Productivity Growth and Spillovers across European Industries: A Global Value Chain Perspective Based on EURO KLEMS[1]

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[1] **THE SEVENTH WORLD KLEMS CONFERENCE 2022, October 12-13.**

- Global value chains (GVCs) promote the diffusion of knowledge and technology among the participants in the international production network and accelerate knowledge sharing and vertical specialization.

- These technological spillovers are main drivers of technological progress and the long-term growth of participating countries.

- For our EU/US KLEMS data the intersectoral network corresponding to the world input–output matrix in 2000 and 2014 are in the figure below.

- Each vertex corresponds to a country-specific sector and the edges between nodes represent intermediate flows of both upstream and downstream resources between sectors.

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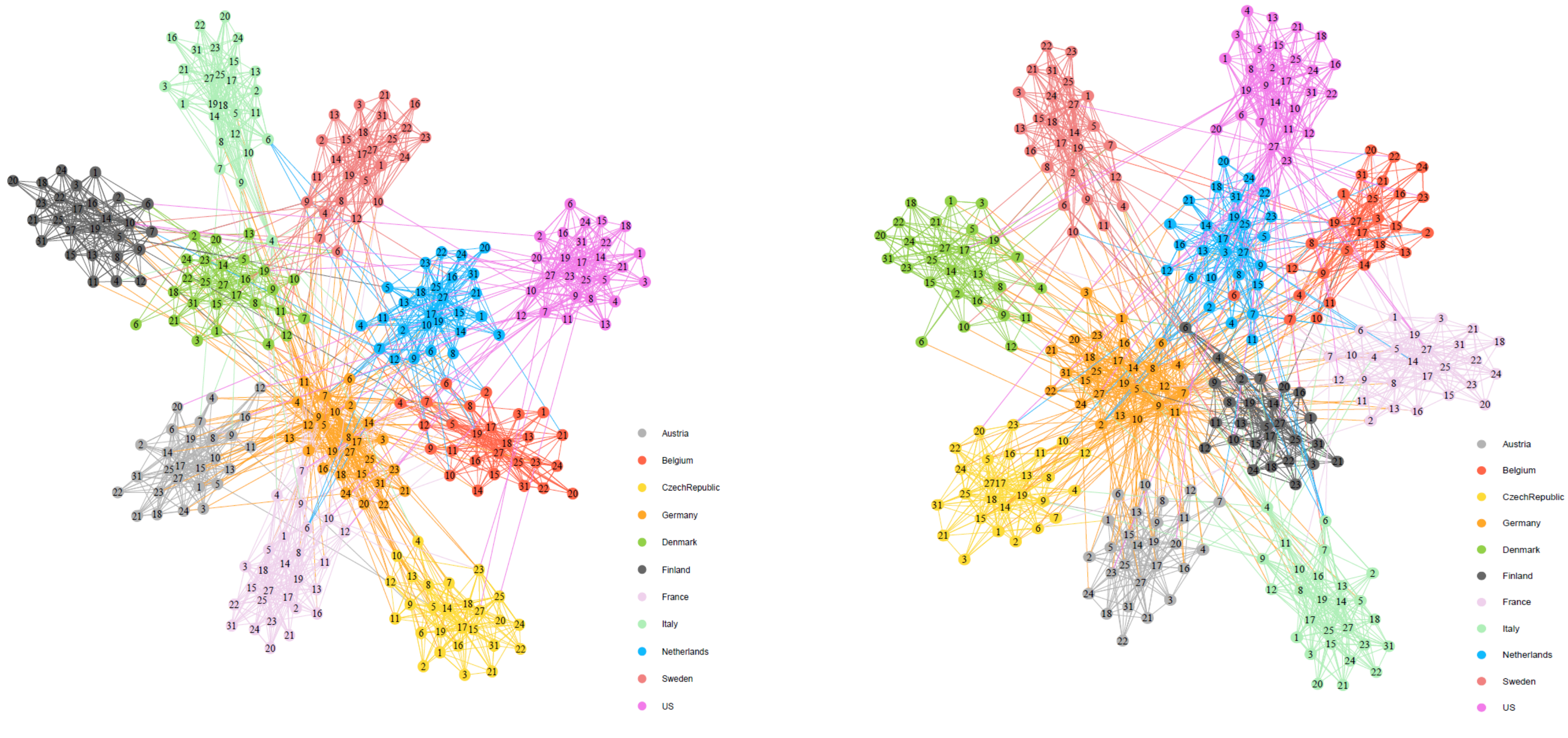

Panel A: Network of EU-10 and the US in 2000

Panel C: Network of EU-10 and the US in 2014

FIGURE 1

Intersectoral network corresponding to the World Input-output tables.

- We construct a spatial production model with technological spillovers and productivity growth heterogeneity at the industry-level.

- We exploit the GVCs' linkages from inter-country input-output tables to describe the spatial interdependencies in technology.

- The spillover effects from capital deepening, intermediate deepening, and technical change are identified using a spatial econometric specification.

- We use industry-level EU KLEMS data for 10 countries and 27 sectors of the economy from 2000 to 2014.

- The spillover effects of intermediate inputs are found to be significantly positive.

- TFP growth in our sample countries falls sharply during the global financial crisis and the Euro Area recession.

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- The estimated international spillovers offered suggest that Germany is the main contributor of international knowledge diffusion.

- Telecommunications industry and Electrical Equipment industry of the EU-10 have the fastest TFP growth over the full sample period from 2000 to 2014.

- These finding provide a better understanding of the impact of spillover effects on TFP growth in the context of GVCs.

- Intermediate deepening in neighbor industries have positive spillover effects.

- There exists a network effect of TFP growth from one country to another through input-output linkages.

MAIN CONTRIBUTION

- By incorporating the spillover effect of production processes, we focus on the impact of the network effect from factor inputs and technology on TFP growth in the context of GVCs.

- We consider the non-linear technology progress which is more consistent with the global trend of slowdown in TFP growth.

- We estimate the network effect of TFP growth for manufacturing sectors of EU countries, based on which we decompose the network effect into a domestic and international component.

- We further investigate the spillover from a more detailed network perspective that distinguish the source and destination of spillover effect by countries.

MODEL

- To account for the technology spillover through the linkage of industries, the effect of cross-sectional dependence should be considered in the production functions.
- We allow each industry to have its own level of technical progress while at the same time allow the industry to absorb knowledge diffusion from its neighbors.
- Productivity growth originating in supplier industries may bring higher quality intermediates.
- Capital deepening in neighboring industries may increase the total capital stock in the society, in which case the economy will accumulate knowledge and bring productivity gains to the industry in question.
- This is in accordance with the Arrow-Romer's physical capital externalities (Arrow,1962; Romer, 1986).

- Similarly, an increase in the intermediate input per worker of its upstream suppliers or downstream customers can promote productivity growth due to a deepening in the division and specialization of the production network (denoted as intermediate deepening).

- This is in accordance with the study on vertical specialization and off-shoring (Grossman and Rossi-Hansberg, 2008; Baldwin and Robert-Nicoud, 2014).

- We allow knowledge diffusion for the *i*th sector to be influenced by the strength of linkage with neighbor-industry j (w_{ij}).

- Productivity growth is then modeled as

$$A_i(t) = \Omega_i(t) \prod_{j \neq i}^{N} A_j(t)^{\rho w_{ij}} \prod_{j \neq i}^{N} k_{jt}^{\phi w_{ij}} \prod_{j \neq i}^{N} m_{jt}^{\varphi w_{ij}}$$

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- and this leads to the per worker production function

$$\ln y = \rho(W \otimes I_T)\ln y + \alpha \ln k + \beta \ln m + \Gamma_0 + \Gamma_1 t + \Gamma_2 t^2 + v$$
$$+ (\phi - \alpha\rho)(W \otimes I_T)\ln k + (\varphi - \beta\rho)(W \otimes I_T)\ln m$$

Technology Spillovers and Spatial Elasticities

- As demonstrated in LeSage and Pace (2009), for spatial models the usual interpretation of α and β as elasticities of input factors is not valid.

- We derive output elasticities for the input factors using the matrix of partial derivatives of output with respect to the corresponding factor.

- Differentiating the reduced-form equation with respect to the time, which we use as a proxy for technical change in this study, we obtain the spillover effects of technical progress.

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Weight Matrix

- We use the inter-industry intermediate flows in the World Input-Output table to construct the spatial weight matrix on an industry level.

- The spatial weight matrix is constructed using the transpose of the input-output matrix and expressed as W_{supply} with elements of $w_{ij}=IO_{ji}$, $\forall j\neq i$, indicating intermediate inputs from industry j to industry i .

- This is consistent with the direction of technology spillovers from upstream industries to downstream industries as discussed in Acemoglu et al. (2012), Acemoglu, Akcigit and Kerr (2016), Autor and Salomons (2018).

- We assume that the productivity spillover is dependent on the share weighted sum of the productivity of a sector's intermediate partners, which is consistent with the seminal work of Coe and Helpman (1995) and row normalize W_{supply} to generate the final normalized spatial weight matrix.

DATA

- We extract the output measures of gross output and input measures of capital service, labor service and intermediate input from the EU KLEMS dataset.

- The sample contains 10 European countries, including Austria, Belgium, the Czech Republic, Germany, Denmark, Finland, France, Italy, the Netherlands and Sweden, and the US.

- We use 2010 as the base year for the countries in our study.

- The inter-country input-output data are drawn from the WIOD database.

- We omitted non-market economy industries, which are mostly local public services that include the Real Estate Activities, Public Administration and Defense, Education, Health and Social Work, Other Community, Social and Personal Services.

EMPIRICAL RESULTS

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- In the next figure 2 we show the TFP growth measured by the own effects for the 10 European countries and the US from 2000 to 2014.

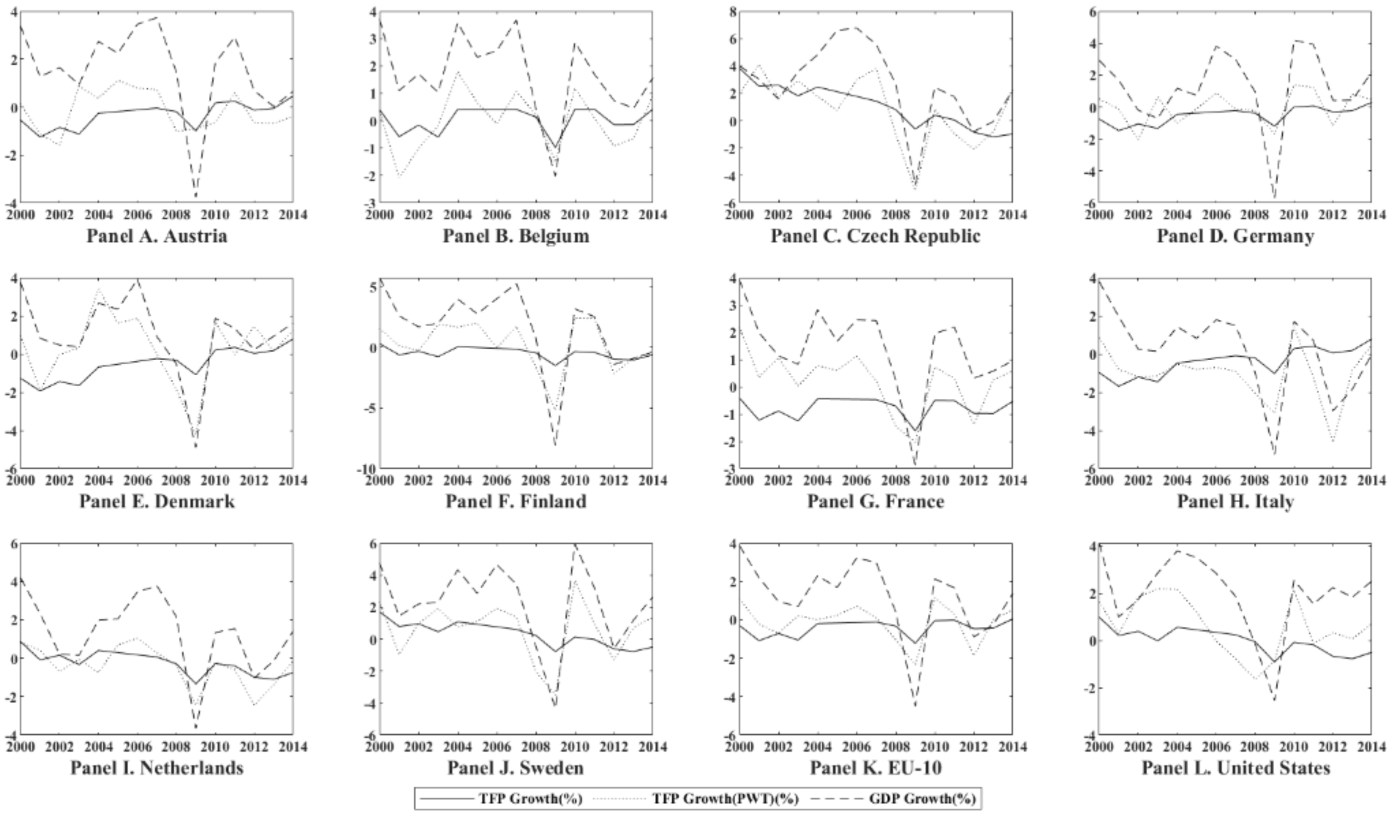

FIGURE 2
Productivity Growth

- The own effect represents the technological growth by the industry itself that mostly comes from the independent innovation or improvement within the industry.

- TFP growth in all of the countries falls sharply in the global financial crisis, and rebounds in 2010, but falls again due to the Euro Area recession.

- The estimates are fairly close to the findings reported by the Penn World Table.

- The trend of TFP growth in these countries is basically consistent with their GDP growth during the 2000-2014 period, but presents a smaller fluctuation.

- The EU-10 (Panel K.) experiences a decrease in TFP growth from -0.29% in 2000 to -1.08% in 2001, gradually recovering to -0.11% in 2007. Then, TFP growth rebounds in 2010 and starts to decline after the Euro Area recession.

- This indicates that the global financial crisis may have long-lasting effects to TFP growth.

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- In the next figure 3 we report the industry TFP growth rate in the EU-10 and the US during three periods: 2000-2007, 2008-2010, and 2011-2014.

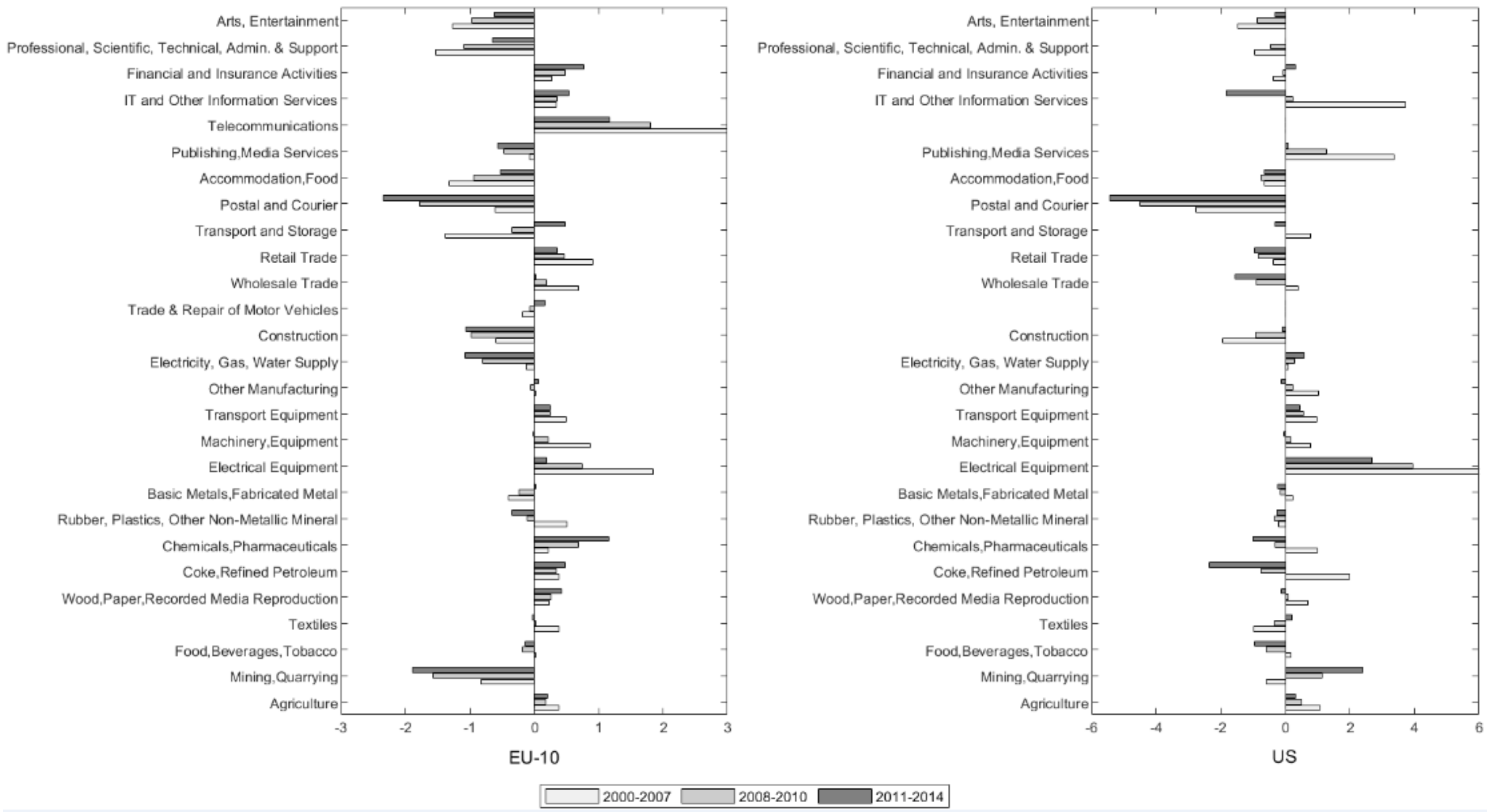

FIGURE 3
Average of industry TFP growth

- The change of TFP growth show less variations in the EU-10 than the US.

- Focusing on the EU-10, the slowdown of TFP growth after the global financial crisis appears to have been widespread and easily visible in several industries. Two exceptions to these trends are the Chemicals & Pharmaceuticals and Transport & Storage industries whose TFP growth after 2008 increase.

- Telecommunications and Electrical Equipment have the fastest TFP growth with an annual average growth of 2.01% and 0.93% over the full sample period from 2000 to 2014.

- Postal & Courier and Mining & Quarrying experience a dramatic decrease in TFP, with the average annual growth from -0.61% and -0.82% to -2.35% and -1.88%, respectively.

- In the next figure 5 we show the aggregate own effect TFP growth superimposed with network effects offered by industries in eleven countries during 2000-2014.

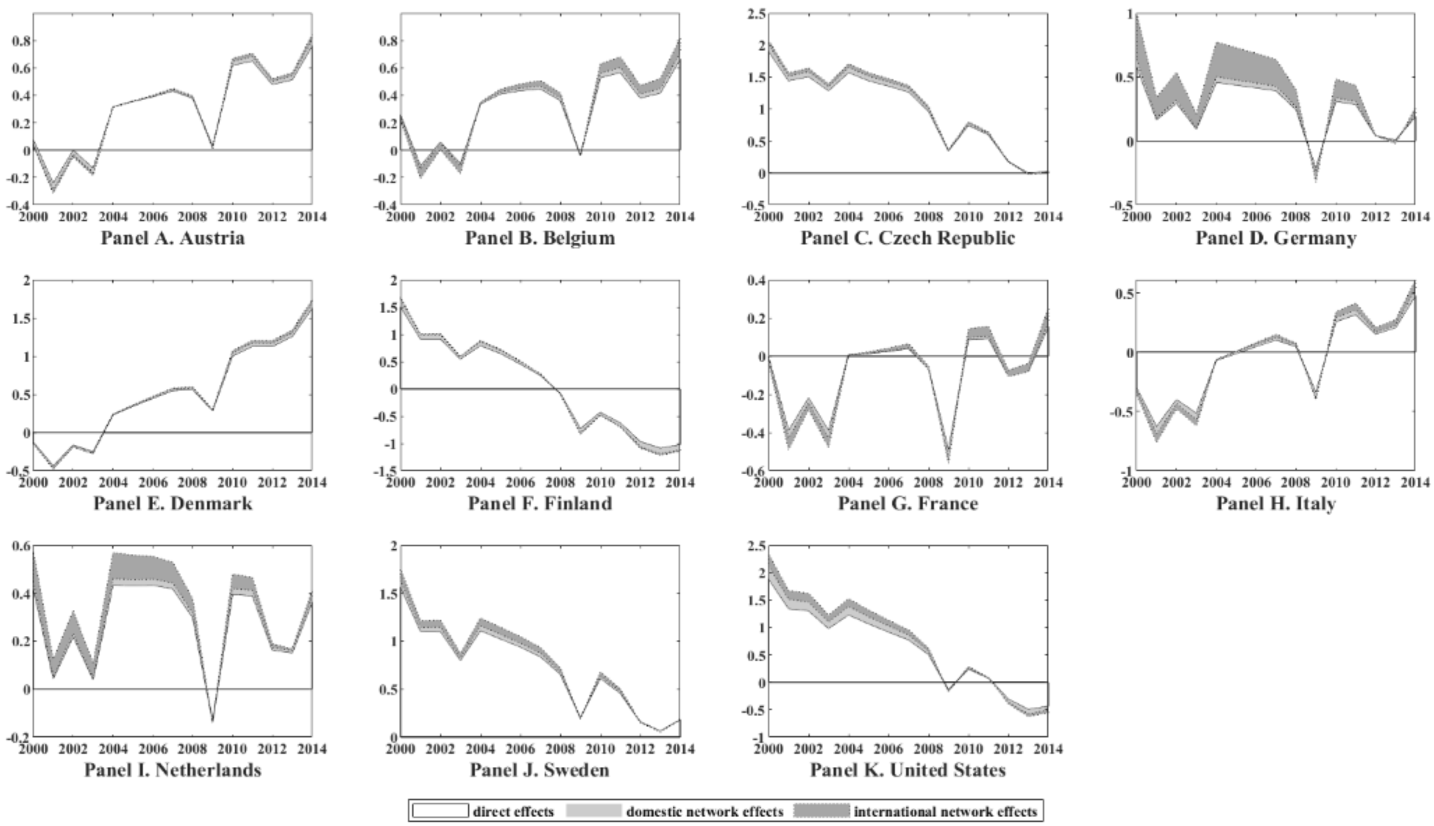

FIGURE 5
Direct and Network Effects of TFP Growth

- The network effects represent the technology spillovers that industries offer through producing intermediate inputs for their user industries.

- In general, the own and network effects of TFP growth vary in the same directions.

- From 2000 through 2014, the trend of overall effects in Austria, Belgium, Denmark, France, and Italy are similar and positive.

- The Czech Republic, Finland, Sweden, Germany, and the Netherlands see declines in the overall effects of manufacturing industry’s TFP growth.

- The annual average network effects for Germany, US, Netherlands, the Czech Republic and Sweden are 1.59‰, 1.32‰, 0.81‰, 0.77‰, and 0.73‰. The other six countries provide a negligible annual average network effect.

- By decomposing the network effects into domestic and international spillovers, we can find that there are more international spillovers in European countries and more domestic spillovers in the US.

- Germany offers the most network effects through international spillovers, with an international network effect of 1.40‰, which constitutes 88.0% of the total spillovers that Germany's industries offer.

- The annual average international spillovers for the US is 1.90‰, which is only 52.6% of the total spillovers in the US.

- In the next figure 6 we show the distribution of network effects of TFP growth between each pair of offering-receiving countries in 2007.

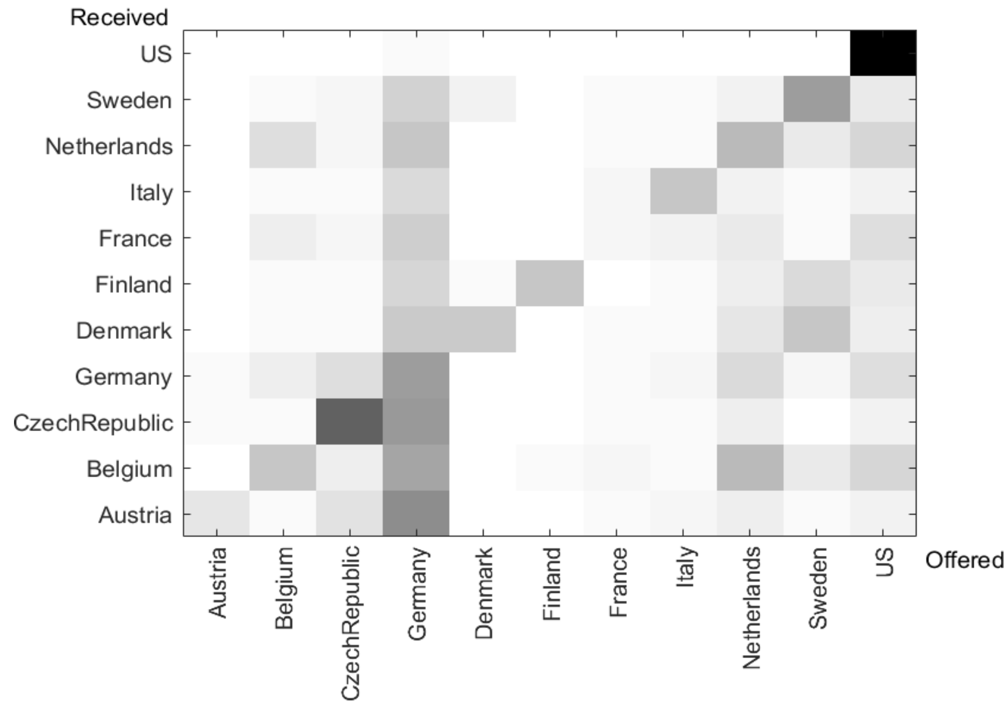

FIGURE 6
Distribution Matrix of Network Effects of TFP Growth among Countries

Notes: each row represents the offering country and each column represents the receiving country. The diagonal blocks of the matrix represent the intra-country spillovers, and the off-diagonal blocks represent the spillover between countries.

- Germany offers the most to other industries in the entire production network (2.45‰), followed by the US (1.78‰), the Netherlands (1.10‰) and the Czech Republic (1.03‰), whereas the rest of countries contribute only limited network effects.

- For almost all countries except Germany, the spillover effects in domestic production networks is higher than the corresponding spillover effects in the bilateral production networks with other countries.

- In the Czech Republic, Denmark and Finland, the domestic network effects account for above 50% of the total network effects, indicating that the TFP growth spillovers are more likely to occur through domestic input–output linkages in these countries.

- In contrast, there are 50% - 86% spillover effects across borders in the United States, Austria, Italy, Sweden, Belgium, the Netherlands, France and Germany.

- Germany contributes the most technology spillovers to other countries, with international network effects of 2.11‰.

- Germany offers TFP growth spillovers of 0.39‰, 0.35‰, and 0.31‰ to Austria, the Czech Republic and Belgium, respectively.

- The spillover the Czech Republic received from Germany is much more than other countries in our sample.

- Our estimates also suggest that the bilateral technology spillovers in Belgium V.S. the Netherlands, and Denmark V.S. Sweden, are relatively higher than other bilateral technology spillovers, which implies that their co-operation in value chains is more successful in promoting each other's TFP growth.

CONCLUSIONS

- The increasingly close value chain cooperation in the European Union over the past several decades has become an important factor to boost the productivity growth for the countries who integrated into these production networks.

- The input-output linkages provide an important channel for the transmission of the technology and productivity spillovers among countries.

- We develop a spatial production model that features technological interdependence and heterogeneous productivity growth at the industry level and use the spatial model to measure TFP growth and spillover in the Europe.

- Our estimation results suggest that intermediate inputs have positive externalities for gross output and that about 27% of the spillover embodied in intermediate input has transmitted across borders.

THANK YOU!