval in Figure 7. It shows that considerable amount of observation fits into the interval.[15]

Results for final good production function in third column indicate that physical capital has the largest impact on labor productivity. Patent to labor ratio is the second largest effect on labor productivity and our dummy variable for manufacturing industries is significant and positive. Our spillover term has a significant impact on knowledge production. We should also note that impact of indirect R&D spillover is higher more than direct effect. If we had regressed our technology spillover variable to labor productivity function, results would be misleading, and we would not know whether R&D inflow turns into inventions and through that process productivity in final good soars. In our model, we try to isolate "direct" and "indirect" effects of intermediate good transactions.

Our empirical results support the system we have introduced in Figure 1 where both indirect knowledge spillovers are effective through knowledge production and rent spillovers from other industries increase labor productivity of receiving sector. Thus, we create a 'link' via knowledge creation from spillovers to final good production that would be missing otherwise. Finally, backward linkage falls short in its impact on knowledge creation. So that, forward spillover comes forward as the prominent source of externality for our sample.

[14] We present p values for Hansen's J identification test where the null hypothesis suggests that restrictions are over-identified.
[15] Both variables are predicted via multiple equation GMM estimator as it is presented in our models.

Table 6
Estimation Results

		No Externalities		Externalities			
		Eq. 3	Eq. 4	Eq. 3-4		Eq. 3-5	
	VARIABLES	y	a	y	a	y	a
Physical Capital Stock	k_{ict}	0.824***		0.801***		0.800***	
		(0.0608)		(0.0589)		(0.0559)	
Within Sector Intermediate Goods	m_{ict}	0.0192**		0.0199***		0.0196**	
		(0.00787)		(0.00768)		(0.00767)	
Patent Grants	a_{ict}	0.265**		0.250*		0.228*	
		(0.127)		(0.140)		(0.127)	
Forward Spillover	t_{ict}			0.0275**		0.0284**	
				(0.0118)		(0.0111)	
Dummy for Manufacturing Sectors	D^1	0.0324***		0.0313***		0.0314***	
		(0.00682)		(0.00668)		(0.00660)	
Human Capital	$h_{ic(t-1)}$		0.00604		0.00231		0.00274
			(0.0164)		(0.0166)		(0.0170)
R&D Capital Stock	$r_{ic(t-1)}$		0.107***		0.0953***		0.0948***
			(0.0293)		(0.0306)		(0.0312)
Forward Spillover	$t_{ic(t-1)}$				0.0385*		0.0381*
					(0.0211)		(0.0218)
Dummy for High Tech. Sectors	D^2		-0.0132		-0.0133		-0.0128
			(0.0153)		(0.0154)		(0.0158)
Backward Spillover	$b_{ic(t-1)}$						0.00730
							(0.0145)
	Constant	-0.0374***	0.00898	-0.0436***	-0.00164	-0.0426***	-0.00495
		(0.00890)	(0.0175)	(0.00820)	(0.0181)	(0.00802)	(0.0182)
	Hansen's J	0.2201		0.2395		0.3004	
	Observations	532		532		532	

*Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1, all variables are in per labor and log form

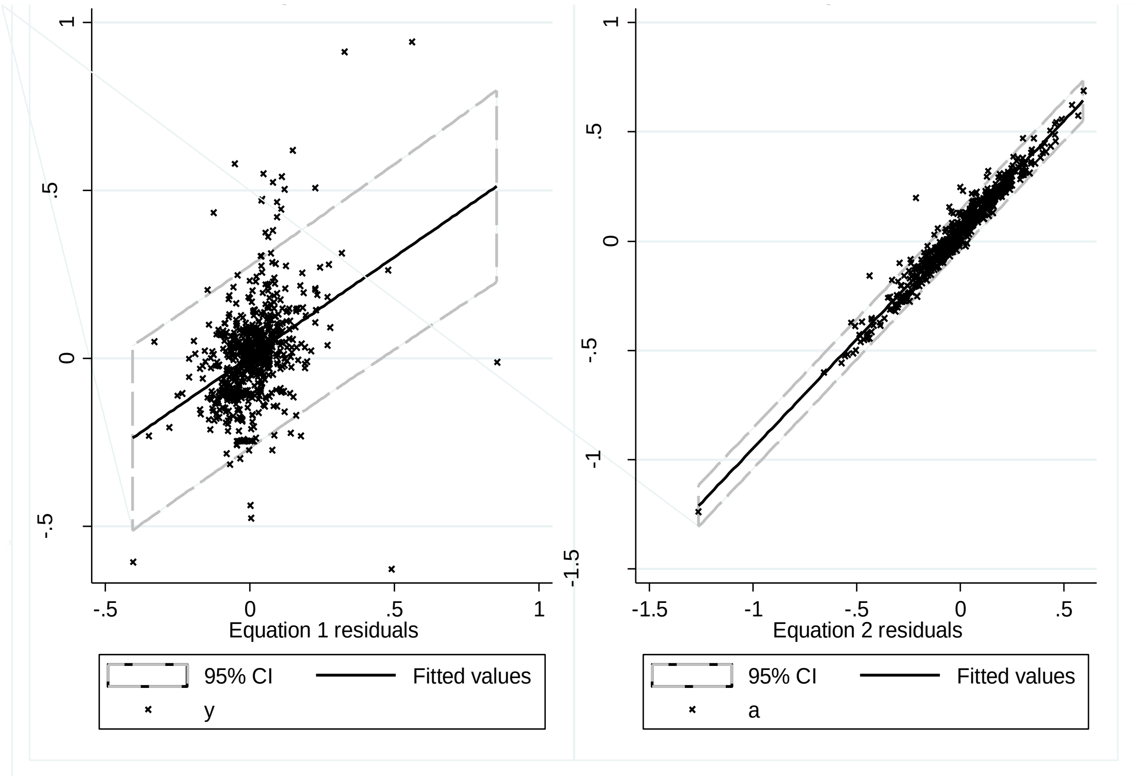


Figure 8. Confidence Interval for Eq. 3 and 5 Prediction

6. CONCLUDING REMARKS

This chapter presents a novel approach to simultaneously analyze different roles of embodied technology transfer through intermediate goods between industries. First, we measure direct impact of transfer networks on labor productivity that is an indicator of rent spillovers. Second, we propose an indirect effect of technology transfer on productivity through knowledge creation. Therefore, receiver sector of research industry diffusion uses higher external research intensity to produce more efficient final output when it also uses it to produce new ideas in knowledge production part of the sector. We also introduce research flows to R&D department of sectors as also backward link where supplier industries adapt their research efforts to their customers'.

We create a sample with 7 economies and 19 sectors between 2009 and 2014. We also utilize multiple equation GMM approach to simultaneously estimate a two-equation system; final good and knowledge production. Results indicate that both channels of embodied technology flow are significant indicators of labor productivity. We also conclude that indirect impact of research transfer is greater than its direct effect when backward linkage on knowledge creation has no significant influence.

In overall, this chapter argues the literature by emphasizing that a direct correlation of embodied technology flow via intermediate goods to productivity of industries is not sufficient to analyze whether there is room for creation of new ideas as a results of externalities. Thus, we create a link between embodied research transfer and labor productivity through knowledge creation along with the direct impact spillovers.

We suggest that policy makers could consider these two channels jointly in order to examine inter-sectoral transactions in an economy in the framework of research diffusion. So that, stimulation of externalities as results of R&D subsidies would be analyzed in terms of not only direct link to productivity levels but also as a nexus between final good and embodied technology transfer via knowledge creation.

CHAPTER 2: NETWORK TOPOLOGY

1. INTRODUCTION

In this section, we extend our examination of input-output tables in section 3.1 to indirect knowledge transfer. So that, we could have a better understanding of how embodied research transfer works in the framework of direction of flow and network structure. Networks are identified depending on whether they are weighted or non-weighted and also directed or undirected. Input-output tables are weighted networks by nature, and they could be treated as directed or undirected in accordance with the purpose of the study.

(Soyyiğit & Çırpıcı, 2018) and (Soyyiğit & Boz, 2018) focus on assortativity analysis for input-output tables. Assortativity of a network enables them to examine whether nodes with higher degree tend to connect to nodes with similar edges, vice versa. Their study points out key points to understand whether a node is a hub or authority which is a research conducted by (Kleinberg, 1999) which introduced HITS algorithm for network of websites. Another method is a Pearson correlation coefficient developed by (Newman, 2010) to examine correlation between node degree and average nearest neighbor degree. So that, another way of examining assortativity is construction of correlation between local degree and ANND. These analyses are conducted in undirected networks. (Blöchl, Theis, Vega-Redondo, & Fisher) study input-output networks to understand structure of an economy and treat them as directed networks. They use random walk and counting betweeness centrality measures to understand global centralities. (Piraveenan, Chung, & Uddin, 2006) and (Piraveenan, Prokopenko, & Zomaya, 2012) propose methods to measure directed ANND where they measure In-In degree and Out-Out degree correlations. Another recent work about assortativity of networks is conducted by (Fagiolo, Reyes, & Schiavo, 2010) where they analyze world trade web however they treat it as undirected network. Their report of ANND-degree scatter plots shed light on to trade pairs of countries. (Garlaschelli & Loffredo, 2005) study world trade web and proposes a twostep analysis of topology where the first step is degree distribution, and the second step is ANND calculation. They measure assortativity of their networks by examining ANND-degree correlation and argue that decreasing correlation indicates a disassortative network. Thus, economies with many trade partners tend connect with the ones with few partners. They calculate ANND in a technique very similar to (Barthelemy, Barrat, Pastor-Satorras, & Vespignani, 2005) which we also utilize in this study.

Aim of this chapter is to examine heterogeneous structure of embodied technology transfer networks for the countries in our sample. To this purpose, section two presents transfer networks, and the rest of the chapter shows the topology of transfer matrix via degree distribution, assortativity, density and visualization of networks.

2. TECHNICAL COEFFICIENT MATRIX

We define technical coefficients as intermediate good transactions weighted by R&D intensity. Sum of each column presents forward and backward spillovers as vectors in previous sections. In this section, we analyze both types of Euclidian distance matrix as networks for each country. Forward and backward technical coefficient matrix are defined as;

$$\mathrm{T} = \frac{R_{jt}}{Y_{jt}}\left(WX_{ijt}\right) \tag{13}$$

$$\mathrm{B} = \frac{R_{jt}}{Y_{jt}}\left(WX_{ijt}\right)^{T} \tag{14}$$

Industries stand for nodes in our networks for each country so that there are 19 nodes (N). We have already subtracted trace of each matrix so that there is no within transaction and value of self-loop is zero for each sector. As a result, there are 342 edges (N(N-1)) for each year.

3. LOCAL CENTRALITY

We treat both adjacency matrix as directed networks and calculate in and out degree to examine local centrality of each node. In forward technology spillover, we use supplier's research intensity as weight and buyer's (customer) R&D intensity for backward linkage. Thus, in degree stands for local centrality of customer and out degree is the position of supplier in forward technology flow matrix. The opposite is valid for backward technical coefficient network. Computation of a node's in and out degree is as follows;

$$D_{in}^{T} = \sum_{i\neq j} T \tag{15}$$

$$D_{out}^{T} = \sum_{i\neq j} T^{T} \tag{15.1}$$

$$D_{in}^{B} = \sum_{i \neq j} B \tag{16}$$

$$D_{out}^{B} = \sum_{i \neq j} B^{T} \tag{16.1}$$

We simply transpose adjacency matrix for both types of spillovers to capture out degree. Equation 15 and 16 gives the same value as eq. 7 and 8. In case of backward linkages, in degree represents buyer sector's importance for the supplier. In following sections, we examine networks for year 2009 and 2014 as the beginning and end of period in Chapter 1.

We present degree distribution attributes of indirect technology flow networks such as kurtosis and skewness for 2009 and 2014. Table 7 indicates that network of all countries demonstrates heterogeneous structure. Only backward-in-degree for Chechia, Slovenia and Poland are exceptions. There is power-law distribution in our networks with heterogeneity. Thus, we expect that some of the industries are more dominant in terms of both knowledge sources and receivers.

4. ASSORTATIVITY

Assortativity is an important characteristic of a network and it indicates how nodes are connected to each other. An assortative network indicates that nodes with similar characteristic tend to link with nodes in same characteristic. In other words, sectors with high degree tends to connect with sectors with high degree. On the other hand, disassortative behavior shows that nodes with high degree links to nodes with lower degree. We calculate "average nearest neighbor degree" (ANND) and measure the correlation between degree and ANND as proposed in (Barthelemy, Barrat, Pastor-Satorras, & Vespignani, 2005). However, we treat it as assortativity in a weighted directed network where all nodes are connected. A positive correlation between these two indicators would point out an assortative behavior in our technical coefficient networks.

We calculate ANND as follows where each node is weighted by its neighbors' degree and the sum is denominated by the degree of node i. ANND is also calculated for in and out directions for both forward and backward linkages.

$$D_{in}^{ANN-T} = \frac{1}{D_i} \sum_{i=1}^{N} T_{ij} D_j \tag{17}$$

$$D_{out}^{ANN-T} = \frac{1}{D_i}\sum_{j=1}^{N} T_{ij}D_j \tag{17.1}$$

$$D_{in}^{ANN-B} = \frac{1}{D_i}\sum_{i=1}^{N} B_{ij}D_j \tag{17.2}$$

$$D_{out}^{ANN-B} = \frac{1}{D_i}\sum_{j=1}^{N} B_{ij}D_j \tag{17.3}$$

We present correlation coefficients in Figure 9 and Table 9 where a negative value indicates a disassortative behavior between local and neighbor degree for each country. Forward linkage with in-degree-assortativtiy shows that how intermediate good purchasing sectors form edges with intermediate good suppliers, which are also R&D transmitters. Backward link shows the opposite where the supplier adapts its research intensity to its customers' needs.

In Figure 10, Czechia demonstrates a dissasortative nature except her backward in links which suggests that industries with higher degree of research intensity tends connect with nodes with similar degree. Therefore, greater knowledge intensive industries adapt to their customers with similar degree. On the other hand, Lithuania follows an assortative pattern in her networks except forward out correlation in 2014. Lithuania sectors which transmits research as suppliers to other sectors tends to transfer to sectors which are also high research intensity suppliers in 2009. Situation is the opposite in 2014. Poland follows a assortative pattern with an increasing trend from 2009 to 2014 in her forward network. Poland's backward in and out tendencies presents opposite patterns. When supplier industries as receivers of knowledge turns dissassortative, customers as sources of knowledge becomes assortative in 2014.

Portugal and Romania are opposite examples in overall when Portugal is always assortative, Romania follows a dissassortative pattern in all cases. Turkey shows a more heterogenous structure except her backward-in links which grows highly assortative. When forward links in both directions demonstrates similar patterns in all countries, backward links is the contrary. Consumers as knowledge sources tends connect with each other in dissimilar degrees and results in a more heterogenous structure of networks. On the other hand, suppliers as host of knowledge tend to connect with industries that has similar degrees. This indicates that sectors which have inflows of high research tends bond with high degree receivers. Although, dissasortative nature would result in a more heterogenous structure, it also prospects a possible convergence between industries in terms of technological intensity. We observe that forward embodied knowledge transfer is closer to a similar structure in 2014.

Table 7
Skewness and Kurtosis

			2009				2014			
Direction		Country	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
In Degree	Forward	Czechia	0.0000	0.0003	21.59	0.0000	0.0000	0.0005	19.99	0.0000
		Lithuania	0.0013	0.1749	12.00	0.0025	0.0002	0.0021	16.68	0.0002
		Poland	0.0062	0.1080	8.43	0.0148	0.0080	0.1334	7.91	0.0192
		Portugal	0.0001	0.0018	18.42	0.0001	0.0000	0.0002	21.16	0.0000
		Romania	0.0000	0.0000	26.94	0.0000	0.0000	0.0002	21.77	0.0000
		Slovenia	0.0007	0.0064	14.05	0.0009	0.0017	0.0326	11.21	0.0037
		Turkey	0.0001	0.0024	16.93	0.0002	0.0000	0.0000	28.19	0.0000
	Backward	Czechia	0.3098	0.0341	5.33	0.0694	0.3723	0.0166	6.05	0.0486
		Lithuania	0.0094	0.1749	7.45	0.0242	0.0004	0.0031	15.49	0.0004
		Poland	0.1386	0.4382	3.19	0.2028	0.0521	0.7630	4.12	0.1273
		Portugal	0.0001	0.0018	17.72	0.0001	0.0001	0.0012	18.32	0.0001
		Romania	0.0011	0.0249	11.96	0.0025	0.0003	0.0025	16.13	0.0003
		Slovenia	0.0624	0.4583	4.24	0.1199	0.0524	0.8089	4.09	0.1294
		Turkey	0.0067	0.2361	7.56	0.0228	0.0000	0.0001	24.39	0.0000
Out Degree	Forward	Czechia	0.0000	0.0000	30.25	0.0000	0.0000	0.0000	30.49	0.0000
		Lithuania	0.0022	0.0556	10.36	0.0056	0.0000	0.0000	27.55	0.0000

	Poland	0.0000	0.0000	25.59	0.0000	0.0010	0.0108	13.01	0.0015
	Portugal	0.0008	0.0235	12.42	0.0020	0.0005	0.0115	13.68	0.0011
	Romania	0.0000	0.0001	23.34	0.0000	0.0000	0.0000	25.65	0.0000
	Slovenia	0.0001	0.0006	19.58	0.0001	0.0000	0.0000	28.94	0.0000
	Turkey	0.0006	0.0114	13.64	0.0011	0.0000	0.0015	18.78	0.0001
Backward	Czechia	0.0001	0.0016	17.43	0.0002	0.0002	0.0020	16.82	0.0002
	Lithuania	0.0129	0.2771	6.62	0.0366	0.0000	0.0002	22.04	0.0000
	Poland	0.0014	0.0232	11.81	0.0027	0.0359	0.5263	4.82	0.0899
	Portugal	0.0004	0.0093	14.36	0.0008	0.0009	0.0222	12.34	0.0021
	Romania	0.0067	0.0965	8.45	0.0146	0.0001	0.0010	18.57	0.0001
	Slovenia	0.0001	0.0012	17.69	0.0001	0.0006	0.0132	13.48	0.0012
	Turkey	0.0067	0.2361	7.56	0.0228	0.0000	0.0001	24.39	0.0000

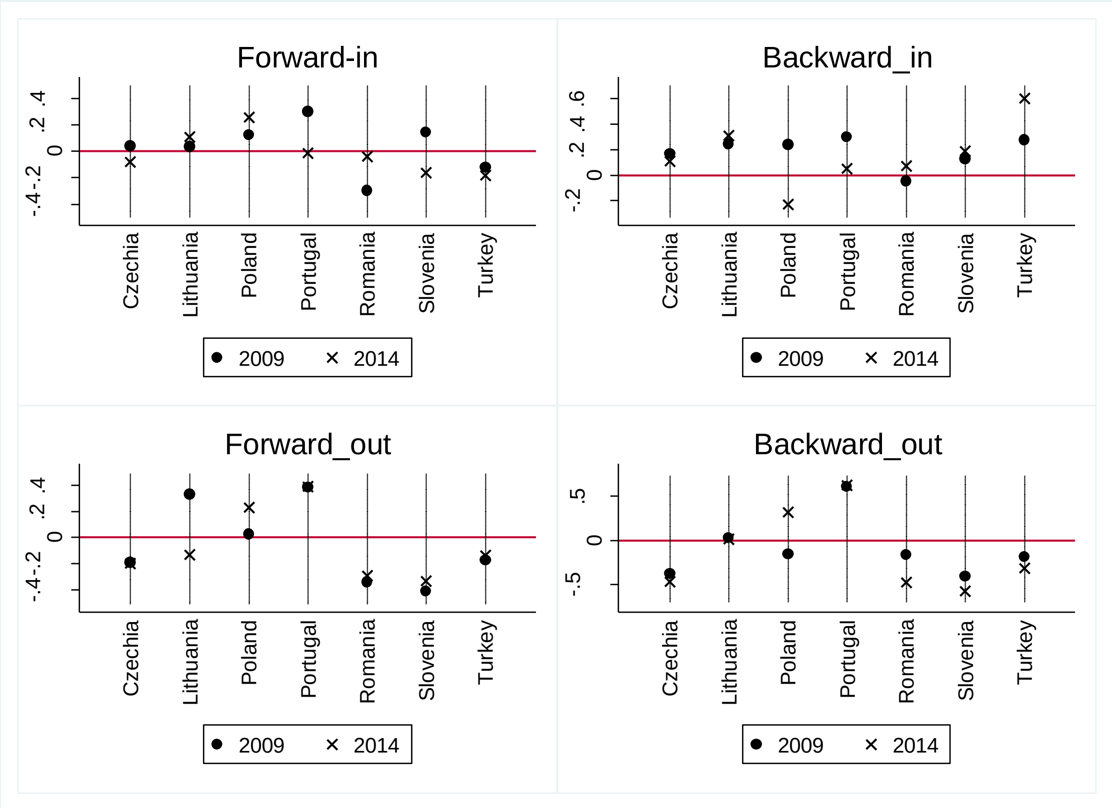


Figure 9. Degree-ANND Correlation

5. LOCAL CENTRALITY AND NEIGHBOR CONNECTIVITY

In this section, we present the most repeated sectors in top 5 and bottom 5 industries for their degree and ANND in all countries.[16] In degrees are dominated by service sectors when high technology sectors are among top out degrees. When information and communication technologies is among in top both direction, computer programming stands out as a prominent technology source. Latter is in the top list for ANND too in many cases. We also observe chemicals and computer manufacturing as top research transmitters. Low technology manufacturing industries are frequently repeated in bottom five such as food products and textile. Medium high technology industries such as electrical equipment and motor vehicles are top sectors in terms of their

[16] There are more or less than 5 industries in case of equal number of repetitions. We also report top 5 and bottom 5 degree and ANND for all countries in Appendix 3.

backward links. Thus, we state that these industries are strong as both adapters to their customers and intensifiers to their suppliers. We also observe that professional services are mostly repeated in top sectors in both directions. It is plausible to say that professional services such as architecture and scientific research and development supplies to all industries and demands from other sectors in a greater variety. ANND follows a different pattern where professional activities are in the bottom list. Construction industry is in bottom five degrees when it is in top five ANND. Thus, construction is not a significant industry in terms of local centrality when it is noticeable for neighbor connectivity.

Table 8
Degree-ANND Correlation Coefficient

			2009	2014
Direction		Country	Correlation	
In Degree	Forward	Czechia	0.0443	-0.0820
		Lithuania	0.0385	0.1082
		Poland	0.1238	0.2562
		Portugal	0.3034	-0.0161
		Romania	-0.2965	-0.0389
		Slovenia	0.1445	-0.1629
		Turkey	-0.1207	-0.1814
	Backward	Czechia	0.1677	0.1093
		Lithuania	0.2479	0.3127
		Poland	0.2390	-0.2268
		Portugal	0.2976	0.0516
		Romania	-0.0426	0.0728
		Slovenia	0.1311	0.1879
		Turkey	0.2781	0.6023
Out Degree	Forward	Czechia	-0.1908	-0.2007
		Lithuania	0.3311	-0.1315
		Poland	0.0281	0.2307
		Portugal	0.3855	0.3893
		Romania	-0.3406	-0.2938
		Slovenia	-0.4098	-0.3325
		Turkey	-0.1724	-0.1389
	Backward	Czechia	-0.3728	-0.4682
		Lithuania	0.0292	0.0123
		Poland	-0.1510	0.3156
		Portugal	0.6019	0.6199
		Romania	-0.1632	-0.4750

		Slovenia	-0.4026	-0.5695
		Turkey	-0.1839	-0.3137

Table 9
The most repeated sector(s) in all countries' top 5 and bottom 5

Direction		Year	Degree Top	Degree Bottom	ANND Top	ANND Bottom
Forward	In	2009	C10-C12, C29, F, J, NOPQS	C13-C15, C20, C26, C30, C31-C32	C20, DE, G45	C13-C15, C22, C28, C29
		2014	DE, F, G45, J, NOPQS	C26, C27, C30	C20, DE	C22, F, J
	Out	2009	C25, C26, J, J62-J63, M	C10-C12, C13-C15, C30, F, NOPQS	C26, F, J, J62-J63, NOPQS	C13-C15, C22, C23, C25, M
		2014	C20, C26, G45, J, J62_J63, M	C10_C12, C13_C15, C31_C32, F, NOPQS	F, J, J62-J63, NOPQS	C22, C23, C25, M
Backward	In	2009	C25, DE, F, M, NOPQS	C13-C15, C26, C29, C30, C31-C32	F, J, J62-J63, NOPQS	C22, C25
		2014	DE, J, M, NOPQS	C10-C12, C31_C32	F, J, J62-J63, NOPQS	C22, C25, C27, M
	Out	2009	C27, C29, G45, J62_J63, M	C10-C12, C13-C15, C23, F, NOPQS	C30, J, J62-J63, NOPQS	C29, M
		2014	C27, C29, J, J62_J63, M	C10_C12, C13_C15, DE, F, NOPQS	J, J62-J62	C29, M

6. COUNTRY NETWORK DENSITY AND VISUALIZATION

Country level technical coefficient networks enable us to examine details of links between sectors in each country. In each, subsection we present networks for initial and final year of time period in case of both forward and backward linkage. Our network graphs are symmetric because all sectors are connected. However, they differ in terms of their edge-weights. We present network density of each in Figure 10 and we calculate as the ratio of sum of node-weights to number of possible edges:

$$\mathrm{ND_T} = \frac{\sum T}{N(N-1)} \tag{18}$$

$$\mathrm{ND_B} = \frac{\sum B}{N(N-1)} \tag{19}$$

Forward and Backward networks present similar density volumes where Turkey is considerably dense. All countries' technology transfer network density increased during the period.

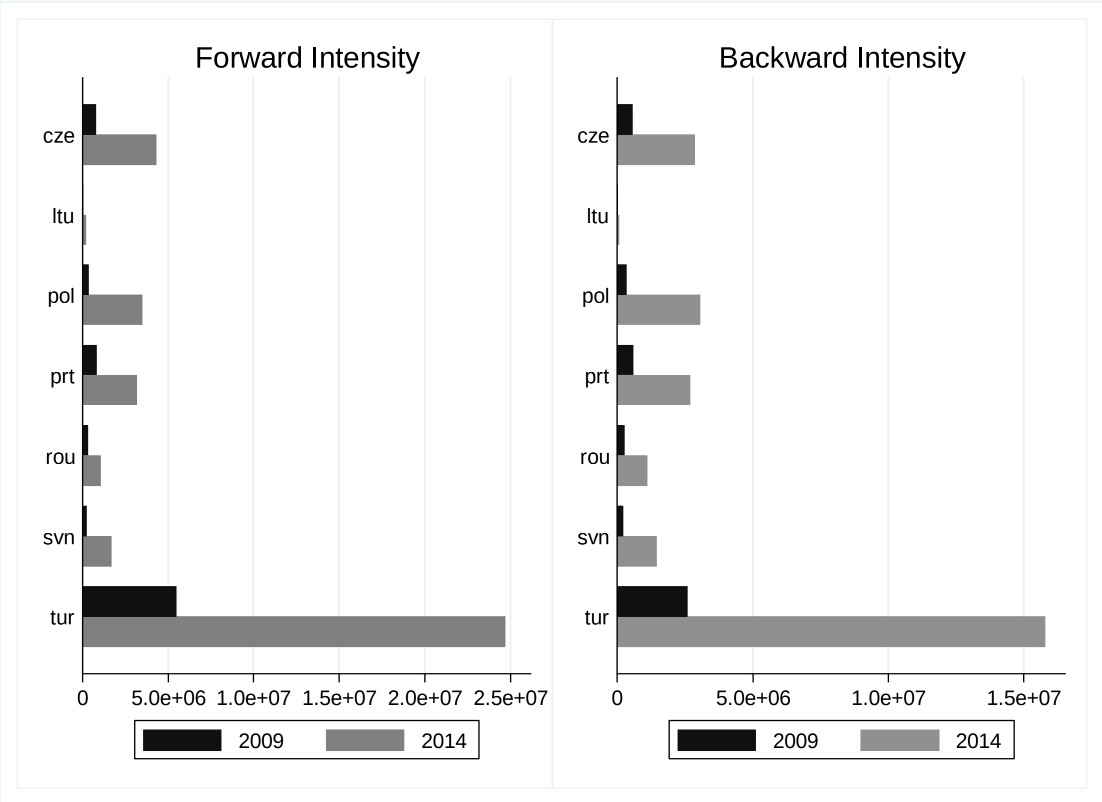


Figure 10. Network Density

In the graphs below, we present visualization for technology transfer networks for each economy. In all economies, we observe a heterogeneous structure where service industries are relatively more connected among each other in terms of quantity. On the other hand, importance of edges of manufacturing industries varies between countries. Another originality of the visualizations come from two different links as forward and backward where industries are technology receivers as both customers and suppliers. Strength of the edges also varies depending on their role in these two types of networks.

6.1 Embodied Technology Flow: Czechia

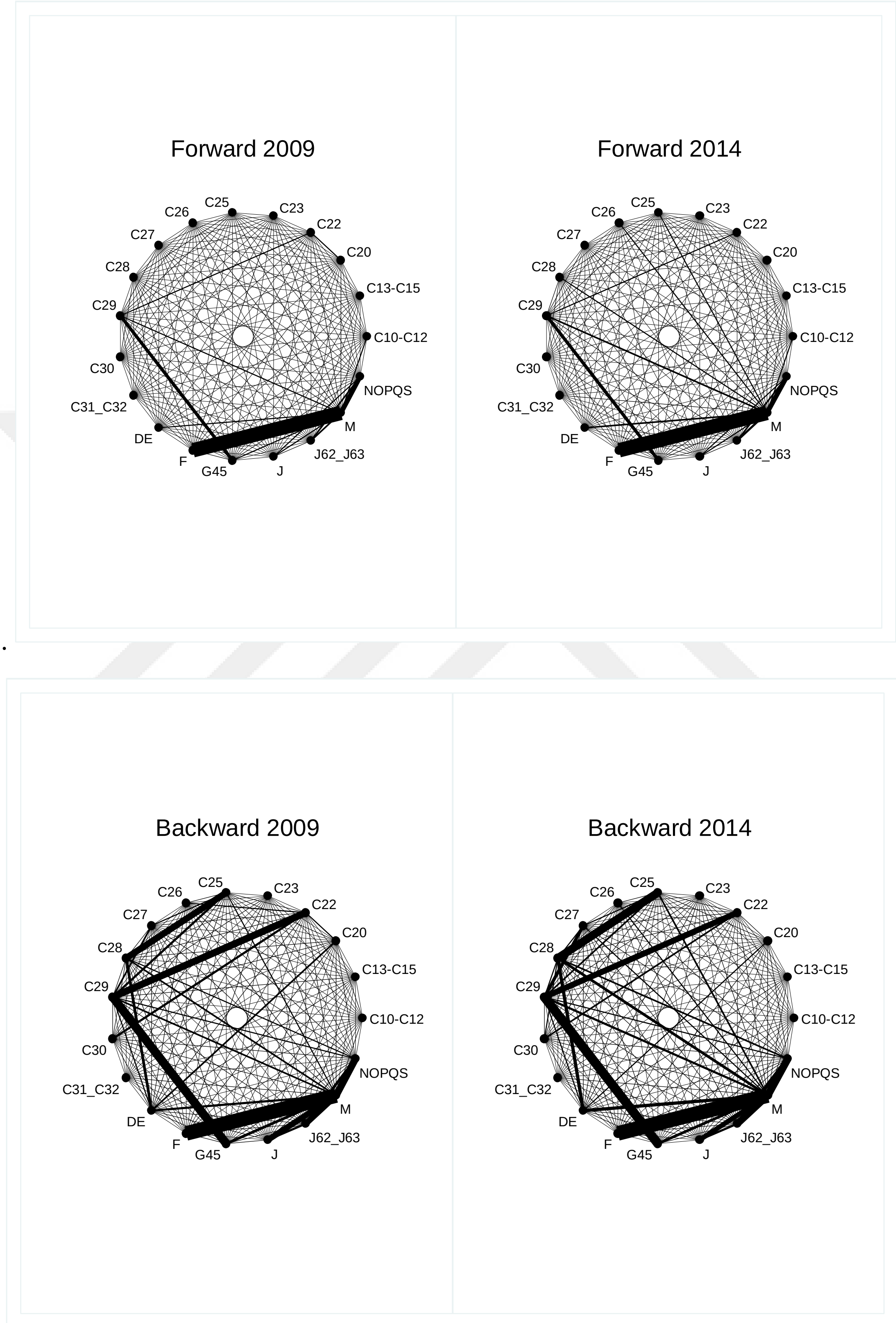


Figure 11. Czechia Technology Transfer Network

In Figure 11, thickness of edges indicates value of technical coefficient between two nodes. Thus, we can observe which sectors have significantly higher technology transfer between them comparing to others. Forward links between construction and professional activities and between professional activities and social services keep their strength through six years. Computer programming has also a persistent strength between professional services. Manufacture of motor vehicles maintain its significant edge to sales of motor vehicles as expected. We also observe that, motor vehicles industry strengthens its link to professional and scientific activities which is a service sector with higher value-added.

6.2. Embodied Technology Flow: Lithuania

Service sectors are weakly forward connected in 2009 in Lithuania. However, their edges get stronger in 2014 where the link between construction and fabricated metals becomes weaker. Manufacture of computer and computer programming established a forward link where out link from manufacturing to service sector is 1881372 that is considerably higher than the opposite in 2009. Thus, we can observe that computer manufacturing industry transfers knowledge to computer programming sector as its hardware supplier. Lithuania has stronger links between service sectors since 2014 in terms of backward technical coefficients. We also observe that her backward network is more homogenous in 2014. Most of the relatively strong manufacturing industries' backward links are less intense in 2014 when the relations between service industries comes forward.

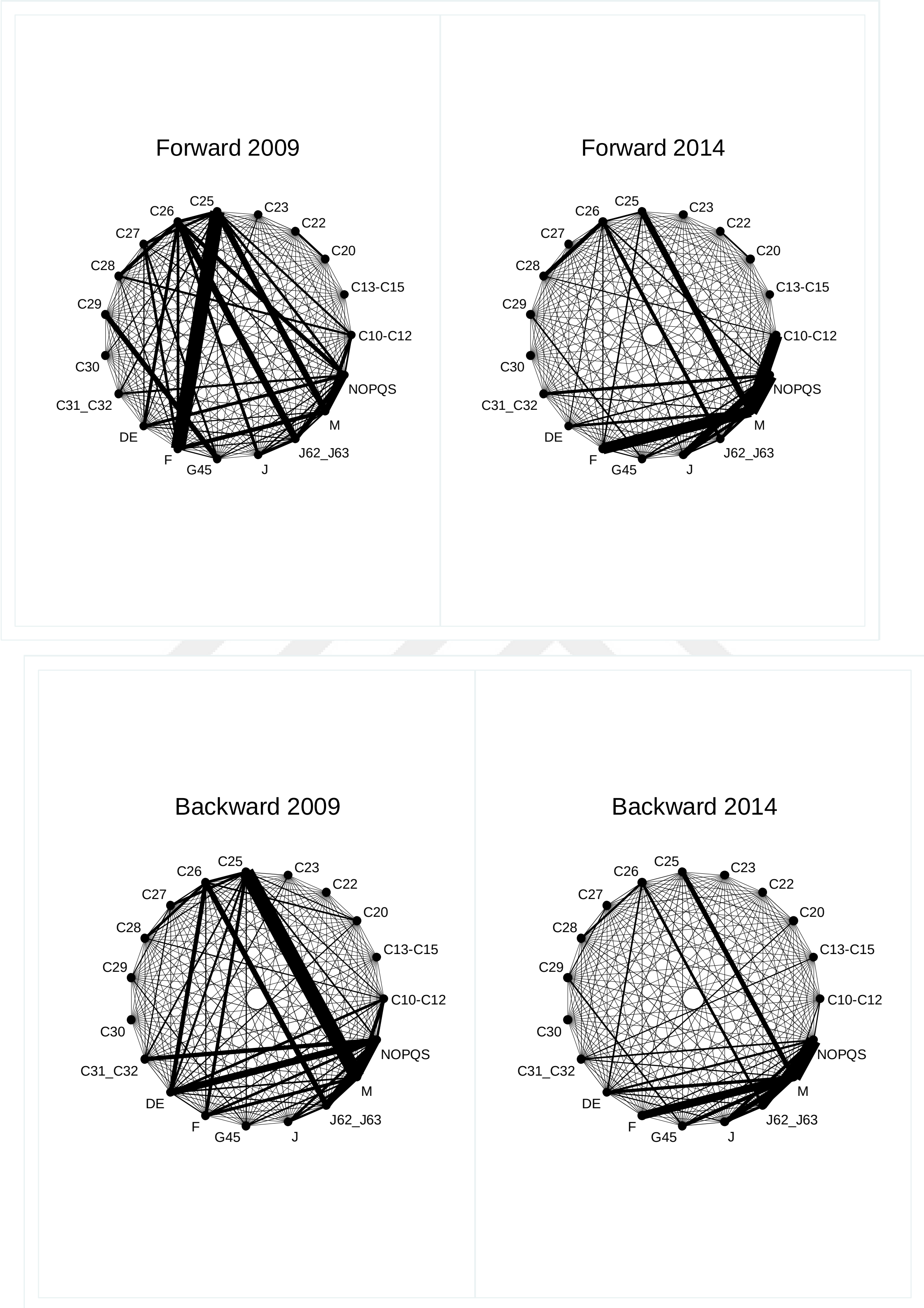


Figure 11.1. Lithuania Technology Transfer Network

6.3. Embodied Technology Flow: Poland

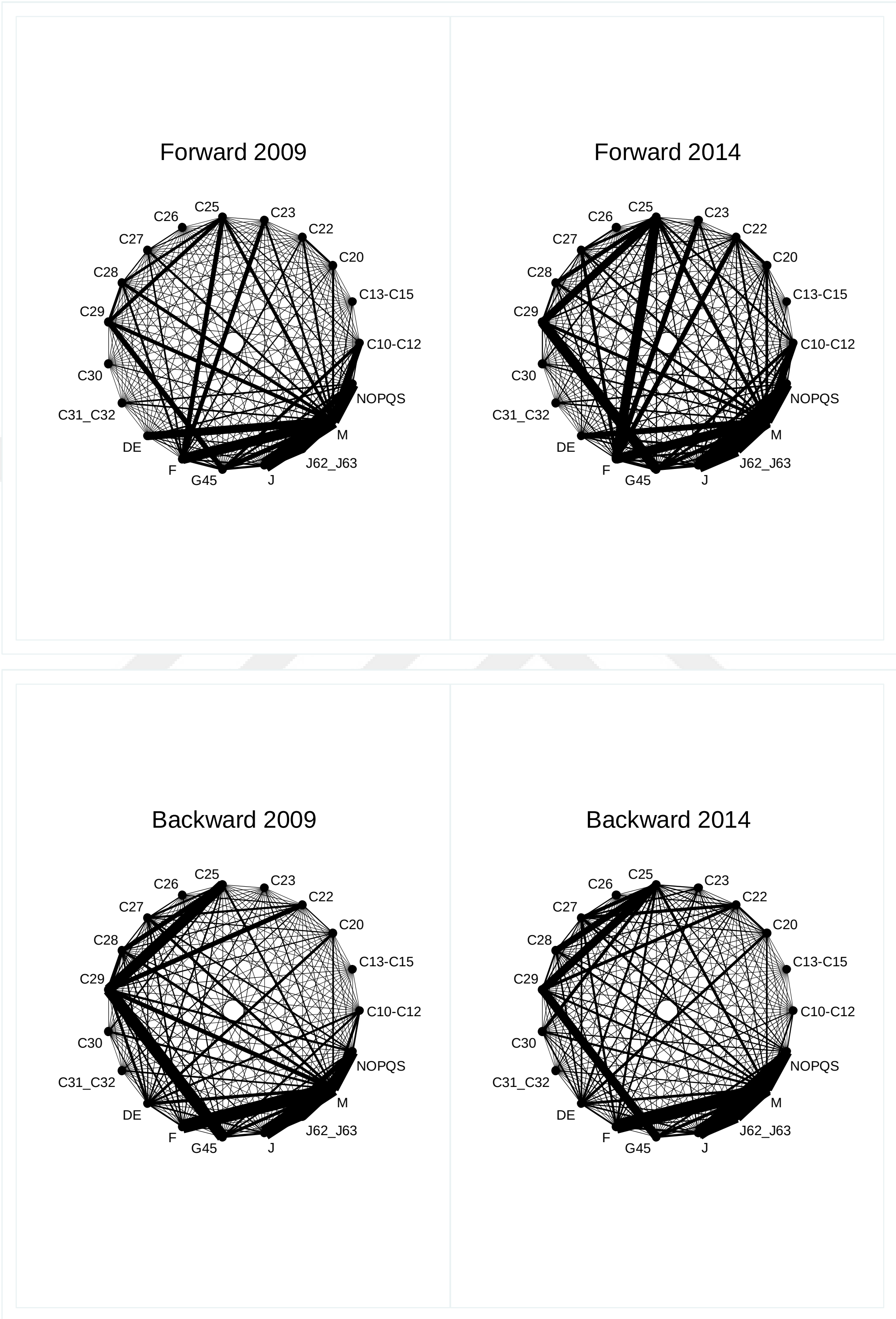
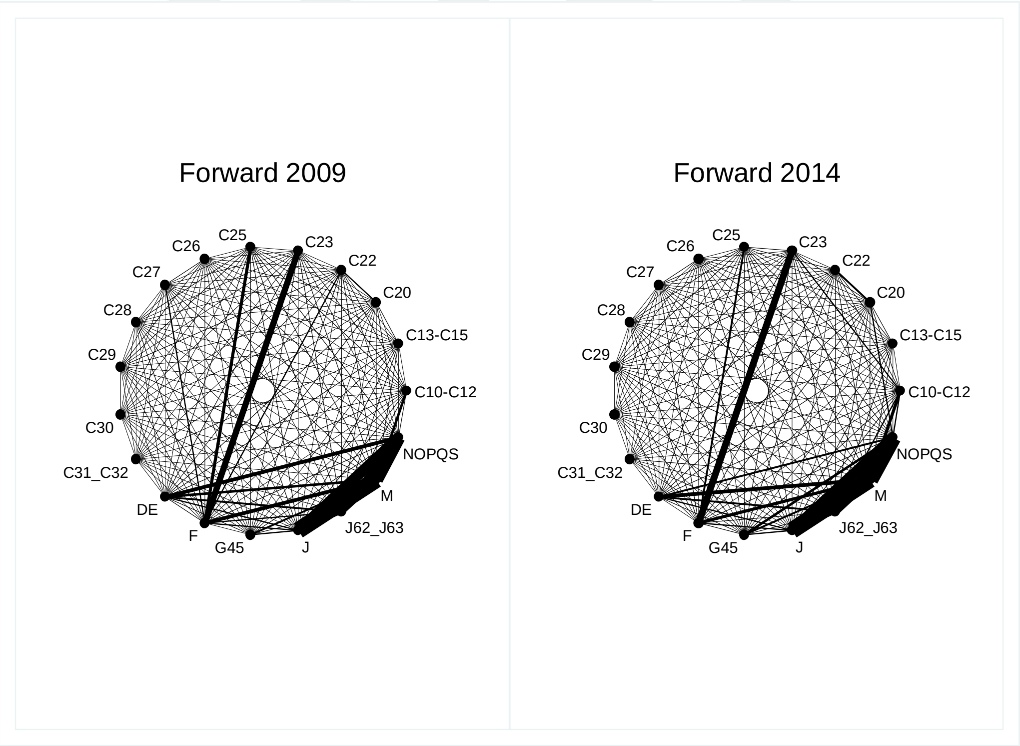


Figure 11.2. Poland Technology Transfer Network

Fair number of edges are relatively stronger in both forward and backward transfer networks in Poland. We observe a triad between motor vehicles, motor vehicle sales and fabricated metals where the third node was missing in Czechia and Lithuania in both networks. The triad is stronger in 2014. We observe another triad between manufacture of motor vehicles, electrical equipment and rubber, plastic production in backward matrix. Edge values indicate that share of demand from motor vehicles to electrical equipment is greater than the opposite interaction and the same is correct for electrical equipment as a customer for manufacture of rubber and plastic. So that, triad of backward linkage flows heavily from medium to low technology sectors.

6.4. Embodied Technology Flow: Portugal

In Portugal's forward network, only a few conventional links are significantly higher than other edges, such as construction and other non-metallic products. This edge is important also in backward transfer in 2009. However, it disappears in 2014. Hardware industry and community, social services is another prominent link emerges significant in backward network in 2014. We observe that portion of service industries are relatively greater in all plots and they are isolated from rest of the network.



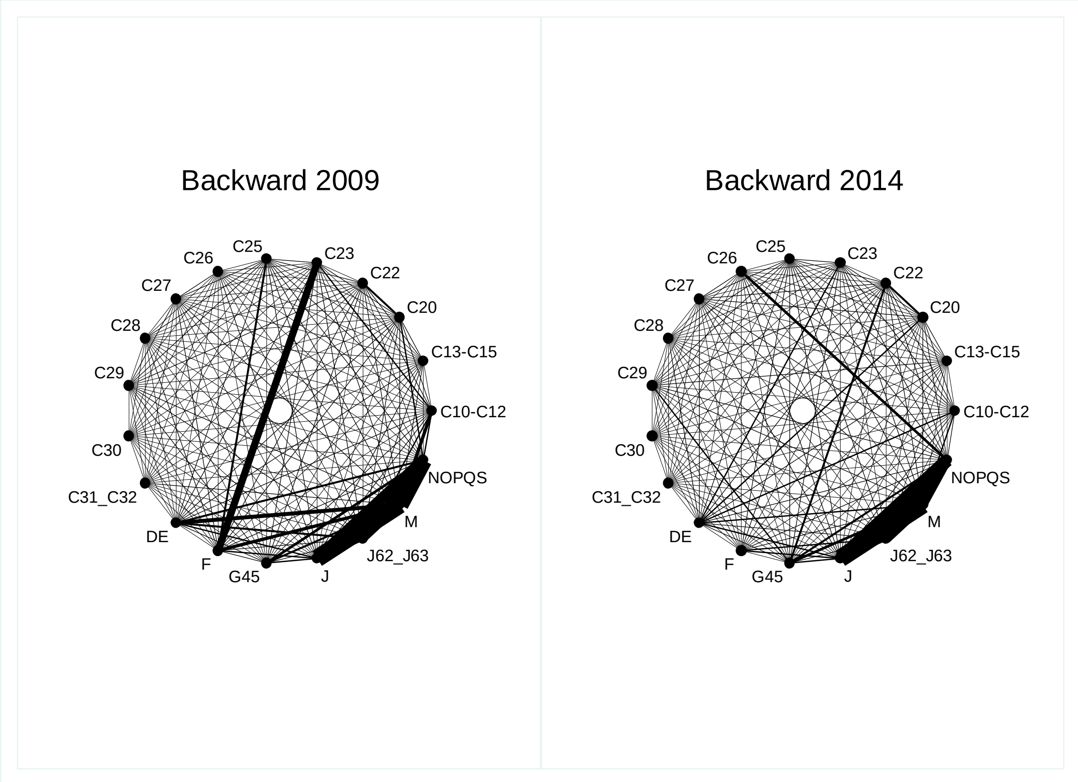


Figure 11.3. Portugal Technology Transfer Network

6.5. Embodied Technology Flow: Romania

Construction sector has weaker links in Romania. Professional and scientific activities has a strong forward link to almost all-manufacturing industries addition to infrastructure sector in forward 2014. The linkage to manufacture of motor vehicles is especially high. It is plausible to say that transaction of knowledge intensive activities to manufacturing in Romania became a main driver of technology flow. When its flow significantly high only to manufacture of furniture in 2009, it became more diverse in 6 years. Power of professional and scientific activities turns out to be relatively weaker in terms of backward flow. Scientific services stand as a R&D provider as customer to rubber and plastic, other non-metallic industries that operates as medium-low manufacturing industries. Motor vehicles sector is also an important intermediate good supplier to these types of activities. Thus, professional and scientific services boost these industries not only as a supplier but also as a customer. As an example, we could argue that firms in rubber and plastic production sector enhance their R&D efforts to provide products that are more efficient to researchers, qualified personnel. It is also possible to see a triangle in backward flow in 2014 between motor vehicles, rubber and plastic and professional activities. Rubber, plastic manufacturer firms innovate to adopt to needs of car manufacturers as their material supplier and professional activities adjust their R&D intensity in accordance with car manufacturers. Both sectors channel their R&D efforts to complement the needs of services delivered by professional, scientific activities.

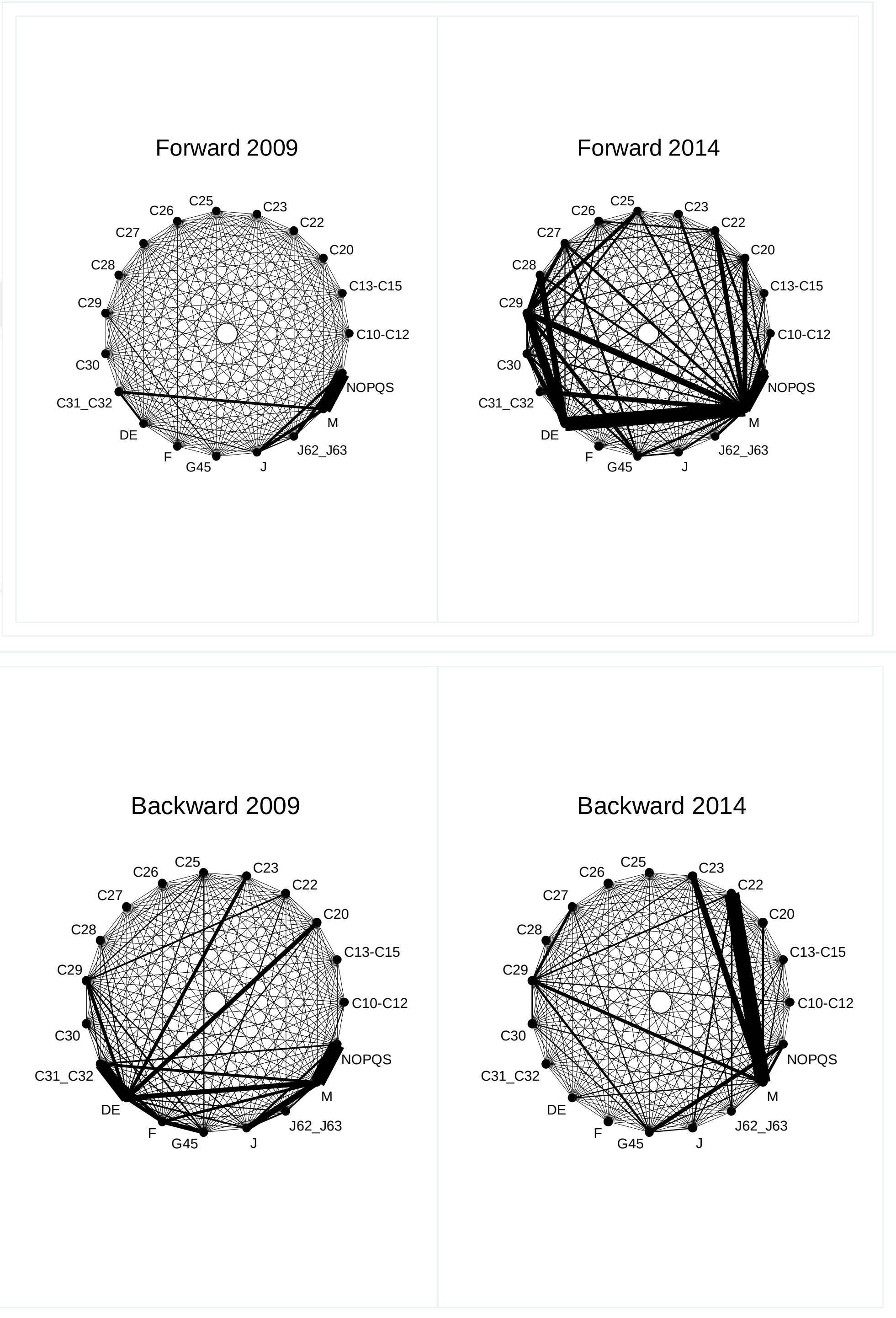
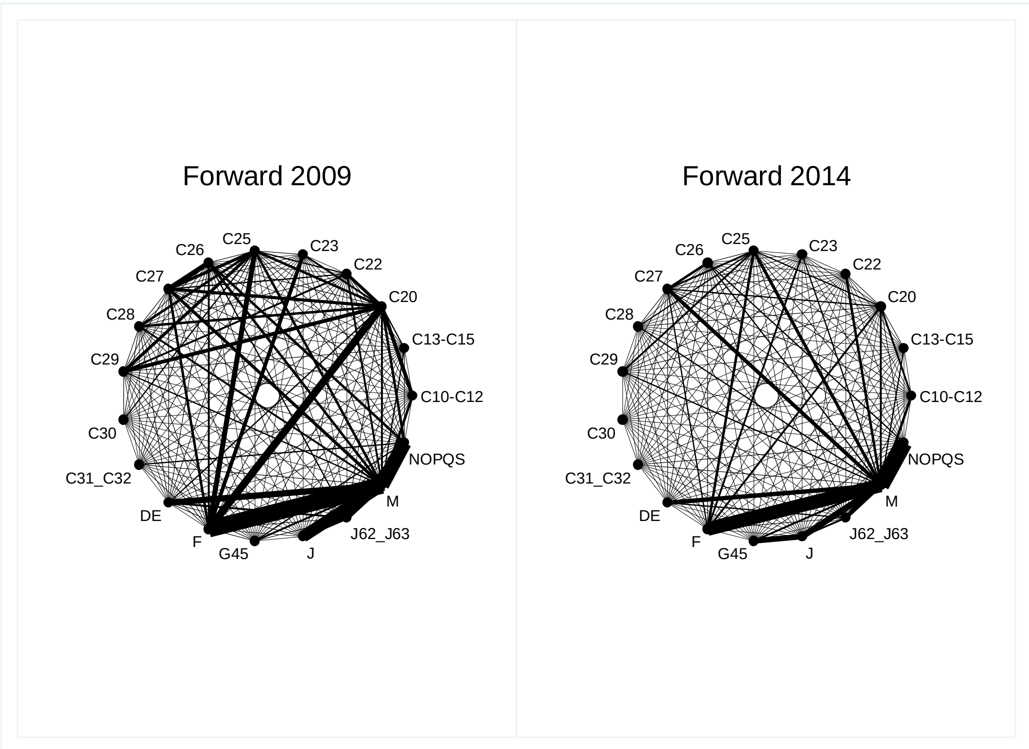


Figure 11.4. Romania Technology Transfer Network

Romania increases her density slowly in both types of technical coefficient matrix. Manufacturing industry has a significant role as forward knowledge sector in this progression. Activities of such as legal, accounting, architecture and engineering, scientific R&D personnel has an imperative place in development of knowledge flow mechanism in Romania.

6.6. Embodied Technology Flow: Slovenia

Intensity of channels between service sectors increases when manufacturing industry falls behind in forward network of Slovenia. A triad can be observed between manufacture of fabricated metals, electrical equipment and professional activities in 2014. It is an intriguing example since fabricated metals is comparatively low technology sector producing materials, electrical equipment is an industry with medium high knowledge and finally professional activities with scientific research and development is a high technology service sector. Backward linkage matrix do not vary qualitatively when its density increases highly between 2009 and 2014. We observe a similar triad between motor vehicles, fabricated metals and chemicals industries. Professional activities have strong backward link to chemicals.



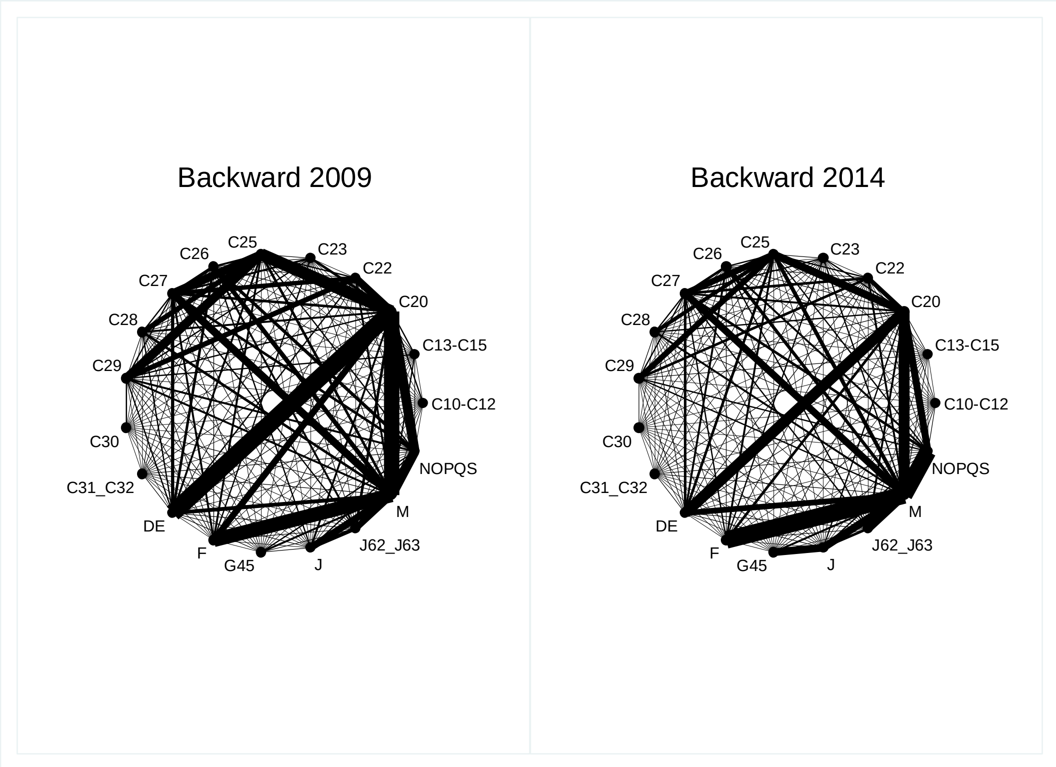


Figure 11.5. Slovenia Technology Transfer Network

6.7. Embodied Technology Flow: Turkey

Network density in Turkey has the largest leap in the sample. However, in absolute terms composition of links does not change significantly. Although forward network composition does not change, links' intensity increases in 2014. Some additional stronger links emerge between service sectors. Backward network has a similar pattern except the link between construction and chemicals industry. We observe that manufacturing sectors have a relatively homogenous structure when service industries have stronger ties between them.

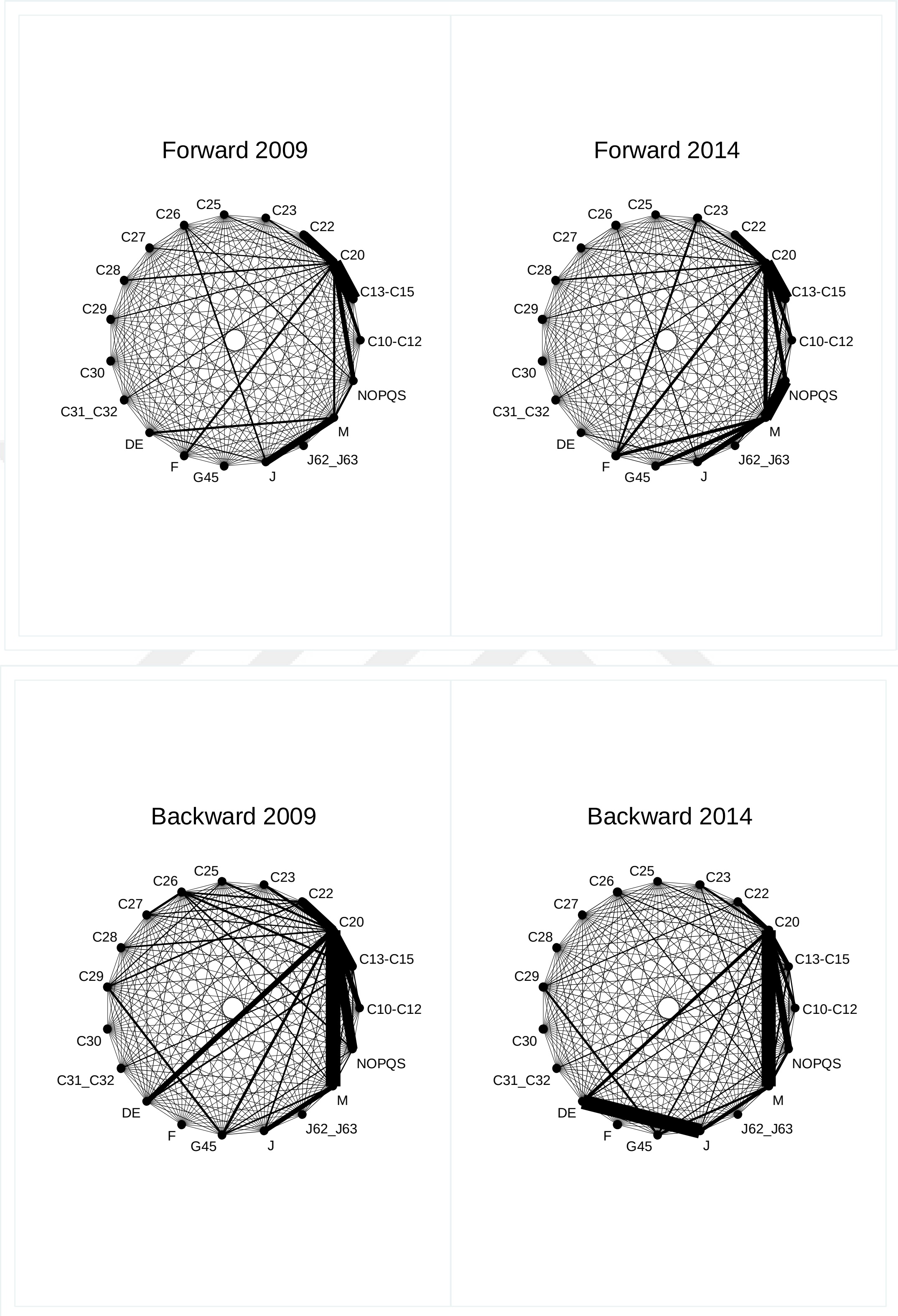


Figure 11.6. Turkey Technology Transfer Network

7. CONCLUDING REMARKS

Second chapter of this thesis presents an analysis for network structure of embodied research transfer in forward and backward links. We focus on seven OECD countries in 2009 and 2014. Our first step analysis shows weighted directed local degree of networks and it enables us to observe which sectors are central to each economy's network. Degree distributions indicate that most of the countries have heterogeneous structure. Therefore, some sectors are in a more central location comparing to others in terms of both receiving and transmitting knowledge. We observe that service industries have prominent role in terms of both supplying and demanding technology. High and medium-high technology industries come forward as major suppliers of research in both manufacturing and service industries.

We calculate average nearest neighbor degree for the second step analysis. In this case, we measure assortativity with correlation between local centrality and neighbor connectivity to understand if industries with similar degrees tend to connect. Our results vary depending on the economy and we observe that degree of assortativity changes from 2009 to 2014 in all countries. In overall, we conclude that when network density of each economy increases in time, in terms of sectors' centrality, all economies present heterogeneous structures. Thus, economies' inter-sectoral technology flows increase in volumes and their sectoral composition is fluid.

This chapter serves as a structural analysis of technology flow networks that are utilized in our empirical model. We show that even though technology transfers positively affect productivity and creation of new ideas, their structure is heterogeneous therefore certain parts of an economy contributes more than other industries. As a policy advice, we suggest that prominent sectors in terms of transfer networks would be considered as sources of multipliers. Therefore, focal points of subsidiary activities would be decided in accordance with the network structure of each economy.

APPENDIX 1

Table A.1.
List of Industries

NACE Rev. 2.	Sector
C10-C12	Manufacture of food products, beverages and tobacco products
C13-C15	Manufacture of textiles, wearing apparel and leather products
C20	Manufacture of chemicals and chemical products
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31_C32	Manufacture of furniture; other manufacturing
DE	Electricity, Gas and Water Supply; Sewerage, Waste Management and Remediation Activities
F	Construction
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
J	Information and communication (except Computer programming, consultancy and related activities)
J62_J63	Computer programming, consultancy and related activities; information service activities
M	Professional, scientific and technical activities (with scientific research and development)
N_O_P_Q_S	Community, Social and Personal Services

APPENDIX 2

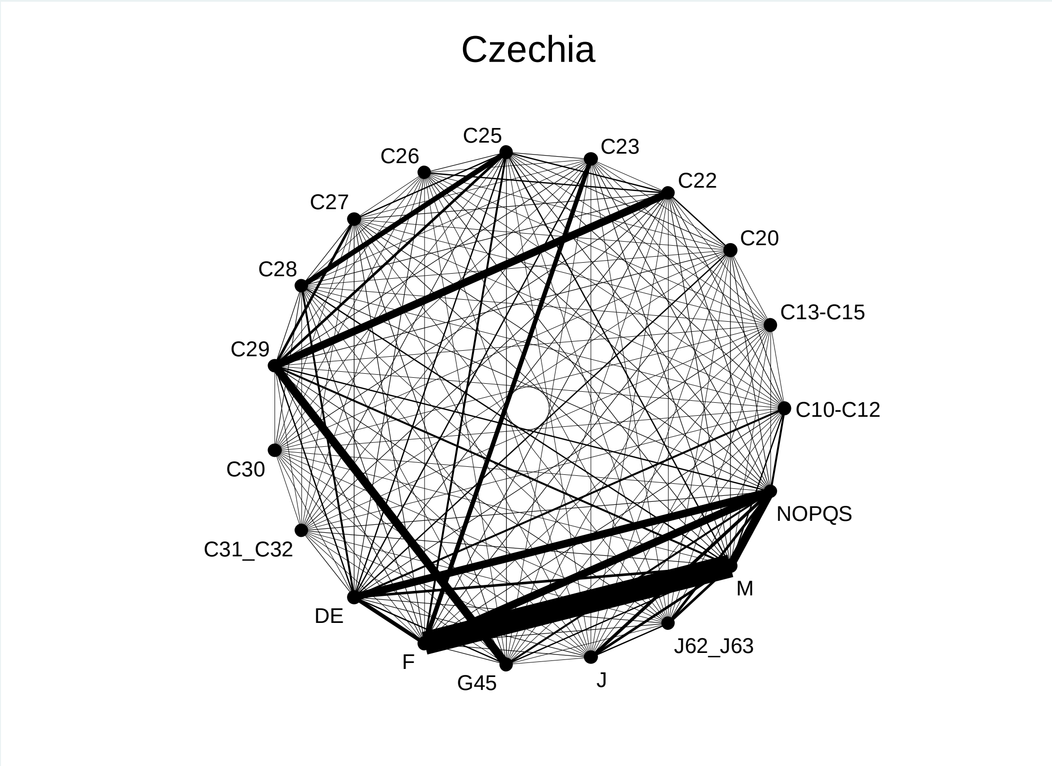


Figure 9. Czechia Input-Output Network

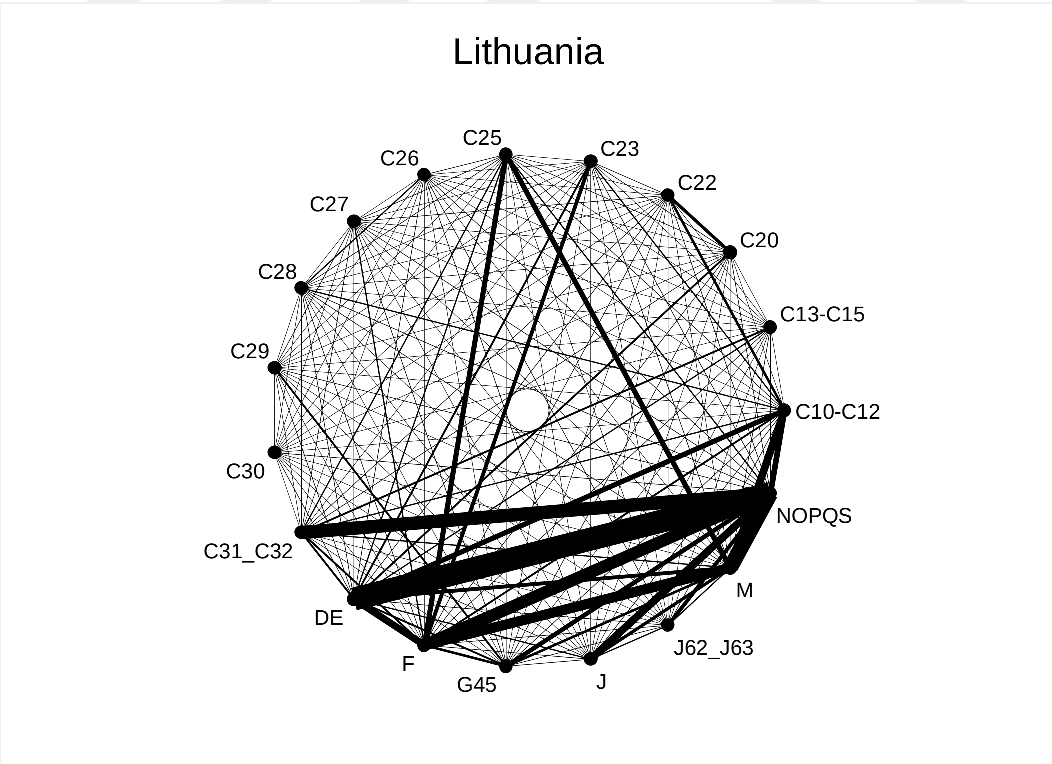


Figure 8.1. Lithuania Input-Output Network

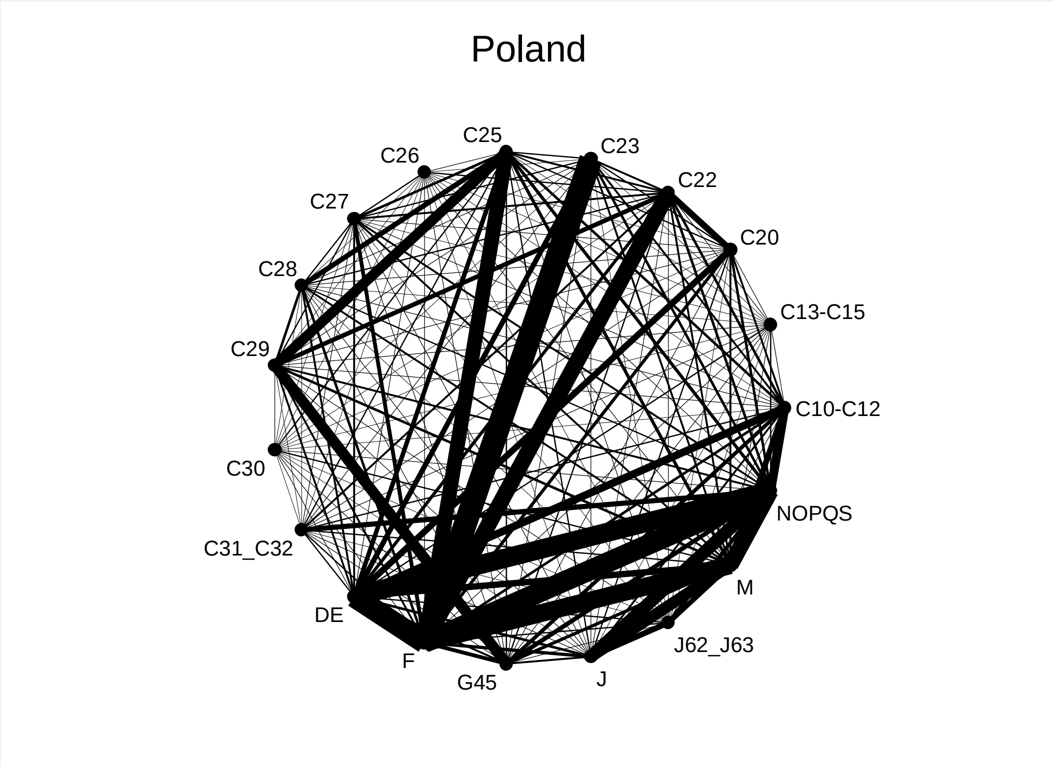


Figure 8.2. Poland Input-Output Network

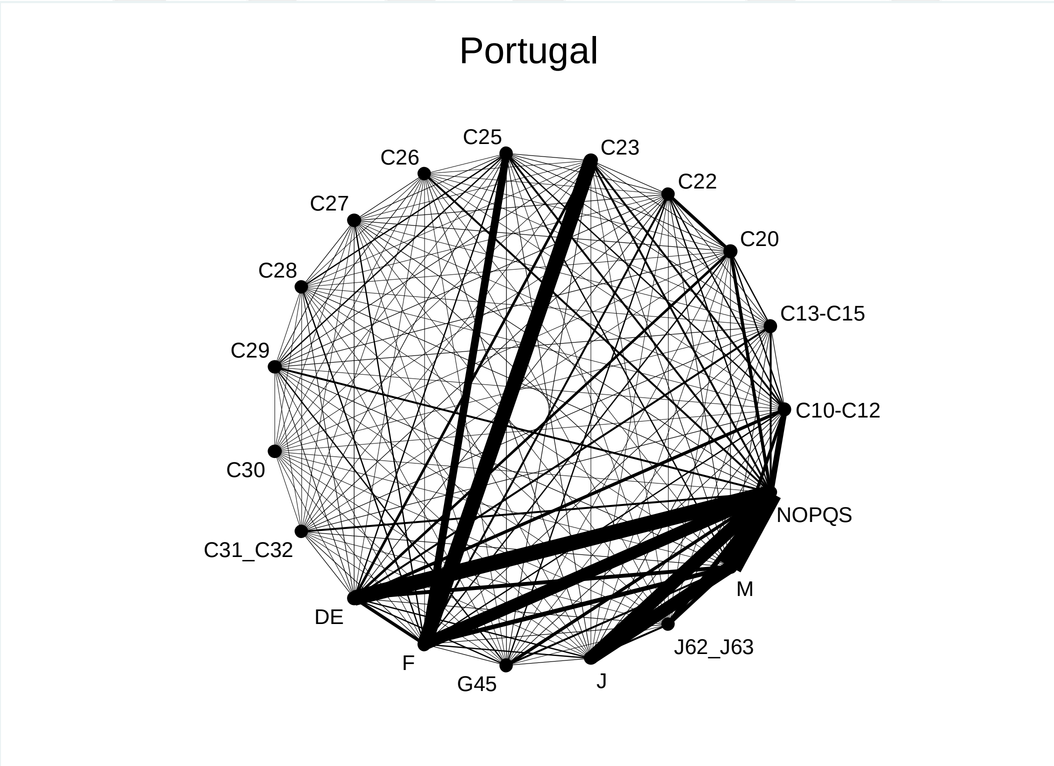


Figure 8.3. Portugal Input-Output Network

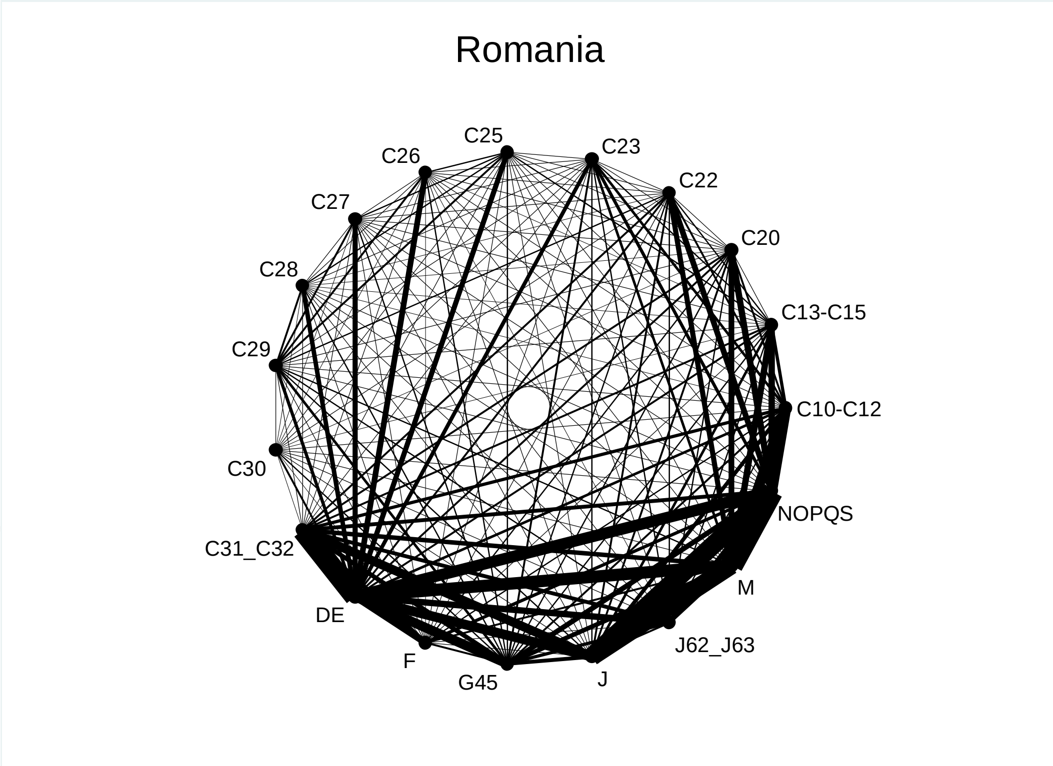


Figure 8.4. Romania Input-Output Network

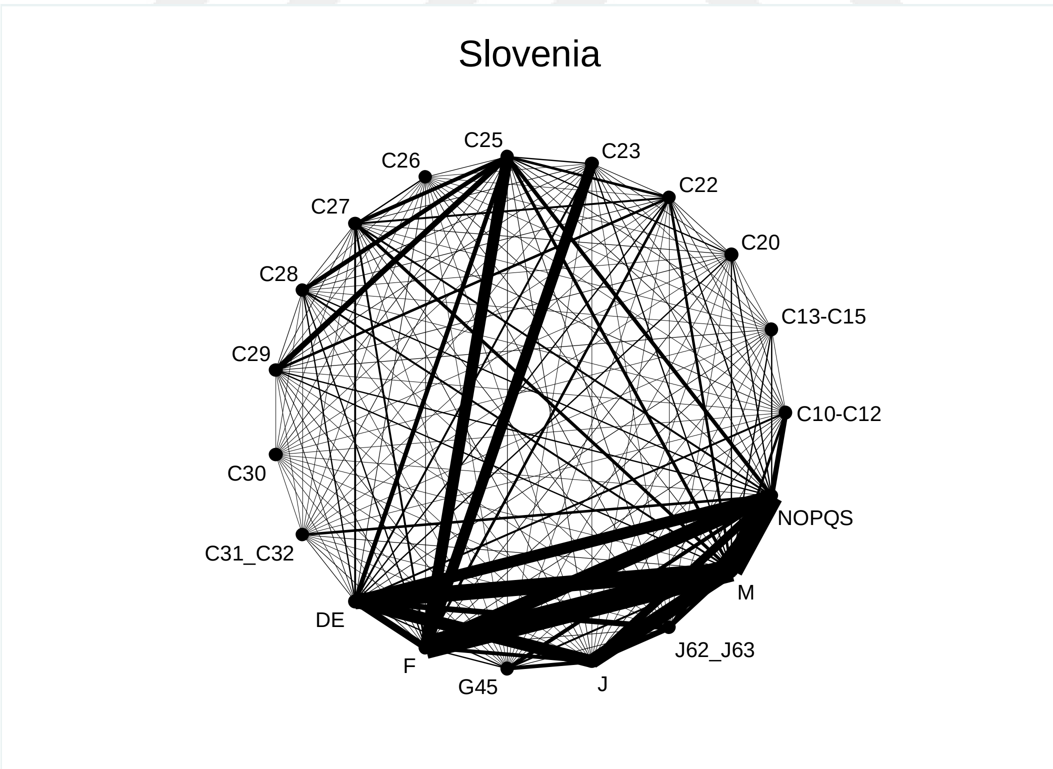


Figure 8.5. Slovenia Input-Output Network

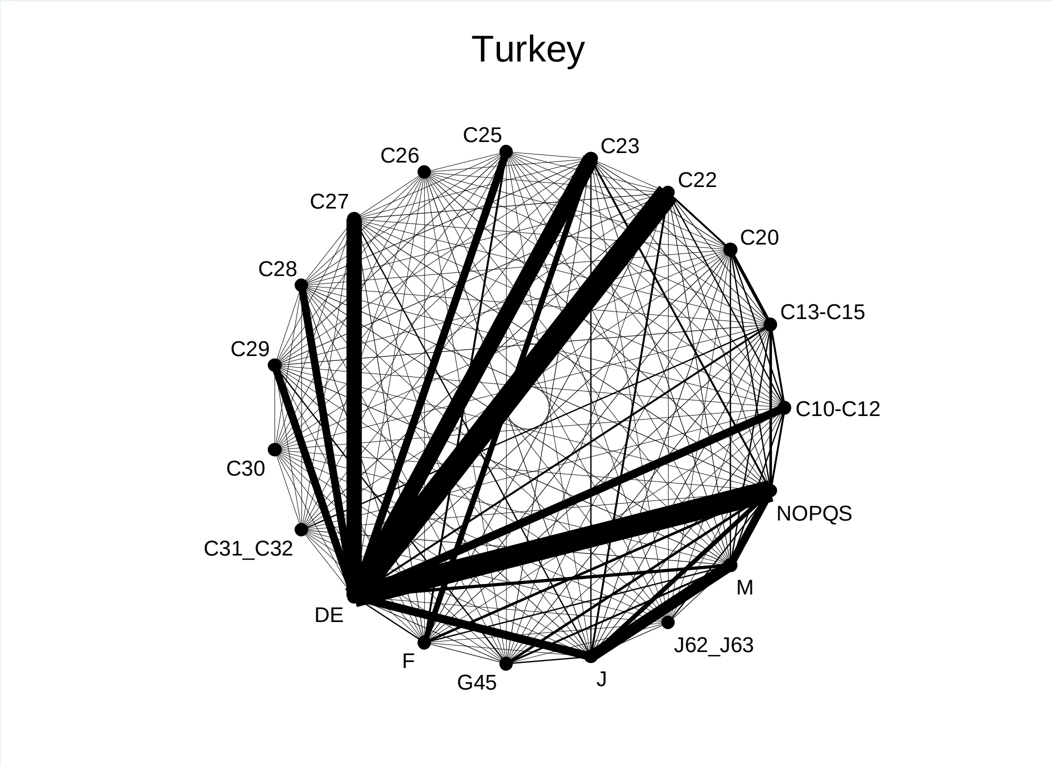


Figure 8.6. Turkey Input-Output Network

APPENDIX 3

Table A.2. Forward-In Degree

		Top 5				Bottom 5			
	Country	Sector	Degree_In	Sector	ANND_IN	Sector	Degree_In	Sector	ANND_IN
Forward_In 2009	CZE	F	87,707,589.40	G45	20,121,625.19	C23	3,217,429.98	C13-C15	9,367,915.67
	CZE	NOPQS	45,593,267.34	C27	13,519,948.91	C20	3,074,298.52	C28	9,329,910.30
	CZE	C29	29,352,950.27	DE	12,341,992.73	C31_C32	3,028,344.06	C31_C32	9,316,447.76
	CZE	M	12,906,721.18	F	12,098,863.26	C13-C15	1,544,960.08	C29	8,402,483.30
	CZE	C28	10,756,128.12	C20	11,700,100.18	C30	1,479,957.28	C22	6,834,103.75
	LTU	F	447,808,639.41	M	397,729.24	C20	23,494,621.38	C25	209,155.70
	LTU	NOPQS	238,423,612.75	C10-C12	370,903.43	C23	16,549,604.51	G45	154,223.50
	LTU	C29	179,893,677.97	C20	346,348.39	C31_C32	15,975,287.89	C22	146,222.94
	LTU	C28	76,290,347.19	C13-C15	336,630.84	C13-C15	11,454,126.58	J62_J63	129,971.34
	LTU	DE	69,483,514.73	C31_C32	325,646.42	C30	7,024,460.28	C28	111,358.50
	POL	F	1,367,975.71	J62_J63	8,167,919.37	C30	72,583.66	F	5,443,329.70
	POL	NOPQS	1,269,742.28	G45	7,595,689.12	C20	62,335.56	C29	5,408,446.91
	POL	C10-C12	547,863.49	C20	7,044,791.95	C13-C15	61,620.02	C22	5,272,468.95
	POL	G45	444,683.22	NOPQS	7,033,705.21	C29	43,464.31	J	5,265,091.69
	POL	DE	437,185.09	M	6,855,953.38	C26	41,258.15	C26	5,254,139.05
	PRT	NOPQS	17,685,399.43	J62_J63	31,445,923.53	C13-C15	633,211.82	C28	12,921,762.52
	PRT	F	9,725,609.98	J	24,696,861.98	C20	428,724.04	F	12,728,967.37
	PRT	C10-C12	8,592,292.40	DE	23,336,624.42	C29	356,059.12	C22	12,339,645.83
	PRT	C25	4,433,825.51	NOPQS	22,747,943.33	C30	255,649.11	C29	11,437,425.06
	PRT	J62_J63	3,424,198.49	C10-C12	19,152,490.49	C26	187,997.50	C26	10,750,490.08
	ROU	F	21,500,644.63	C20	5,449,101.08	C23	2,948,040.45	DE	3,505,112.07
	ROU	NOPQS	20,413,008.70	C23	4,827,569.10	J62_J63	2,846,819.42	C13-C15	3,383,448.15
	ROU	J	12,002,890.42	C29	4,775,623.68	C26	1,956,572.47	C22	3,080,918.22
	ROU	C29	11,137,545.79	C30	4,682,016.28	C13-C15	1,678,861.33	J	2,598,695.44

	ROU	C10-C12	10,240,186.71	C25	4,410,927.46	C30	1,609,290.80	G45	2,385,672.55
	SVN	F	200,166,169.63	C20	3,308,303.51	C31_C32	25,861,822.90	C10-C12	2,409,115.13
	SVN	NOPQS	171,177,600.88	C30	3,235,529.10	C23	25,216,027.72	C31_C32	2,319,870.55
	SVN	C29	122,940,394.09	J	3,028,093.66	C30	19,148,594.88	C23	2,265,399.99
	SVN	C10-C12	98,401,679.94	DE	3,008,737.39	C26	19,014,631.78	M	2,103,529.26
	SVN	J	96,174,791.17	G45	2,983,245.31	C13-C15	11,935,651.71	C27	2,014,885.43
	TUR	NOPQS	88,361,597.22	C20	118,245,610.65	C27	3,329,957.17	C27	38,024,090.16
	TUR	F	46,810,211.06	DE	101,461,313.63	C31_C32	3,171,064.57	C25	37,969,246.69
	TUR	M	38,377,710.34	C31_C32	99,158,543.67	C28	3,113,472.97	C23	30,665,805.20
	TUR	J	21,396,334.57	G45	68,134,376.85	C26	3,025,514.05	C13-C15	23,514,566.60
	TUR	C10-C12	16,516,708.54	C29	64,289,642.55	C30	425,317.81	C22	22,968,005.08
Forward_In 2014	CZE	NOPQS	339,889,471.44	G45	129,744,395.06	C27	13,272,032.53	M	57,537,347.36
	CZE	F	136,252,276.78	C27	85,619,979.71	C31_C32	13,080,653.20	C31_C32	56,941,929.26
	CZE	M	136,095,060.49	C20	66,551,638.67	C28	11,131,473.74	C28	55,689,217.54
	CZE	J	79,333,574.60	DE	66,238,288.36	C26	9,442,166.94	J	52,304,474.53
	CZE	C10-C12	77,596,746.72	C23	66,237,378.05	C30	2,861,609.31	C29	42,444,545.83
	LTU	NOPQS	46,437,989.07	M	4,059,122.73	C28	952,854.16	C27	1,738,727.89
	LTU	C31_C32	14,464,553.06	C31_C32	2,880,589.64	C30	837,391.13	G45	1,601,604.06
	LTU	J	9,263,836.29	C20	2,838,877.24	C27	808,647.59	J62_J63	1,582,494.67
	LTU	DE	7,142,418.90	C10-C12	2,637,183.90	F	580,187.38	C22	1,225,703.21
	LTU	G45	6,126,906.32	C30	2,486,729.19	J62_J63	344,777.75	C28	701,508.86
	POL	DE	91,152,704.13	J62_J63	83,225,731.40	C23	9,427,481.26	C22	51,328,007.87
	POL	NOPQS	41,188,417.62	G45	76,173,903.38	C13-C15	8,148,595.54	J	50,906,046.05
	POL	C29	33,378,615.83	DE	67,530,123.26	C26	5,700,020.34	F	50,717,571.02
	POL	G45	26,714,021.18	NOPQS	67,213,989.53	F	4,405,803.17	C29	48,192,838.19
	POL	C31_C32	20,753,323.74	C20	66,362,370.23	C30	4,363,290.50	C26	46,121,201.27
	PRT	F	16,953,975.51	J62_J63	114,759,418.34	C31_C32	1,291,045.45	C28	51,382,717.59
	PRT	NOPQS	11,955,081.62	J	97,279,782.78	C13-C15	1,224,637.36	C30	49,598,250.10
	PRT	J	6,695,533.77	DE	86,149,009.68	C20	1,065,209.17	C29	48,747,720.26

	PRT	C27	5,453,744.02	NOPQS	84,792,878.62	C26	691,670.78	C22	48,019,813.99
	PRT	C29	4,843,856.25	G45	73,478,611.51	C30	248,638.50	F	47,361,934.26
	ROU	NOPQS	113,188,637.25	C28	20,737,548.61	C23	9,167,674.88	C31_C32	14,145,048.99
	ROU	F	104,916,525.19	C25	19,865,012.18	C13-C15	7,964,432.99	C20	13,743,548.31
	ROU	J	61,628,285.92	C27	19,852,852.56	C31_C32	7,399,482.43	F	13,607,998.79
	ROU	C27	39,793,047.67	C26	19,098,552.87	C26	6,246,668.31	M	12,867,818.47
	ROU	DE	35,478,911.93	J	18,147,204.95	C30	1,190,555.13	C22	12,202,069.29
	SVN	NOPQS	121,069,319.17	C20	24,833,649.24	C23	3,742,132.55	C25	21,240,991.74
	SVN	J	75,709,432.27	C26	24,317,642.10	C26	3,329,788.32	C10-C12	21,200,273.66
	SVN	DE	56,483,620.21	J62_J63	24,298,505.83	C25	2,811,275.58	C31_C32	21,068,636.08
	SVN	F	25,896,609.18	C22	23,572,538.08	J62_J63	2,260,045.04	C27	18,667,635.21
	SVN	C13-C15	14,588,898.16	F	23,447,203.90	C30	868,766.39	J	17,749,331.81
	TUR	NOPQS	540,738,166.03	C31_C32	482,405,915.58	C27	14,013,659.25	F	262,245,920.34
	TUR	J	150,731,588.76	DE	366,707,843.33	C26	9,251,999.73	C27	258,949,958.72
	TUR	F	97,353,999.60	C20	355,337,921.86	C25	8,706,149.67	C22	244,639,200.84
	TUR	G45	66,495,046.61	C29	344,917,871.48	J62_J63	7,068,309.68	C13-C15	242,907,105.17
	TUR	C13-C15	60,970,023.03	C26	343,525,331.09	C30	2,879,239.05	J	231,318,529.15

Table A.3. Forward-Out Degree

		Top 5				Bottom 5			
	Country	Sector	Degree_Out	Sector	ANND_OUT	Sector	Degree_Out	Sector	ANND_OUT
Forward_Out 2009	CZE	M	143,553,610.78	F	48,479,220.74	C31_C32	1,666,484.97	DE	9,478,890.67
	CZE	J62_J63	21,931,021.95	J62_J63	41,258,546.92	C13-C15	1,262,830.60	C13-C15	8,615,161.45
	CZE	G45	21,773,202.43	J	36,746,431.54	C26	933,557.43	C22	8,279,637.65
	CZE	J	13,214,238.67	NOPQS	34,955,049.60	C10-C12	742,233.89	C23	5,053,088.53
	CZE	C22	10,872,161.04	G45	15,744,987.37	NOPQS	289,707.64	M	3,405,841.39
	LTU	C25	1,519,691.08	C26	437,636.59	J	89,009.88	C22	181,214.20
	LTU	C26	1,420,018.51	NOPQS	415,979.40	C13-C15	18,452.87	C13-C15	180,282.67
	LTU	M	936,104.24	F	335,390.28	C30	9,641.47	C29	171,662.85
	LTU	J62_J63	571,794.12	J	282,822.37	F	3,562.75	C20	137,152.56
	LTU	C27	441,173.13	G45	281,159.31	C22	3,160.95	C23	79,969.79
	POL	M	49,610,191.77	J62_J63	15,903,475.08	C30	1,603,377.24	G45	3,427,381.49
	POL	J62_J63	13,123,781.24	NOPQS	13,938,696.39	C26	518,942.37	C25	3,258,186.38
	POL	J	12,631,562.29	J	12,070,909.24	F	497,886.07	C13-C15	3,237,581.48
	POL	G45	12,274,107.28	F	11,802,865.54	C13-C15	227,478.32	C22	2,375,837.91
	POL	C25	9,635,369.95	C29	6,379,167.06	NOPQS	126,682.05	C23	2,121,891.48
	PRT	M	77,474,848.35	J	34,545,864.50	C31_C32	1,607,328.68	C28	7,229,003.33
	PRT	J	65,698,900.27	NOPQS	34,454,440.78	NOPQS	1,281,070.28	C22	6,742,121.93
	PRT	J62_J63	45,265,294.35	C26	30,708,901.89	F	1,134,917.01	C31_C32	6,656,308.73
	PRT	C23	17,823,108.06	J62_J63	27,031,744.66	C13-C15	968,405.19	C25	5,884,793.97
	PRT	DE	16,707,382.47	M	15,584,990.76	C30	679,899.71	C23	2,699,863.94
	ROU	M	43,447,304.40	NOPQS	22,098,773.15	C22	471,737.05	C13-C15	4,383,723.60
	ROU	J62_J63	17,053,066.97	C23	8,898,139.66	C23	420,125.99	DE	3,992,079.34
	ROU	J	11,254,307.54	C26	7,585,526.13	C10-C12	195,331.59	C20	3,654,418.99
	ROU	DE	10,617,300.85	C31_C32	7,080,365.77	C13-C15	65,827.33	C30	3,177,585.88
	ROU	C29	5,106,276.80	C28	6,674,975.65	NOPQS	34,710.58	M	1,858,817.63
	SVN	M	26,258,054.50	F	7,906,605.20	C13-C15	772,263.74	C20	2,271,239.73

	SVN	C20	13,925,509.48	NOPQS	7,474,392.83	DE	306,635.95	C25	2,186,448.66
	SVN	C26	7,304,371.21	J	7,350,086.04	C10-C12	98,872.79	C10-C12	1,969,375.13
	SVN	J62_J63	6,789,467.72	J62_J63	5,958,011.21	NOPQS	46,533.66	C23	1,297,324.13
	SVN	C25	6,203,721.13	C28	5,150,459.13	F	6,000.63	M	1,110,342.73
	TUR	C20	1,105,409,845.83	C10-C12	157,598,627.83	DE	3,621,055.58	C23	34,501,955.52
	TUR	M	349,937,999.43	NOPQS	120,681,315.76	C29	3,597,198.41	J62_J63	27,733,608.69
	TUR	C26	131,667,576.68	C13-C15	108,169,994.78	C10-C12	2,206,028.41	J	22,287,862.65
	TUR	C27	46,435,233.44	C22	101,626,254.29	NOPQS	383,022.91	F	18,591,077.71
	TUR	J	36,011,949.63	C29	93,119,198.44	F	5,806.19	C30	6,941,415.44
Forward_Out 2014	CZE	M	865,336,914.02	F	266,774,238.80	C26	5,922,158.53	C25	54,667,542.77
	CZE	J62_J63	134,995,911.11	J62_J63	234,819,348.46	C31_C32	5,541,620.50	C30	52,345,432.95
	CZE	G45	115,092,835.99	J	195,151,047.67	NOPQS	2,857,672.75	C22	48,245,412.35
	CZE	J	61,975,229.52	NOPQS	185,308,208.25	C10-C12	2,572,263.27	C23	34,926,612.88
	CZE	C29	48,226,008.11	G45	90,248,131.45	C13-C15	2,404,279.84	M	18,475,915.55
	LTU	M	29,124,484.80	NOPQS	8,030,326.71	F	315,638.31	C31_C32	1,448,055.03
	LTU	C26	8,169,940.96	F	4,992,197.87	C22	204,409.84	M	1,075,406.12
	LTU	J	6,379,299.50	G45	4,967,246.53	C10-C12	104,411.39	C20	741,296.35
	LTU	J62_J63	3,575,742.37	J	4,299,953.43	C13-C15	87,056.03	C22	682,175.48
	LTU	G45	2,288,608.34	J62_J63	4,182,415.57	C30	39,967.92	C23	587,751.97
	POL	M	312,707,808.63	J62_J63	121,117,257.73	F	10,981,716.83	C13-C15	29,822,255.39
	POL	J62_J63	183,537,315.64	NOPQS	103,035,378.84	C10-C12	9,271,513.22	G45	27,413,416.38
	POL	J	145,124,213.79	J	88,528,229.79	C26	6,011,486.06	C25	26,926,080.63
	POL	C25	137,394,457.26	F	81,368,993.34	NOPQS	3,936,050.10	C23	24,720,459.67
	POL	G45	108,091,710.24	C29	62,446,401.37	C13-C15	2,196,649.16	C22	24,549,663.04
	PRT	M	317,971,800.95	J	138,953,713.27	C29	5,920,342.90	C22	31,781,320.13
	PRT	J	224,352,941.47	NOPQS	129,680,143.05	C31_C32	5,776,633.71	C20	29,760,057.23
	PRT	J62_J63	178,351,985.36	J62_J63	104,657,672.22	C13-C15	5,218,916.01	C25	26,999,842.05

	PRT	C23	80,026,539.20	C26	82,282,570.88	F	4,369,647.47	C31_C32	26,706,132.12
	PRT	G45	52,110,880.80	C29	63,144,161.05	C30	1,388,674.08	C23	13,166,851.40
	ROU	M	151,241,656.88	C22	48,165,936.51	C13-C15	1,327,824.29	F	11,098,658.77
	ROU	C29	49,701,885.69	DE	40,831,806.09	C31_C32	1,162,361.35	M	9,640,849.95
	ROU	C30	33,675,487.29	C23	39,789,915.96	NOPQS	687,520.90	J	9,439,112.06
	ROU	C20	22,256,369.53	G45	38,850,841.89	DE	489,907.69	C29	8,347,511.97
	ROU	C22	20,794,070.32	C20	32,217,875.98	F	79,230.06	C28	3,396,022.01
	SVN	M	276,448,679.86	J	86,884,751.83	DE	3,237,157.64	C25	19,906,215.81
	SVN	C20	49,202,871.48	F	80,292,026.86	C13-C15	2,662,799.68	C10-C12	18,945,838.33
	SVN	J62_J63	47,858,200.04	NOPQS	77,273,902.47	C10-C12	1,294,559.71	C23	15,130,910.25
	SVN	C25	38,258,437.37	J62_J63	64,283,719.18	F	1,025,493.50	G45	13,938,853.04
	SVN	C26	35,275,072.77	C26	43,186,313.50	NOPQS	925,177.61	M	9,228,247.01
	TUR	C20	3,615,195,213.15	C10-C12	699,393,451.55	C30	19,772,929.86	DE	161,726,811.24
	TUR	M	2,921,970,390.24	NOPQS	673,076,375.30	C29	17,433,258.25	C23	161,630,176.94
	TUR	C23	300,485,922.34	C29	502,983,154.12	C31_C32	11,364,634.05	J62_J63	136,309,039.29
	TUR	C26	298,416,744.49	C13-C15	499,149,323.96	NOPQS	7,782,319.98	F	115,397,803.23
	TUR	C13-C15	195,137,937.18	J	495,480,791.55	F	1,393,475.97	C30	106,503,800.60

Table A.4. Backward-In Degree

		Top 5				Bottom 5			
	Country	Sector	Degree_In	Sector	ANND_IN	Sector	Degree_In	Sector	ANND_IN
Backward_In 2009	CZE	F	25,854,030.61	F	15,844,773.18	C27	2,532,067.05	DE	8,094,102.36
	CZE	NOPQS	24,673,099.88	J62_J63	14,858,413.80	C31_C32	1,726,756.06	C27	7,907,149.39
	CZE	DE	22,139,393.10	J	13,892,615.00	C13-C15	1,489,915.03	C22	7,159,415.38
	CZE	C22	20,898,724.44	C20	12,502,822.25	C26	990,235.87	C30	6,310,145.98
	CZE	C25	19,641,169.32	NOPQS	12,396,647.79	C30	966,432.80	C25	5,468,501.95
	LTU	NOPQS	127,878,456.74	F	457,923.37	C20	8,876,895.51	C29	211,078.37
	LTU	F	121,181,833.93	G45	438,701.67	C26	8,376,834.89	M	208,623.29
	LTU	M	110,327,894.57	J62_J63	399,911.12	C30	6,500,598.67	C27	197,132.25
	LTU	DE	106,566,194.81	J	384,256.33	C31_C32	6,445,187.21	C22	178,293.01
	LTU	C25	105,351,848.63	C31_C32	382,154.16	C13-C15	2,801,617.32	C26	133,568.21
	POL	M	866,353.40	F	12,678,589.53	C23	47,151.39	C28	3,624,460.04
	POL	DE	752,014.41	J62_J63	11,817,957.06	C22	44,867.06	C13-C15	3,062,680.97
	POL	NOPQS	534,808.62	J	10,525,184.31	C13-C15	41,968.79	G45	2,781,487.59
	POL	F	447,249.27	NOPQS	10,136,160.36	C29	34,619.06	C22	2,702,019.17
	POL	C26	349,991.72	C31_C32	8,052,492.44	C30	21,254.49	C25	2,615,638.09
	PRT	NOPQS	8,737,160.66	J	35,062,421.20	C13-C15	426,449.74	C23	9,697,789.06
	PRT	M	4,291,498.97	J62_J63	27,200,913.96	C22	416,788.24	C28	9,052,889.10
	PRT	DE	4,091,009.69	NOPQS	20,625,856.24	C10-C12	373,283.39	C13-C15	8,879,462.31
	PRT	F	3,982,192.57	F	20,126,690.73	C23	289,454.91	C20	8,775,730.84
	PRT	J	1,865,877.83	C10-C12	19,752,528.76	C30	143,201.45	C22	8,127,234.38
	ROU	M	18,512,291.51	C23	14,387,804.33	C31_C32	1,229,602.23	C13-C15	3,644,606.15
	ROU	NOPQS	17,677,572.69	C28	7,466,440.51	C29	991,764.30	C22	3,198,906.46
	ROU	F	13,491,269.88	F	6,393,189.60	C13-C15	637,891.04	C30	2,539,048.53
	ROU	G45	12,181,670.80	C25	5,066,435.72	C30	433,084.62	C29	2,361,922.83
	ROU	C25	11,953,231.98	J	5,038,044.64	C26	345,579.07	DE	2,313,120.79
	SVN	NOPQS	171,126,894.82	F	6,819,329.90	C29	15,282,147.04	C23	2,498,511.77

	SVN	M	154,388,694.34	C30	5,380,063.60	C31_C32	11,328,728.17	C29	1,966,196.24
	SVN	F	117,757,989.10	J	5,293,121.94	C30	5,641,891.64	M	1,874,881.12
	SVN	C25	107,764,276.60	G45	4,948,905.38	C13-C15	4,470,654.73	C25	1,677,538.73
	SVN	DE	90,121,094.37	J62_J63	4,556,207.94	C26	3,909,856.84	C22	1,577,760.58
	TUR	NOPQS	63,970,336.03	J	73,038,260.14	C13-C15	2,663,608.16	C28	45,768,270.01
	TUR	M	45,242,179.06	C20	63,298,121.17	C10-C12	2,518,732.20	C22	42,039,012.66
	TUR	J	21,315,279.17	C10-C12	62,438,655.08	C29	2,143,919.40	G45	38,692,508.61
	TUR	DE	13,262,506.34	NOPQS	59,302,704.83	C31_C32	1,238,080.16	C25	34,638,112.00
	TUR	F	10,070,329.62	C31_C32	59,083,559.59	C30	231,338.98	C27	26,924,700.36
Backward_In 2014	CZE	NOPQS	289,508,957.12	F	95,801,629.83	C13-C15	10,929,557.47	DE	49,593,904.45
	CZE	M	189,319,345.10	J62_J63	85,770,656.71	C28	7,661,138.05	C27	49,451,599.65
	CZE	DE	82,058,153.88	J	82,072,443.93	C26	5,742,279.12	M	49,271,739.66
	CZE	J	76,868,462.09	G45	73,459,547.01	C31_C32	4,871,170.93	C30	34,311,823.24
	CZE	C25	38,374,439.73	NOPQS	71,542,625.18	C30	1,126,853.43	C25	32,371,679.50
	LTU	DE	21,691,762.15	C31_C32	5,003,185.79	C20	1,078,503.96	C27	1,564,065.13
	LTU	NOPQS	16,268,905.27	F	4,025,595.92	C26	911,770.01	C13-C15	1,537,959.56
	LTU	F	13,659,652.86	J	3,816,941.27	C27	630,342.75	C20	1,363,587.34
	LTU	M	5,489,333.10	G45	3,720,853.98	C28	423,565.54	C26	1,247,887.24
	LTU	J	4,930,914.18	DE	3,193,987.09	G45	284,761.22	C22	1,115,868.41
	POL	C22	101,628,911.35	F	105,382,222.91	J62_J63	4,393,729.60	C27	39,788,112.21
	POL	NOPQS	49,874,419.89	J62_J63	95,916,784.91	J	4,321,102.45	C13-C15	37,040,509.76
	POL	C23	47,473,498.81	NOPQS	79,744,833.00	C31_C32	4,283,395.58	C22	32,578,295.88
	POL	M	43,934,298.92	J	77,355,405.52	DE	2,369,780.19	G45	29,871,555.30
	POL	C30	20,468,543.69	C31_C32	66,625,435.29	F	1,456,517.64	C25	26,361,791.17
	PRT	M	11,618,239.44	J	138,822,123.50	C31_C32	840,755.68	C23	37,671,662.39
	PRT	C25	10,616,164.37	J62_J63	108,899,866.78	G45	815,027.74	C28	37,414,727.03
	PRT	NOPQS	10,031,307.88	C10-C12	77,972,591.50	C20	749,132.08	C27	33,505,887.56
	PRT	DE	9,636,224.75	NOPQS	76,923,337.78	C10-C12	612,667.59	C29	29,800,219.85
	PRT	F	8,285,549.88	F	76,275,290.48	C30	200,333.67	C22	26,738,170.92

	ROU	NOPQS	83,768,228.66	C22	31,774,299.07	C31_C32	4,253,613.84	J	12,571,692.57
	ROU	M	72,877,443.40	C23	29,098,292.69	C10-C12	4,065,840.68	C31_C32	12,183,327.41
	ROU	C25	63,079,463.03	DE	27,111,013.36	C20	4,005,020.35	M	11,285,715.36
	ROU	DE	62,777,593.84	C20	24,708,519.03	C13-C15	3,824,143.00	C29	11,136,998.11
	ROU	F	56,465,432.70	C25	19,925,572.49	C30	1,015,760.56	C28	8,668,769.40
	SVN	C29	50,308,346.75	F	56,047,367.59	C13-C15	2,325,146.71	C23	22,252,774.64
	SVN	J	47,412,395.82	J	48,378,299.32	C23	2,316,420.83	C29	17,605,126.62
	SVN	J62_J63	41,386,775.67	J62_J63	41,808,009.32	C10-C12	2,097,786.09	M	14,534,860.61
	SVN	C26	25,492,788.42	NOPQS	39,354,549.90	NOPQS	1,808,073.11	C25	14,095,678.96
	SVN	C27	17,038,441.67	C30	38,971,967.04	F	1,226,458.53	C22	13,115,395.07
	TUR	J	496,019,537.56	J	582,128,988.13	C31_C32	5,809,160.01	M	242,813,284.75
	TUR	J62_J63	188,604,981.63	C31_C32	412,926,182.48	C10-C12	4,976,903.17	C27	229,543,000.66
	TUR	C29	147,909,763.05	NOPQS	404,097,075.04	F	4,451,554.51	G45	211,079,568.03
	TUR	M	66,487,906.21	C26	377,354,262.30	NOPQS	2,688,630.13	C22	203,929,234.15
	TUR	C27	38,031,757.72	C20	376,352,179.38	DE	991,679.38	C25	197,739,173.92

Table A.5. Backward-Out Degree

		Top 5				Bottom 5			
	Country	Sector	Degree_Out	Sector	ANND_OUT	Sector	Degree_Out	Sector	ANND_OUT
Backward_Out 2009	CZE	M	57,664,147.68	F	33,408,919.63	C23	2,074,844.11	C20	9,440,028.62
	CZE	C29	33,023,683.57	G45	25,238,402.38	C10-C12	1,508,849.14	C13-C15	9,188,487.93
	CZE	C28	24,965,072.59	J	22,520,500.55	C13-C15	1,455,402.72	C29	9,075,198.75
	CZE	J62_J63	14,704,551.51	J62_J63	17,814,379.29	NOPQS	629,900.99	C28	8,860,854.07
	CZE	G45	10,341,477.33	NOPQS	15,711,883.14	DE	528,916.66	M	4,961,487.45
	LTU	C25	960,119.68	C27	484,806.82	J	45,928.28	C13-C15	203,402.58
	LTU	NOPQS	714,299.25	C30	447,452.99	C13-C15	22,245.74	C23	187,966.32
	LTU	J62_J63	678,989.84	J	442,062.49	C22	11,409.74	C26	166,499.62
	LTU	M	470,482.76	J62_J63	428,678.17	C30	6,129.94	NOPQS	145,207.71
	LTU	C10-C12	414,331.47	F	402,488.88	F	3,997.67	C22	130,882.19
	POL	C29	25,553,783.90	G45	12,080,789.31	C23	1,958,994.07	C22	5,858,434.41
	POL	M	23,445,729.73	J62_J63	11,386,862.57	C22	1,156,272.97	C29	5,768,655.20
	POL	J	11,463,996.59	J	10,796,558.57	F	743,142.41	C23	5,650,663.98
	POL	C27	9,018,709.41	C30	8,812,059.97	C13-C15	580,295.41	F	5,544,587.00
	POL	C28	8,296,839.96	C28	7,238,731.01	NOPQS	196,966.56	M	3,439,897.98
	PRT	J	59,620,263.53	M	27,071,645.67	C28	2,570,398.12	C30	9,284,662.76
	PRT	M	40,041,239.80	J62_J63	23,769,122.50	C13-C15	2,186,714.55	F	9,098,006.91
	PRT	J62_J63	36,995,727.95	NOPQS	22,506,048.85	NOPQS	2,087,057.55	C22	8,139,567.11
	PRT	C29	11,557,308.72	DE	18,669,986.23	C31_C32	1,673,939.39	C29	7,643,335.41
	PRT	G45	8,443,378.49	J	17,537,600.17	C30	960,019.51	C26	7,123,644.05
	ROU	M	21,389,432.49	NOPQS	11,142,584.32	C23	156,569.35	J62_J63	4,021,792.12
	ROU	C31_C32	16,420,042.69	J	9,350,152.19	C10-C12	150,995.51	C27	3,982,261.17
	ROU	G45	10,217,179.04	C31_C32	7,120,894.75	NOPQS	104,620.54	G45	3,143,687.27
	ROU	C29	9,416,775.81	C25	5,518,736.38	C13-C15	100,708.83	M	2,454,794.99
	ROU	DE	8,307,128.39	C20	5,491,949.68	F	47,307.33	DE	1,434,104.55

	SVN	C20	22,875,449.91	J	7,004,622.52	C23	693,281.84	C29	3,250,967.89
	SVN	M	11,100,763.50	F	4,990,612.99	C10-C12	276,720.44	C20	3,233,537.74
	SVN	C27	9,815,015.26	C30	4,914,975.84	DE	228,255.07	C25	3,140,874.20
	SVN	C29	6,639,246.72	C13-C15	4,533,460.40	NOPQS	84,760.68	C23	2,677,783.10
	SVN	C26	5,365,159.05	DE	4,367,103.82	F	8,821.12	M	936,026.49
	TUR	C20	426,824,148.22	C22	232,725,333.23	DE	6,858,293.30	J	37,439,857.97
	TUR	C26	83,980,411.27	C13-C15	143,130,548.00	C23	6,652,950.38	DE	34,110,842.87
	TUR	C13-C15	60,934,995.45	C23	81,516,679.56	C10-C12	3,960,836.67	F	28,079,027.67
	TUR	C29	60,536,684.38	C25	78,766,735.07	NOPQS	906,235.47	G45	27,300,463.17
	TUR	C27	41,994,311.16	C27	75,372,022.71	F	63,663.69	C20	22,737,530.27
Backward_Out 2014	CZE	M	286,199,148.19	F	179,159,013.32	C31_C32	9,876,692.19	C20	59,018,895.40
	CZE	C28	146,538,010.38	G45	127,917,361.57	C13-C15	6,960,066.63	C28	55,941,523.03
	CZE	C29	144,360,940.57	J	114,843,201.65	C10-C12	5,595,279.38	C30	54,245,885.69
	CZE	J62_J63	81,796,604.66	DE	97,079,597.11	NOPQS	5,439,105.18	C29	47,585,595.43
	CZE	C27	58,830,561.10	J62_J63	94,236,197.56	DE	2,617,518.27	M	29,384,633.63
	LTU	M	11,599,943.63	C25	6,534,613.08	F	381,724.86	M	1,677,425.93
	LTU	J62_J63	5,834,206.11	J	5,200,212.70	C22	289,077.26	C26	1,391,015.11
	LTU	J	2,711,670.41	C10-C12	4,380,479.22	C23	208,137.22	C29	1,360,794.74
	LTU	NOPQS	2,409,001.20	F	4,069,846.22	C13-C15	93,946.67	C27	1,238,667.88
	LTU	C26	1,795,286.76	J62_J63	3,934,790.16	C30	23,276.79	C22	964,505.91
	POL	M	176,242,632.68	G45	92,548,860.09	F	16,706,944.05	C31_C32	47,888,511.39
	POL	J62_J63	124,420,350.36	J62_J63	90,172,500.43	C23	12,732,992.87	C22	44,426,429.66
	POL	C29	123,018,204.03	J	86,954,623.16	DE	12,272,678.00	F	44,267,648.68
	POL	J	121,865,354.56	C30	68,309,476.43	NOPQS	5,616,237.26	C23	43,504,016.46
	POL	C27	85,141,912.19	C28	60,258,436.34	C13-C15	4,797,870.19	M	39,691,919.23
	PRT	J	229,531,734.12	M	96,753,735.11	DE	11,996,720.43	C28	37,260,752.18
	PRT	M	154,944,613.45	J62_J63	90,205,052.94	NOPQS	11,992,339.66	C30	36,653,062.42
	PRT	J62_J63	154,700,773.63	NOPQS	84,183,671.28	F	9,885,756.84	C29	33,611,402.34
	PRT	G45	78,779,234.87	DE	77,920,371.02	C31_C32	7,329,104.93	C22	32,964,067.83

	PRT	C10-C12	39,800,831.98	J	71,093,498.23	C30	3,541,991.17	C26	29,188,349.44
	ROU	M	125,716,078.23	C20	59,920,012.08	C10-C12	1,532,357.14	C13-C15	20,260,734.00
	ROU	C29	73,502,826.48	C28	50,516,974.64	C13-C15	1,105,054.10	F	18,791,820.87
	ROU	G45	44,678,668.70	C23	47,663,536.27	NOPQS	687,269.18	J	18,710,223.62
	ROU	J62_J63	23,554,379.32	C25	43,055,069.26	C23	505,669.06	G45	15,884,235.65
	ROU	J	22,725,467.72	C10-C12	39,636,608.72	F	242,838.30	M	3,193,508.95
	SVN	M	133,023,531.93	F	55,353,718.19	C30	4,115,784.29	C25	30,662,915.48
	SVN	C20	117,030,191.17	J62_J63	51,327,771.91	C10-C12	3,704,363.88	C23	29,674,291.39
	SVN	C27	61,876,952.06	NOPQS	48,338,097.92	DE	2,172,250.98	C29	27,984,078.55
	SVN	C29	33,087,490.59	C13-C15	45,883,636.07	NOPQS	1,484,606.91	J	27,225,501.84
	SVN	J	28,045,656.79	G45	45,352,197.82	F	1,332,017.06	M	9,142,457.85
	TUR	C20	2,020,243,142.37	C22	967,742,718.39	C10-C12	54,820,920.86	C30	336,564,975.14
	TUR	J	833,067,090.05	C13-C15	610,007,256.19	C25	45,660,717.03	C29	247,139,621.55
	TUR	M	491,490,109.59	DE	476,442,973.08	NOPQS	18,238,042.96	C20	247,052,503.67
	TUR	C13-C15	365,646,406.21	M	434,473,385.30	F	14,928,324.23	F	194,128,190.03
	TUR	C29	318,075,027.21	J62_J63	418,129,340.07	DE	6,782,765.84	J	57,960,867.24

REFERENCES

Aldieri, L. (2013). Knowledge technological proximity: evidence from US and European patents. *Economics of Innovation and New Technology*, *22*(8), 807-819.

Aldieri, L., Sena, V., & Vinci, C. (2018). Domestic R&D spillovers and absorptive capacity: Some evidence for US, Europe and Japan. *International Journal of Production Economics, 198*, 38-49.

Aldieri, L., Sena, V., & Vinci, C. (2018). Domestic R&D spillovers and absorptive capacity: Some evidence for US, Europe and Japan. *International Journal of Production Economics, 198*, 38-49.

Barthelemy, M., Barrat, A., Pastor-Satorras, R., & Vespignani, A. (2005). Characterization and modeling of weighted networks. *Physica A, 346*, 34-43.

Bloom, N., Schankerman, M., & van Reenen, J. (2013). “Identifying Technology Spillovers and Product Market Rivalry. *Econometrica*, *81*(4), 1347-1393.

Blöchl, F., Theis, F., Vega-Redondo, F., & Fisher, E. (n.d.). Vertex Centralities in Input-Output Networks Reveal the Structure of Modern Economies.

Coe, D. T., & Helpman, E. (1995, May). International R&D spillovers. *European Economic Review*, *39*(5), 859-887.

Davidson, R., & MacKinnon, J. (1993). Estimation and Inference in Econometrics. *Oxford University Press*.

Domingo, G., & Borrás, B. (2017). Direct and indirect knowledge spillovers and industrial productivity. *Industry and Innovation, 24*(2), 165-189.

Fagiolo, G., Reyes, J., & Schiavo, S. (2010). The evolution of the world trade web: a weighted-network analysis. *Journal of Evolutionary Economics, 20*, 479-514.

Garlaschelli, D., & Loffredo, M. I. (2005). Structure and evolution of the world trade network. *Physica A*, 138-144.

Gonçalves, E., & B. Ferreira Neto, A. (2016). Intersectoral flows of technological knowledge in emerging countries: An input-output analysis. *CEPAL review*.

Gonçalves, E., Perobelli, F., & Araújo, I. (2017). Estimating intersectoral technology spillovers for Brazil. *The Journal of Technology Transfer, 42*, 1377-1406.

Grilliches, Z. (1976). Issues in Assessing the Contribution of Research and Development to Productivity Growth. *Bell Journal of Economics, 10*(1), 92-116.

Grilliches, Z. (1992). The Search for R&D Spillovers. *The Scandinavian Journal of Economics, 94*, 29-47.

Grossman, G. M., & Helpman, E. (1991a). Quality Ladders in the Theory of Growth. *The Review of Economic Studies, 58*(1), 43-61.

Grossman, G. M., & Helpman, E. (1991b). Trade, knowledge spillovers, and growth*. *European Economic Review, 35*, 517-526.

Hansen, L. P. (1982). Generalized instrumental variables estimation of nonlinear rational expectations models. *Econometrica, 50*, 1269–1286.

Hayashi, F. (2000). *Econometrics.* Princeton University Press.

Hu, A. G., & Jaffe, A. (2003). Patent citations and international knowledge flow: the cases of Korea and Taiwan. *International Journal of Industrial Organization, 21*(6), 849-880.

Jaffe, A. (1986). Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits and Market Value. *American Economic Review, 76*, 984-1001.

Keller, W. (1997). Technology Flow Between Industries: Identification and Productivity Effects. *Economic Systems Research, 9*(2), 213-219.

Kleinberg, J. (1999). Authoritative sources in a hyperlinked environment. *Journal of the ACM, 46*, 604-632.

Link, A. (1983). Inter-firm technology flows and productivity growth. *Economics Letters, 11*(1-2), 179-184.

Los, B., & Vespagen, B. (2000). R&D spillovers and productivity: Evidence from U.S. manufacturing microdata. *Empirical Economics*, *25*, 127-148.

Madsen, J. B. (2007). Technology spillover through trade and TFP convergence: 135 years of evidence for the OECD countries. *Journal of International Economics*, *72*, 464–480.

Malerba, F., Mancusi, M., & Montobbio, F. (2013). Innovation, international R&D spillovers and the sectoral heterogeneity of knowledge flows. *Review of World Economics, 149*(4), 697-722.

Neuhäusler, P., Frietsch, R., & Kroll, H. (2019). Probabilistic concordance schemes for the re-assignment of patents to economic sectors and scientific publications to technology fields. *Fraunhofer ISI Discussion Papers Innovation Systems and Policy Analysis*, *60*.

Newman, M. (2010). Networks: an introduction. *Oxford University Press, Oxford*.

Oikawa, K. (2017). Inter-firm Technological Proximity and Knowledge Spillovers. *Public Policy Review, 13*(3).

Piraveenan, M., Chung, K., & Uddin, S. (2006). Assortativity of links in directed networks. *The 2012 International Conference on Foundations of Computer Science.*

Piraveenan, M., Prokopenko, M., & Zomaya, A. (2012). Assortative Mixing in Directed Biological Networks. *TRANSACTIONS ON COMPUTATIONAL BIOLOGY AND BIOINFORMATICS, 9*(1).

Romer, P. (1990). Endogenous Technological Change. *Journal of Political Economy, 98*(5), 71-102.

Scherer, F. M. (1982). Inter-Industry Technology Flows and Productivity Growth. *The Review of Economics and Statistics, 64*(4), 627-634.

Schmidt, P. (1990). Three-stage least squares with different instruments for different equations. *Journal of Econometrics, 43*(3), 389-394.

Solow, R. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics, 70*(1), 65-94.

Soyyiğit, S., & Boz, Ç. (2018). Global Input - Output Analysis: A Network Approach. *Yıldız Socia Science Review*.

Soyyiğit, S., & Çırpıcı, Y. (2018). An Input-Output Network Structure Analysis Of Selected Countries. *Yıldız Social Science Review*.

Terleckyj, N. (1980). Effects of R&D on the productivity growth of industries. In e. John W. Kendrick and Beatrice N. Vaccara. University of Chicago Press.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015), An illustrated user guide to the world input–output database: the case of global automotive production. Review of International Economics, 23, 575–605.

Vespagen, B. (1997). Measuring Intersectoral Technology Spillovers: Esimates from the European and US Patent Office Databases. *Economic Systems Research, 9*(1), 47-65.

Wooldridge, J. (2002). *Econometric Analysis of Cross Section and Panel Data.* Cambridge, Massachusetts, London: The MIT Press.