Routledge
Taylor & Francis Group

Economic Research-Ekonomska Istraživanja

ISSN: 1331-677X (Print) 1848-9664 (Online) Journal homepage: https://www.tandfonline.com/loi/rero20

TFP spillover effects via trade and FDI channels

Jacek Pietrucha & Rafał Żelazny

To cite this article: Jacek Pietrucha & Rafał Żelazny (2019): TFP spillover effects via trade and FDI channels, Economic Research-Ekonomska Istraživanja, DOI: 10.1080/1331677X.2019.1629327

To link to this article: https://doi.org/10.1080/1331677X.2019.1629327

Published online: 02 Jul 2019.

ECONOMIC RESEARCH-EKONOMSKA ISTRAŽIVANJA
https://doi.org/10.1080/1331677X.2019.1629327

TFP spillover effects via trade and FDI channels

Jacek Pietrucha and Rafał Żelazny

Department of Economics, University of Economics, Katowice, Poland

ABSTRACT

As a consequence of globalisation, economic growth and productivity have become more sensitive to developments beyond national frontiers. This paper explores trade (import and export) and foreign direct investment (FDI) as channels of international total factor productivity (TFP) spillovers. FDI and trade are potentially important sources of productivity growth; however, empirical literature is inconclusive as to the nature and extent of spillovers and does not simultaneously cover all three channels. Our main goal is to examine the transmission of TFP spillover effects jointly through trade and FDI channels in 41 countries (members of the EU and OECD) during the period 1995–2014. We use dynamic panel estimation strategies. The main findings are: 1) Each of the spillover channels of TFP is significant for TFP when studied separately; 2) Joint examination of all channels allows for concluding that the export channel is the dominant one.

ARTICLE HISTORY
Received 27 December 2017
Accepted 25 March 2019

KEYWORDS
Technical progress; FDI; import; export; TFP

JEL CODES
O11; O33; O50; C23

Introduction

Total factor productivity (TFP) occupies a special place among economic categories that explain sources of economic growth. As noted by McMorrow, Röger, and Turrini (2010), "total factor productivity (TFP) is the main driver of growth in most mature economies, and understanding the determinants of TFP growth is essential in devising policies that help to enhance growth prospects." Solow (2001) also suggested that, "(…) TFP (or its growth rate) should be the left-hand side variable in cross-country analysis of economic performance." Growth of total factor productivity (TFP) provides society with an opportunity to increase the fundamentally based and sound economic growth and hence to long term growth of welfare.

A number of potential factors have been identified which have a statistically significant impact on the TFP level and growth (Danquah, Moral-Benito, & Ouattara, 2014; Isaksson, 2007; Islam, 2008). In key studies, special attention was paid to the channels of spillover effects of technical progress, expressed as TFP or identified via selected proxies for innovation. This is particularly true in the international context (Filippetti, Frenz, & Ietto-Gillies, 2017).

CONTACT Jacek Pietrucha jacek.pietrucha@ue.katowice.pl

Most studies on international technology spillovers have focused on import and foreign direct investments (FDI). Other potential channels have not been explored in great detail. Furthermore, while spillovers take place simultaneously via numerous channels, the existing research focuses almost exclusively on the role of a single channel. Only a few studies have examined two or more channels in parallel.

Export, import, and foreign direct investments (FDI) seem to be the main spillover channels of technical progress across countries (Chang, Chen, & Mcaleer, 2013). In most cases, international spillovers take place in parallel by all channels, which should be taken into consideration when exploring the determinants of TFP. In existing studies, there is a gap in this area as the performed analyses do not simultaneously cover all three channels.

Thus, our research questions are: which channels are used for technology and productivity spillovers, and what is the relative significance of such channels? In our study we would like to test the external effects of productivity growth in one country with respect to productivity in other countries. We wish to expand the existing literature with a joint study of three channels (export, import and FDI) using a new dataset that includes Central and Eastern Europe countries. Thus, the aim of the paper is to jointly examine export, import, and FDI as the channels of international TFP spillovers for 41 developed and upper mid-developed countries (member states of the Organisation for Economic Cooperation and Development (OECD) and European Union (EU) member states which do not belong to the OECD) over the period 1995–2014. We employ dynamic panel estimation strategies, which take into account spillover effects and a relevant set of control variables.

Literature review

Technology spillovers have been the subject of numerous empirical studies. In their seminal paper, Coe and Helpman (1995) studied a sample of 22 advanced countries over the period 1971–1990 and investigated the trade-related channel of international knowledge transmission. To account for this channel, they built import-weighted sums of trade partners' cumulative R&D expenditures as measures of foreign knowledge stocks. They found statistically significant and relatively large values for the trade-related channel.

The paper gave rise to a wide surge of empirical research using diversified economic tools and data sets. The studies were focused on various channels of spillover effects, with special attention paid to the trade channel (more precisely: import) and the FDI channel.

Coe and Helpman's findings were confirmed by Coe, Helpman, and Hoffmaister (2009), wherein the analysis is repeated on an expanded sample of 24 countries over the period 1971–2004. Similar results were obtained when analysing the transfer of technology between highly-industrialised countries and 77 countries belonging to the group of developing countries (Coe, Helpman, & Hoffmaister, 1997). The nexus between the import of capital goods and knowledge transfer was also confirmed by Xu and Wang (1999).

Madsen (2007), using a dataset on import of technology and total factor productivity for OECD countries over 135 years, tried to verify whether knowledge has been internationally transferred through the channel of trade. The research showed that TFP growth is strongly influenced by import of knowledge. Similarly, Madsen (2008) found that international patent stock is highly influential for economic growth and, together with knowledge spillovers through the channel of import, has contributed significantly to TFP growth. Coe et al. (2009) showed that domestic and foreign R&D capital stocks have a measurable impact on TFP, even after controlling for the impact of human capital and institutions. Fracasso and Vittucci Marzetti (2015) found evidence that trade (import) patterns positively affect the international transmission of knowledge, particularly when considering bilateral trade flows.

Export, as the potential channel of external TFP effects, has been included in existing studies to a much slighter degree. Obviously, export is a well-documented determinant of economic growth and growth of productivity. Export sectors usually display greater productivity in relation to sectors with local market production. However, export as a channel of technology and productivity transfer is less intuitively obvious than the channel of import or FDI. This channel has also rarely been investigated in existing empirical studies. In the 1990s, some studies focused on the transfer of knowledge via export (Bernard & Jensen, 1997; Clerides, Lach, & Tybout, 1998). None of these confirmed the dependence between technology transfer and export. Nonetheless, Funk (2001) found strong evidence indicating that exporters receive research spillovers from their customers. It is also necessary to mention the growing literature on 'learning by exporting'. 'Learning by exporting' refers to productivity gains experienced by firms after they start exporting. Such gains are argued to result from increased access to new knowledge and resources (Damijan, Kostevc, & Polanec 2010; Hosono, Miyakawa, & Takizawa, 2015; Manjon-Antolin, Manez, Rochina-Barrachina, & Sanchis-Llopis, 2013). Filippetti et al. (2017) also found support for the 'learning by exporting' hypothesis. By conducted research from a different approach and methodology, these studies supported the argument that export may also constitute an important spillover channel.

As with the import channel, FDI has been the subject of numerous empirical studies. Borensztein, De Gregorio, and Lee (1998) found a positive relationship between inward FDI and technology diffusion. However, foreign investment is found to be more productive than domestic investment only when the host country has a minimum threshold of human capital. Lichtenberg & Van Pottelsberghe de la Potterie (1996) researched the importance of FDI for international technology diffusion in 13 OECD countries with the same R&D weighting approach that Coe and Helpman (1995) used for import. They rejected the hypothesis that inward FDI supports technology transfer. A negative impact was also reported by Chang et al. (2013). Krammer (2010) confirmed that FDI has a significant, yet definitely slighter, impact on the growth of efficiency in developing countries, in the case of which the differences in productivity between domestic and foreign companies are greater. Blomström and Kokko (2011) confirmed that the positive effect of FDI is not automatic but is strongly influenced by a country's absorption capacity. Amann and Virmani (2014) studied the effect of R&D spillovers resulting from outward FDI flows from 18

emerging economies into 34 OECD countries over the period 1990–2010, comparing the impact with that of spillovers resulting from inward FDI flows. The results confirmed that FDI enhances productivity growth; however, the impact is much larger when R&D-intensive developed countries invest in emerging economies rather than the other way around. In a meta-analysis, Demena and van Bergeijk (2017) explored whether FDI actually generates productivity spillovers: they found that the empirical evidence is inconclusive and contradictory. Approximately one-third of the empirical estimates validate a significantly positive effect. Meanwhile, approximately half the spillover estimates are insignificant; one in six finds a significantly negative effect. It is also worth mentioning that the impact of FDI on the economy of CEE countries was extensively discussed (Antanavičienė 2014; Capik & Drahokoupil, 2011; Kornecki & Raghavan, 2011; Kucharčíková, Tokarčíková, Klučka, & Koňusíková, 2015; Makiela & Ouattara 2018; Pietrucha & Żelazny, 2017; Rapacki & Próchniak, 2009; Šabasevičienė & Grybaitė, 2014; Simionescu, Lazányi, Sopková, Dobeś & Balcerzak, 2017; Tsitouras & Nikas, 2016). Most of the studies find a large impact of FDI stock on output growth but mainly for the group of economies that entered the European Union.

In most studies, the role of only one channel of international spillover effects has been tested. Individual papers differ with respect to the adopted methodology and samples; therefore, it is very difficult to draw conclusions about the relative significance of individual channels. Only a few studies make an attempt to show the relative importance of individual channels and results are mixed. Lee (2006) examined the significance of international knowledge spillovers through four different channels: inward FDI, outward FDI, intermediate goods import, and a disembodied direct channel. Using panel data from 16 OECD countries for the period 1981–2000, he found that international knowledge spillovers through inward FDI and the disembodied direct channel are significant and robust. In contrast, outward FDI and import of intermediate goods are not conducive to international knowledge spillovers. Contrary results are reported by Krammer (2010). He studied a panel of 27 emerging economies and 20 developed countries for the period 1990–2006. This study found that import continues to exist as a main channel of diffusion for both groups of countries, while FDI remains a less significant factor for recipients. Chang et al. (2013) examined outward direct investment (ODI), inward direct investment (IDI), cross-border mergers, and acquisitions (M&A) by foreigners, R&D expenditure, exports, and imports. The empirical results showed that increased export and ODI are able to stimulate an increase in approved patents. In contrast, IDI exhibits a negative correlation with domestic patents. Import is shown not to have a significant impact on international technology spillovers.

Recent work by Ali, Cantner, and Roy (2016) considered the relationship between knowledge spillovers from import and inward FDI. They argued that domestic productivity is affected by FDI and import-related spillovers. Filippetti et al. (2017) tested imports, export, outward, and inward foreign direct investment. Their overall findings supported the learning by exporting hypothesis for countries with low absorptive capacity (AC); low-AC countries reap benefits from import; the benefits from knowledge and learning that countries reap from outward FDI increase with the level of AC of a

country; high-AC countries benefit from inward FDI. Pietrucha, Żelazny, Kozłowska, and Sojka (2018) employed dynamic spatial auto-regression (SAR) methods for 41 developed and upper mid-developed countries over the period 1995–2014. They found that both trade (import) and investment channels are important for TFP transfer, but they examined each channel in isolation.

Overall, we can conclude that literature to date, even though diversified in terms of methods and results, presents evidence of the positive and significant spillovers via import and (to a much lesser degree) FDI channels, examined separately. Less attention has been paid to export, and the results in this case are equivocal (even though, which should be emphasised once again, there is well-grounded evidence for the relations between export and productivity in economic theory). While studied rarely, joint examination of channels offers strongly diversified conclusions. Building from the demonstrated gap in existing research, we wish to expand the literature into a joint study of selected channels using a new set of data.

Research methodology & data

The main focus of our study is the examination of international spillover channels of productivity using aggregated data. The basic specification used in this paper follows the general regression model used in other studies that deal with TFP determinants:

$$\mathrm{TFP}_{it} = \alpha + \beta \mathrm{SE}_{it} + \gamma X_{it} + \eta_i + \in_{\mathrm{it}} \tag{1}$$

where TFP represents growth of total factor productivity, SE represents the relevant spillover channel, X represents the vector of macroeconomic control variables, η is a country-specific effect, ϵ is the time-varying error term, and 'i' and 't' represent country and time period, respectively. We examine the dynamic version, where lagged TFP is one of the explanatory variables.

Estimation of equation (1) poses a number of difficulties that need to be addressed. First we assumed that the process is dynamic, i.e., that TFP is determined by previous realisation of TFP. It could be expected that the endogeneity of the lagged dependent variable and the possible endogeneity of other variables is due to measurement error, omitted variables, and/or reverse causality. Difference GMM estimator attributed to Arellano and Bond (1991) and system GMM estimator (Arellano & Bover, 1995) address most of the above issues. Both are general estimators designed for situations with 'small T, large N' panels (a few time periods and many individuals), when one left-hand-side variable is dynamic (depending on its own past realisations), and independent variables are not strictly exogenous (Baltagi, 2013; Roodman, 2009). Blundell and Bond (1998) argue that a difference estimator may not perform well when there is persistence in the dependent variable and demonstrate that the system GMM estimator, initially proposed by Arellano and Bover (1995), may be better suited in terms of asymptotic efficiency. In all estimations, we employ two-step estimation, where the standard covariance matrix is robust to panel-specific autocorrelation and heteroskedasticity. Additionally, we use a finite-sample corrected covariance matrix (Windmeijer, 2005).

Unbiased estimation requires the absence of second-order serial correlation in the error term. To test this requirement, we perform the Arellano-Bond AR(2) test. A sufficiently high p-value implies the absence of second-order autocorrelation. To test whether the system GMM estimator has the correct error structure, we test also for the absence of a higher order autocorrelation using the Arellano-Bond AR(3) and AR (4) test. Failure to reject the null hypothesis (p-value of greater than 0.05) indicates the absence of higher order serial correlation. Secondly, to test the validity of the instruments, we perform the Hansen J-test (Sargan test in case the robust estimation does not apply).

Especially when working with yearly data, we need to avoid instrument proliferation. Having numerous instruments, which usually is the case in GMM estimation, can result in an over-fitting of the model (Roodman, 2009). In this case, Hansen tests may produce unreliable results (e.g., very high p-values, often close to 1). To avoid instrument proliferation, the instrument set should be reduced by either restricting the number of lags or by 'collapsing' the instrument set into a smaller dimension matrix (Roodman, 2009). We have used the 'collapse' option from xtabond2.

TFP data were taken from the Penn World Table version 9.0 – PWT (Feenstra, Inklaar, & Timmer, 2015). There are two basic approaches in studies relating to TFP. First, authors single-handedly calculate total factor productivity (especially in country studies). Secondly, most of the cross-country studies use calculations from existing databases, especially from PWT. PWT is a database with information on relative levels of income, output, input and productivity covering 182 countries between 1950 and 2014.

We examine TFP at constant national prices (2011 = 1) and the TFP level at current PPPs (USA = 1). The first is useful for comparing the growth of productivity over time in each country, and the second is useful for comparing the productivity level across countries in each year. TFP at constant national prices is the independent variable (TFP_{it}), and the TFP level at current PPPs is one of the control variables, which is a proxy of the distance from the technological frontier.

The TFP at constant national prices in PWT is calculated as follows:

$$TFP_{it} = \frac{\frac{GDP_{i,t}}{GDP_{i,t-1}}}{Q^{T}_{i,t,t-1}} \tag{2}$$

where:
TFP_{it} – TFP at constant national prices (2011 = 1); $GDP_{i,t}$ - real GDP at constant 2011 national prices in a given country at a given year; $GDP_{i,t-1}$ - real GDP at constant 2011 national prices in a given country at a previous year; $Q^{T}_{i,t,t-1}$ - Törnqvist quantity index of factor inputs in country '' between 't' and 't-1'time.

$Q^{T}_{i,t,\ t-1}$ is calculated as follows:

$$\begin{aligned} Q^{T}_{i,t} = &\frac{1}{2}(LABSH_{i,t} + LABSH_{i,t-1})\left(\frac{EMP_{i,t}}{EMP_{i,t-1}} x \frac{HC_{i,t}}{HC_{i,t-1}}\right) \\ &+ \left[1 - \frac{1}{2}\ (LABSH_{i,t} + LABSH_{i,t-1})\right]\frac{K_{i,t}}{K_{i,t-1}} \end{aligned} \tag{3}$$

where: $LABSH_{i,t}$ – denotes the share of labour in total factor income in country '' at a given time 't' and 't-1'; $EMP_{i,t}$ – denotes employment in country 'I' at a given time 't' and 't-1'; $HC_{i,t}$ – denotes o measure of human capital in country '' at a given time 't' and 't-1'; $K_{i,t}$ – capital stock at constant 2011 national prices in country '' at a given time 't' and 't-1'.

The TFP level at current PPPs (USA =1) is calculated in a similar way. The difference is that the value of variables in the previous year 't-1' in equations (2) and (3) is replaced by the value of variables for the U.S.A. at a given time 't'. For a more detailed discussion of TFP, see: Feenstra et al. (2015).

Based on Coe and Helpman's (1995) proposal, the externalities in the study were measured with the use of the weighted average of shares of trade partners in the total inflow of FDI, import or export, respectively. It was assumed that the focus of interest is the TFP change of a given country as the result of a change of the weighted average change of the TFP of economic partners. For example, in the case of the FDI as a spillover channel (SE_FDI), the weighted average of TFP of countries that are sources of FDI in the host country is taken into account, in line with an assumption that transfer of technology and know-how may be a result of FDI. As a result, the index of spillover effects transferred via FDI may be shown in the following formula:

$$SE\_FDI_{it} = \sum_{j=1}^{N} w_{jt} TFP_{jt} \tag{4}$$

i - country for which the index is calculated; t - year for which the index is calculated; j - countries which are the sources of FDI; w - weight calculated as the share of FDI from 'j' country in total FDI inflow to 'i' country in a given year.

For import (SE_IMP) and export (SE_EXP), the spillover effect indices were calculated analogously with the use of weights calculated as import or export from/to "'j' country in the total import or export from/to the analysed group of countries. Thus, we want to stress that our measures of spillover channels do not simply mirror the stream of the FDI, export or import. Rather, they reflect to a certain extent the structure of exports, imports, and FDI. Correlation between SE variables and import, export and FDI is very low (between 0.02 and 0.05).

The set of macroeconomic control variables includes relevant variables in line with previous studies (review of studies pertaining to TFP determinants, cf. e.g., Isaksson, 2007). They are:

- Distances from technological frontier (Colino, Benito-Osorio, & Rueda-Armengot, 2014;) – our proxy is the TFP level at current PPPs (USA = 1);
- Human capital (Tientao, Legros, & Pichery, 2016; Tvaronavičienė, Tarkhanova, & Durglishvili, 2018; Vandenbussche, Aghion, & Meghir, 2006) – in our research expressed as mean years of schooling;
- Institutions (Balcerzak & Pietrzak, 2016; Coe et al., 2009; Jantoń-Drozdowska & Majewska, 2015) – in our study, the institutional environment is measured by

Table 1. Variables and data sources.

Abbreviation	Variable	Data source
TFP	TFP at constant national prices (2011 = 1)	Feenstra et al., 2015; available at: www.ggdc.net/pwt
SE_FDI	Spillover effects index for foreign direct investments	Own calculations based on equation (2) and Bilateral FDI Statistics 2014, UNCTAD; available at: http://unctad.org/en/Pages/DIAE/FDI%20Statistics/FDI-Statistics-Bilateral.aspx
SE_IMP	Spillover effects index for import	Own calculations based on equation (2) and Direction of Trade Statistics (DOTS); available at: http://www.imf.org/en/data
SE_EXP	Spillover effects index for import	Own calculations based on equation (2) and Direction of Trade Statistics (DOTS); available at: http://www.imf.org/en/data
TFP_L	TFP level at current PPPs (USA = 1)	Feenstra et al., 2015; available at: www.ggdc.net/pwt
CS	Capital stock at current PPPs	Feenstra et al., 2015; available at: www.ggdc.net/pwt
SCH	Mean years of schooling (years)	Human Development Report 2015, United Nations Development Programme; available at: http://hdr.undp.org/en/data
PS	Political stability and absence of violence/terrorism	Worldwide Governance Indicators, 2016 Update; available at: www.govindicators.org
GE	Government effectiveness	Worldwide Governance Indicators, 2016 Update; available at: www.govindicators.org
R&D	R&D expenditures	World Development Indicators, World Bank; available at: http://databank.worldbank.org/data
PA	Patent applications	World Development Indicators, World Bank; available at: http://databank.worldbank.org/data
EXP	Export of goods and services (% of GDP)	World Development Indicators, World Bank; available at: http://databank.worldbank.org/data
IMP	Import of goods and services (% of GDP)	World Development Indicators, World Bank; available at: http://databank.worldbank.org/data

selected governance indices of the World Bank: government effectiveness and political stability;

- Trade openness (Danquah et al., 2014; Filippetti et al., 2017; Fracasso et al., 2015) – measured with the use of export of goods and services as percentage of GDP, import of goods and services as percentage of GDP;
- Knowledge stock (Coe & Helpman, 1995; Fracasso & Vittucci Marzetti, 2015; Madsen, 2008; Tientao et al., 2016) – measured with the use of patent applications;
- Knowledge investments – measured with the research and development expenditures as percentage of GDP;
- Capital stock – quantified directly as a capital stock at current PPPs.

Considering the above TFP determinants, we have decided on the set of independent variables, including control variables (see Table 1).

Our panel comprises data from 41 developed and upper mid-developed countries over the period 1995–2014. We take into account 35 members of the OECD and six EU states that are not in the OECD: Bulgaria, Croatia, Cyprus, Lithuania, Malta, and Romania. The full list of the countries is presented in Table 2.

Due to the fact that one of the motives for research is inclusion of transition countries from Central and Eastern Europe, the time period is abbreviated. For the majority of these countries, only data from the mid-1990s may be taken into account (some of these countries even did not exist independently before 1990).

Our basic approach is to estimate the dynamic equation using the Arellano and Bond two-step difference GMM estimator (Arellano & Bond, 1991) and five-year

Table 2. List of countries in alphabetical order.

No.	Country
1	Australia
2	Austria
3	Belgium
4	Bulgaria
5	Canada
6	Chile
7	Croatia
8	Cyprus
9	Czech Republic
10	Denmark
11	Estonia
12	Finland
13	France
14	Germany
15	Greece
16	Hungary
17	Iceland
18	Ireland
19	Israel
20	Italy
21	Japan
22	Korea Rep.
23	Latvia
24	Lithuania
25	Luxembourg
26	Malta
27	Mexico
28	Netherlands
29	New Zealand
30	Norway
31	Poland
32	Portugal
33	Romania
34	Slovakia
35	Slovenia
36	Spain
37	Sweden
38	Switzerland
39	Turkey
40	United Kingdom
41	United States

averages. In line with prior work, we employ five-year, non-overlapping averages of the available data, which isolate and remove business cycle effects, focusing on the relationship between each variable and the sources of TFP growth. Unfortunately, in the case of spillover effects via FDI, this causes a significant reduction in the number of periods and, as a consequence, some technical issues that are difficult to eliminate and which are related to the testing of model specification correctness (two-level autocorrelation). Thus, the results pertaining to FDI should be treated with significant caution. As an alternative, a model using annual data was calculated. As in this case persistence of TFP is more visible (i.e., autocorrelation is greater) we changed the estimation technique to system GMM. All models passed the basic tests of model specification correctness (e.g., the Arellano-Bond test for the presence of two-level autocorrelation and the Hansen's over-identifying restrictions tests), verifying the correctness of the selection of the instruments and moments.

Results and discussion

In the first step, each of the spillover channels was examined separately (models I, II and III in Table 3). We start with examination of separate channels due to the fact that we would like to obtain consistency with previous studies (that researched all channels in isolation). Both the FDI and the trade channels (export and import) show a statistically significant, positive impact on the TFP growth. Thus, each of the trade partner spillover channels of the TFP constitutes a determinant of TFP growth, when researched in isolation. These results give new evidence to support the dominant view in previous studies (in the case of FDI and import) and provide evidence for important role of the export channel.

Nevertheless, a joint analysis of the spillover channels offers distinctive and quite surprising results when compared to existing literature. A joint examination of spillover channels, taking the export channel into account, significantly changes the conclusions obtained for channels examined in isolation. In the case of the three channels (model IV), only the export channel is statistically significant while variables describing the roles of the remaining channels become insignificant. This should be

Table 3. Results.

	model						
variable	I	II	III	IV	V	VI	VII
lagged TFP	0.274**	0.255**	0.077	0.058	0.449***	0.367***	0.447***
	(0.117)	(0.126)	(0.130)	(0.114)	0.064	0.062	(0.060)
TFP_L	0.168	0.212	0.393***	0.169	−0.035	−0.077	−0.051
	(0.120)	(0.141)	(0.150)	(0.158)	0.051	0.052	(0.051)
IMP	0.001	0.002	0.001	−0.000	−0.001	−0.002*	−0.001*
	(0.002)	(0.003)	(0.001)	(0.001)	0.0001	0.001	.0001
EXP	0.000	0.000	0.002	0.002	0.001	0.001*	0.001*
	(0.001)	(0.001)	(0.003)	(0.001)	0.001	0.001	0.001
PA	0.000	0.000	0.000	0.000	0,000	0,000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	0,000	0,000	(0.000)
SCH	−0.014	−0.015	0.013	−0.017	−0.002	−0.003	−0.003
	(0.010)	(0.009)	(0.018)	(0.014)	0.003	0.002	(0.002)
GE	0.032	0.034	0.026	0.018	0.020**	0.019**	0.016*
	(0.039)	(0.040)	(0.037)	(0.032)	0.009	0.008	(0.009)
PS	0.051**	0.050**	0.070*	0.061*	−0.002	0.002	0.001
	(0.022)	(0.021)	(0.040)	(0.036)	0.004	.0040	(0.004)
CS	0.000	0.001*	0.000	0.000	0,000	0,000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0,000)	0,000	(0.000)
R&D	−0.018	−0.017	−0.018	−0.001	0.007	−0.005	−0.006
	(0.013)	(0.014)	(0.019)	(0.013)	(0.005)	0.004	(0.004)
SE_EXP	0.960***			1.675***		1.825***	
	(0.242)			(0.527)		0.651	
SE_IMP		0.938***		−0.683		−0.477	
		(0.282)		(0.951)		0.694	
SE_FDI			1.280***	0.462	0.830***	−0.177	
			(0.327)	(0.596)	0.150	0.198	
SE-TOTAL							0.384***
							0.041
AR(2) p-value	0.940	0.968	–	–	0.138	0.125	0.148
Hansen test p-value	0.151	0.228	0.257	0.501	0.334	0.740	0.471
number of instruments	24	24	21	21	45	47	45
N	119	119	77	77	451	451	451

Robust standard errors are reported in parentheses. Significant coefficients are denoted with stars (* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$). AR(2) contain the results of the Arellano-Bond autocorrelation test in first differences.
Source: own calculations.

interpreted as that the export channel is the most important channel for productivity transfer.

In the case of FDI, as mentioned above, there are technical issues when estimating the model using five-year, non-overlapping averages. We re-estimated the models using annual data and the system GMM. This has an obvious negative consequence. Data are dominated by short-term fluctuations, e.g., related to the business cycle. Nevertheless, the results in Table 3 and conclusions are similar to the previous ones. Also, in this case, the FDI channel examined separately show a positive impact on TFP (model V). However, joint examination of the three channels allows for concluding that the export channel is the dominant one (model VI). The total effect of three channels (calculated as a product from SE_IMP, SE_EXP and SE_FDI) is positive for productivity (model VII). The study also found that direction of trade matter, i.e., larger learning (and spillover) effects comes from trade with advanced economies.

Our estimations are relatively robust with regard to instruments choice. Other sets of instruments give similar results for all SE variables. In addition, various sets of control variables from Table 1 were tested but there are no basic differences in conclusions.

It is also necessary to draw attention to certain results concerning control variables (even though this is not the main area of interest of the article). TFP is determined by lagged TFP and spillover effects, and only institutional variables (government effectiveness or political stability) are significant. Proxy variables for human capital do not show any significance. This result is not surprising with respect to some of the existing studies (Balta & Mohl, 2013). However, it should be mentioned that results for control variables are strongly dependent on the chosen instruments.

Nevertheless, the most interesting and well-confirmed effect of our study is the dominant role of the spillovers via the export channel. The link between innovation and export is well known but most of the research assumes (which is not always directly tested) direction of causality that goes from innovation to export (Wagner 2007; 2012). Our view (based on macro data) is rather close to the learning by exporting hypothesis, i.e., causality running from export to innovation. The literature on learning by exporting is mostly based on micro data and research consequences of exporting for innovation on a micro level.

The mechanism of boosting productivity via export to countries with higher productivity is relatively easy to explain on the narrative level. Exporters can often access diverse knowledge not available in the domestic market. This includes, for example, contact with the requirements of a competitive market in countries with higher productivity. When entering such a market, firms have to adequately adjust to it. Subsequently, by being present there, they receive feedback from their clients, which may also have a pro-efficiency effect. Exporting firms may also receive technical assistance from overseas buyers. The buyer has incentives to transmit knowledge to the supplier, even if that technology diffuses to other sellers and thereby benefits other buyers (Blalock & Gertler, 2004). Moreover, exporters encounter international best practice and can acquire tacit knowledge. In order to provide competitive goods, they have to gain and use tacit and proprietary knowledge from market trendsetters.

It is also likely that a synergy effect will emerge if trading partners have additional knowledge.

As a consequence, at least in export-focused industries, productivity increases but the above identified potential positive externalities for exporters could be used by other exporters and non-exporters. Knowledge flows to co-operators in the domestic market. Acquisition and implementation of a specific technology by one exporter reduces also adaptation costs to the others. Implementation of new organisational methods aimed at a foreign partner may benefit other sectors. As noted by López (2005), "(…) exports may cause positive externalities and technological spillovers within the exporting sector and on non-exporter sectors."

Mion and Opromolla (2014), Fernandes and Tang (2014), Mion, Opromolla, and Sforza (2016), Kamal and Sundaram (2016) document such diffusion. For example, Mion et al. (2016) find that the export experience gained by managers in their previous firms leads their current firm towards higher export performance. Fernandes and Tang (2014) study how learning from neighbouring firms affects new exporters' performance. As a result, the total factor productivity growth will increase across the whole economy. Of course, one can expect differences in the size of spillover effects between sectors – for example, a higher TFP growth rate in the export manufacturing sector than in locally oriented services.

This last finding is compliant with the well-grounded economic theory that export industries show higher productivity. Of course, other potential mechanisms could explain higher productivity of exporting firms – for example, existence of self-selection of the more productive firms into export markets (because of additional cost of selling goods in foreign markets). In this case, exporting is a result of a productivity increase rather than a cause (Blalock & Gertler, 2004). Innovation/productivity and export nexus need further in-depth research.

There is some evidence based on micro data supporting learning by exporting. For example, de Loecker (2007) finds (based on Slovenian micro data) that export entrants become more productive once they start exporting. Salomon and Shaver (2005) find that exporting is associated with innovation in a sample of Spanish manufacturing firms. Benkovskis, Masso, Tkacevs, Vahter, and Yashiro (2017) provide evidence that Latvian and Estonian firms respectively realise more than 23% and 14% higher labour productivity levels as the result of export entry. Furthermore, de Loecker (2007) finds larger learning effects in firms exporting to advanced economies. Benkoviskis et al. (2017) show that gains in productivity and employment are particularly large when firms enter export markets that are related to participation in knowledge-intensive activities found in the upstream of Global Value Chains. Our macro data results are consistent with above micro data studies.

In summary, the presented studies show that the export channel is (in the examined group of countries – limitations below) a more important mechanism than learning via import and import of knowledge via FDI. Total effect of three channels is positive for productivity. Moreover, for spillovers, the level of economic and technological development of trading partners matters.

The presented results are encumbered by certain limitations that may influence the interpretation.

1. Our study deals with a group of OECD and EU countries, i.e., relatively well-developed countries, in the categories of GDP per capita, technology, and institutions. The examined group also includes the former transition countries (and currently members of the EU). They - in global categories - even though some distance to the leaders is still present - also belong to relatively well-developed countries. As a result, spillover channels typical for countries with a lower level of development may be underestimated in the study.
2. The requirements of including a broad group of OECD and EU countries mean that the time period of the study is greatly restricted (some countries did not even exist before 1990). This is particularly shortened in the case of FDI. As a result, the final confirmation of results would require further studies on different data sets. In the case of interpreting the results for FDI, it is worth noting one more limitation. Data often do not show the actual country of origin of capital but the country where its' "re-packaging" took place on account of tax or legal issues (e.g., Cyprus).
3. The significance of the export channel with respect to other channels should not be misinterpreted. Export, import, and FDI may be seen through the perspective of their inter-dependence - which is, however, out of the scope of our research. It should be once more mentioned that our variables SE (SE_EXP, SE_IMP, SE_FDI) did not reflect size of the export, import, or FDI and should not be interpreted as a mirror of the size of trade relation or capital flows. The links between size of exports, imports, and FDI were outside the scope of the research and we want to emphasise it clearly to avoid misinterpretation. Our variables reflect to a certain extent the structure of exports, imports, and FDI - however, there are no essential links between, for example, the direction of import and direction of export. In relation to this, the presented results should not be interpreted in a manner that internationalisation may exclusively take place via export. Both from the point of view of individual countries and globally, it is impossible to obtain effects on the side of productivity exclusively via export with limited import and capital flows.

Conclusions

The article presents a joint study of three potential international TFP spillover channels: export, import and FDI, on panel data for 41 countries between 1995 and 2014. Such an approach is novel, due to the fact that the determinants of TFP spillover effects present in previous studies are not examined jointly, but the channels of their dissemination are analysed individually or in a group of import - FDI. We use three indexes of international spillover effects: index for import (SE_IMP), index for export (SE_EXP), and index for inward foreign direct investments (SE_FDI). They reflect channels of the international productivity spillover effects. Additionally, to take account of diversity between countries, a set of control variables was used.

We present evidence that the spillover channel that is the most important with respect to statistical significance in the group of analysed countries is the export channel. This channel dominates the others. Such a conclusion is, to the best our

knowledge, novel compared to previous studies on international spillover effects as the determinant of TFP. Another conclusion from our research is that direction of trade matters, i.e., larger learning effects come from trade with advanced economies.

There are some policy implications for exploiting of productivity spillover effects via the export channel

- ensuring institutional environment that affects firms to engage in export and will enable learning by exporting;
- promoting export activities;
- reducing or eliminating trade barriers;
- creating conditions for the dissemination of gained external knowledge within the internal market.

Acknowledgements

We thank Dr Jan Acedański as well as participants at the conference Global Economy and Governance - Challenges in a Turbulent Era (GEG 2017) where the earlier version of the paper was presented for many helpful comments and discussion.

Disclosure Statement

No potential conflict of interest was reported by the author.

ORCID

Jacek Pietrucha http://orcid.org/0000-0001-5777-9666
Rafał Żelazny http://orcid.org/0000-0002-4710-3483

References

Ali, M., Cantner, U., & Roy, I. (2016). Knowledge spillovers through FDI and trade: the moderating role of quality-adjusted human capital. *Journal of Evolutionary Economics*, *26*(4), 837–868. doi:10.1007/s00191-016-0462-8

Amann, E., & Virmani, S. (2014). Foreign direct investment and reverse technology spillovers: The effect. *Oecd Journal: Economic Studies*, *2014*(1), 129–153. doi:10.1787/eco_studies-2014-5jxx56vcxn0n

Antanavičienė, J. (2014). Foreign direct investment: driving factors and outcomes for secure and sustainable development. *Journal of Security and Sustainability Issues*, *3*(3), 55–67. doi:10.9770/jssi.2014.3.3(5)

Arellano, M., & Bond, S. R. (1991). Some tests of specification for panel data: monte carlo evidence and an application to employment equations. *Review of Economic Studies*, *58*(2), 277–297. doi:10.2307/2297968

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components model. *Journal of Econometrics*, *68*(1), 29–51. doi:10.1016/0304-4076(94)01642-D

Balcerzak, A., & Pietrzak, M. (2016). Quality of institutions and total factor productivity in the European Union. *Statistics in Transition New Series*, *17*(3), 497–514.

Balta, N., & Mohl, P. (2013). The drivers of total factor productivity in catching-up economies. *Quarterly Report on the Euro Area*, *13*(1), 7–19.

Baltagi, B. (2013). *Econometric analysis of panel data*. Chichester. John Willey & Sons Ltd.

Benkovskis, K., Masso, J., Tkacevs, O., Vahter, P., & Yashiro, N. (2017). Export and productivity in global value chains: Comparative evidence from Latvia and Estonia (Working Paper No. 1448). Paris: OECD Economics Department.

Bernard, A., & Jensen, J. B. (1997). Exceptional *exporter performance*: Cause, *effect, or both* (Working Paper No. 6272). Cambridge: National Bureau of Economic Research.

Blalock, G., & Gertler, P. J. (2004). Learning from exporting revisited in a less developed setting. *Journal of Development Economics*, *75*, 397–416. doi:10.1016/j.jdeveco.2004.06.004

Blomström, M., &., & Kokko, A. (2011). Foreign direct investment and spillovers of technology. *International Journal of Technology Management*, *22*(5–6), 435–454. doi:10.1504/IJTM.2001.002972

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, *87*(1), 115–143. doi:10.1016/S0304-4076(98)00009-8

Borensztein, E., De Gregorio, J., & Lee, J.-W. (1998). How does foreign direct investment affect economic growth? *Journal of International Economics*, *45*(1), 115–135. doi:10.1016/S0022-1996(97)00033-0

Capik, P., & Drahokoupil, J. (2011). Foreign direct investments in business services: Transforming the Visegrád four region into a knowledge-based economy? *European Planning Studies*, *19*(9), 1611–1163.

Chang, C., Chen, S., & Mcaleer, M. (2013). Globalization and knowledge spillover: international direct investment, exports and patents. *Economics of Innovation and New Technology*, *22*(4), 329–352.

Clerides, S., Lach, S., & Tybout, J. (1998). Is learning-by-exporting important? Micro-dynamic evidence from Colombia, Mexico and Morocco. *Quarterly Journal of Economics*, *454*(3), 903–947.

Coe, D. T., Helpman, E., & Hoffmaister, A. W. (2009). International R&D spillovers and institutions. *European Economic Review*, *53*(7), 723–741.

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

Coe, D. T., Helpman, E., & Hoffmaister, A. W. (1997). North-South R&D spillovers. *The Economic Journal*, *107*(44), 134–149.

Colino, A., Benito-Osorio, D., & Rueda-Armengot, C. (2014). Entrepreneurship culture, total factor productivity growth and technical progress: Patterns of convergence towards the technological frontier. *Technological Forecasting & Social Change*, *88*, 349–359.

Damijan, J. P., Kostevc, C., & Polanec, S. (2010). From innovation to exporting or vice versa? *World Economy*, *33*(3), 374–398. doi:10.1111/j.1467-9701.2010.01260.x

Danquah, M., Moral-Benito, E., & Ouattara, B. (2014). TFP growth and its determinants: a model averaging approach. *Empirical Economics*, *47*(1), 227–251. doi:10.1007/s00181-013-0737-y

Demena, B. A., & van Bergeijk, P. A. G. (2017). A meta-analysis of FDI and productivity spillovers in developing countries. *Journal of Economic Surveys*, *31*(2), 546–571. doi:10.1111/joes.12146

Feenstra, R. C., Inklaar, R., & Timmer, M. P. (2015). The next generation of the Penn World table. *American Economic Review*, *105*(10), 3150–3182. doi:10.1257/aer.20130954

Fernandes, A. P., & Tang, H. (2014). Learning to export from neighbors. *Journal of International Economics*, *94*(1), 67–84. doi:10.1016/j.jinteco.2014.06.003

Filippetti, A., Frenz, M., & Ietto-Gillies, G. (2017). The impact of internationalization on innovation at countries' level: the role of absorptive capacity. *Cambridge Journal of Economics*, *41*(2), 413–439.

Fracasso, A., & Vittucci Marzetti, G. (2015). International trade and R&D spillovers. *Journal of International Economics*, *96*(1), 138–149.

Funk, M. (2001). Trade and international R&D spillovers among OECD countries. *Southern Economic Journal*, *67*(3), 725–736.

Hosono, K., Miyakawa, D., & Takizawa, M. (2015). Learning by export: Does the presence of foreign affiliate companies matter? (Discussion Paper No. 15-E-053). Tokyo: RIETI.

Isaksson, A. (2007). Determinants of total factor productivity: a literature review (Staff Working Paper 02). Vienna: United Nations Industrial Development Organization.
Islam, N. (2008). Determinants of productivity across countries: An exploratory analysis. *The Journal of Developing Areas*, *42*(1), 201–242.
Jantoń-Drozdowska, E., & Majewska, M. (2015). Social capital as a key driver of productivity growth of the economy: Across-countries comparison. *Equilibrium*, *10*(4), 61–83. doi:10.12775/EQUIL.2015.035
Kamal, F., & Sundaram, A. (2016). Buyer–seller relationships in international trade: Do your neighbors matter? *Journal of International Economics*, *102*, 128–140. doi:10.1016/j.jinteco.2016.07.006
Kornecki, L., & Raghavan, V. (2011). Inward FDI stock and growth in Central and Eastern Europe. *The International Trade Journal*, *25*(5), 539–557. doi:10.1080/08853908.2011.604297
Krammer, S. M. S. (2010). International R&D spillovers in emerging markets: The impact of trade and foreign direct investment. *Journal of International Trade and Economic Development*, *19*(4), 591–623.
Kucharčíková, A., Tokarčíková, E., Klučka, J., & Koňusíková, L. (2015). Foreign direct investment: impact on sustainable development in regions of Slovak Republic. *Journal of Security and Sustainability Issues*, *5*(1), 59–71. doi:10.9770/jssi.2015.5.1(5)
Lee, G. (2006). The effectiveness of international knowledge spillover channels. *European Economic Review*, *50*(8), 2075–2088. doi:10.1016/j.euroecorev.2005.10.001
Lichtenberg, F., & Van Pottelsberghe de la Potterie, B. (1996). International R&D Spillovers: A Re-examination (Research Working Paper No. 5668). Cambridge: National Bureau of Economic Research.
Loecker, J. (2007). Do exports generate higher productivity? Evidence from Slovenia. *Journal of International Economics*, *73*(1), 69–98.
López, R. A. (2005). Trade and growth: reconciling the macroeconomic and microeconomic evidence. *Journal of Economic Surveys*, *19*(4), 623–648.
Makiela, K., & Ouattara, B. (2018). Foreign direct investment and economic growth: Exploring the transmission channels. *Economic Modelling*, *72*, 296–305. doi:10.1016/j.econmod.2018.02.007
Madsen, J. B. (2007). Technology spillover through trade and TFP convergence: 135 years of evidence for the OECD countries. *Journal of International Economics*, *72*(2), 464–480. doi:10.1016/j.jinteco.2006.12.001
Madsen, J. B. (2008). Economic growth, TFP convergence and the world export of ideas: A century of evidence. *Scandinavian Journal of Economics*, *110*(1), 145–167. doi:10.1111/j.1467-9442.2008.00530.x
Manjon-Antolin, M., Manez, J. A., Rochina-Barrachina, M. E., & Sanchis-Llopis, J. A. (2013). Reconsidering learning by exporting. *Review of World Economy*, *149*(1), 5–22.
McMorrow, K., Röger, W., & Turrini, A. (2010). Determinants of TFP growth: A close look at industries driving the EU–US TFP gap. *Structural Change and Economic Dynamics*, *21*(3), 165–180. doi:10.1016/j.strueco.2010.03.001
Mion, G., & Opromolla, L. D. (2014). Managers' mobility, trade performance, and wages. *Journal of International Economics*, *94*(1), 85–101. doi:10.1016/j.jinteco.2014.06.001
Mion, G., Opromolla, L. D., & Sforza, A. (2016). The diffusion of knowledge via managers' mobility (CEPR Discussion paper 11706). London: Centre for Economic Policy Research.
Pietrucha, J., & Żelazny, R. (2017). Interdependence of innovations and institutions: consequences for GDP growth. *Ekonomista*, *13*, 527–543.
Pietrucha, J., Żelazny, R., Kozłowska, M., & Sojka, O. (2018). Import and FDI as channels of international TFP spillovers. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *13*(1), 55–72.
Rapacki, R., & Próchniak, M. (2009). The EU enlargement and economic growth in the CEE new member countries (Economic Paper No. 367). Brussels: European Commission.

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal: Promoting Communications on Statistics and Stata*, *9*(1), 86–136. doi:10.1177/1536867X0900900106

Salomon, R. M., & Shaver, J. M. (2005). Learning by exporting: new insights from examining firm innovation. *Journal of Economics Management Strategy*, *14*(2), 431–460. doi:10.1111/j.1530-9134.2005.00047.x

Solow, R. M. (2001). Applying Growth Theory across Countries. *The World Bank Economic Review*, *15*(2), 283–288. doi:10.1093/wber/15.2.283

Šabasevičienė, V., & Grybaitė, V. (2014). Main foreign direct investments factors as precondition of sustainable entrepreneurship: evidence from Lithuania, Central and Eastern Europe. *Entrepreneurship and Sustainability Issues*, *1*(4), 230–238. doi:10.9770/jesi.2014.1.4(5)

Simionescu, M., Lazányi, K., Sopková, G., Dobeš, K., & Balcerzak, A. P. (2017). Determinants of economic growth in V4 countries and Romania. *Journal of Competitiveness*, *(9)*(1), 103–116. doi:10.7441/joc.2017.01.07

Tientao, A., Legros, D., & Pichery, M. C. (2016). Technology spillover and TFP growth: A spatial Durbin model. *International Economics*, *145*, 21–31. doi:10.1016/j.inteco.2015.04.004

Tsitouras, A., & Nikas, C. (2016). The Dynamic Links Between Exports, Foreign Direct Investment, and Economic Growth: Evidence from European Transition Economies. *Journal of East-West Business*, *22*(3), 198–235. doi:10.1080/10669868.2016.1180658

Tvaronavičienė, M., Tarkhanova, E., & Durglishvili, N. (2018). Sustainable economic growth and innovative development of educational systems. *Journal of International Studies*, *11*(1), 248–256. doi:10.14254/2071-8330.2018/11-1/19

Vandenbussche, J., Aghion, P., & Meghir, C. (2006). Growth, distance to frontier and composition of human capital. *Journal of Economic Growth*, *11*(2), 97–127.

Wagner, J. (2007). Exports and productivity: a survey of the evidence from firm-level data. *The World Economy*, *30*(1), 60–82. doi:10.1111/j.1467-9701.2007.00872.x

Wagner, J. (2012). International trade and firm performance: a survey of empirical studies since 2006. *Review of World Economics*, *148*(2), 235–267. doi:10.1007/s10290-011-0116-8

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, *126*(1), 25–51. doi:10.1016/j.jeconom.2004.02.005

Xu, B., & Wang, J. (1999). Capital Goods Trade and R&D Spillovers in the OECD. *Canadian Journal of Economics*, *32*(5), 1258–1274.