Import-based technology shocks. Evidence from Poland

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Abstract

From the perspective of a less developed country most innovations occur abroad. To capitalize on technological progress such country must obtain innovations. International trade is one of the major channels for technology transfer. It may significantly contribute to productivity growth by providing products and services that embody new technology which would otherwise be unavailable or too costly to acquire. In the case of a less developed country import-based technology transfer may cause a so-called technology shock.

International trade as a channel of technology diffusion has received much study recently. Researchers share an opinion that it transmits a significant amount of knowledge, but their quantitative estimates differ across countries. We check the importance of foreign technology spillovers to Poland by testing indicators able to capture and measure technology shocks that stem from import of intermediate inputs. Of particular interest are indices of import penetration combined with price-to-weight ratio. We employ these measures in a VAR model which we Granger-test for causality. The results show that foreign technology spillovers embodied in capital goods trade have a positive effect on Polish TFP. The effects are stronger in more innovative sectors.

The empirical findings offer interesting implication for innovation policy in less developed countries, which is the modernization of equipment through acquisition of imported machinery.

Key Words: international trade, technology diffusion, productivity, Granger causality test

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1. Introduction

A technology shock is defined as a leap in total factor productivity (TFP), that results from innovation. The technology shock begins with the introduction of a new solution (of the nature of a product or process change) by a technology leader, followed by its diffusion, namely the use (adoption) of that solution by other firms. In the case of countries which are economically and technologically less developed, with significant deficiencies in both the accumulation of capital and the qualifications of workers, it may be extremely difficult – or simply impossible – for those countries to initiate a technology shock themselves. In this situation, many of them obtain technical knowledge from abroad. The effectiveness of such action is confirmed by even a superficial analysis of statistics relating to productivity, which has a much more uniform distribution among countries than innovation does. While research and development are concentrated in a small number of countries, the benefits gained from them are felt all over the world, which proves the great importance of the diffusion of technical knowledge across national borders in the course of a technology shock.

In recent years many detailed studies have been made of the connection between levels of economic openness and productivity. From a theoretical standpoint, it is possible to indicate the following channels by which liberalization has a positive influence on productivity:

- scale effects (visible in relation both to production and to research and development), brought about due to increase in market size (Helpman and Krugman, 1985; Eaton and Kortum, 2006);
- intensified competition, forcing firms to improve their cost-effectiveness, and forcing those which are highly inefficient out of the market (Melitz and Ottaviano, 2008);
- easier access to foreign technology in the form of imported intermediate inputs (Grossman and Helpman, 1991, Barro and Sala-i-Martin, 2004);
- movement of some technologically advanced production to less developed countries, while in developed countries the resources of the highly qualified labour force are concentrated on producing goods with the highest level of innovation, leading to dynamic economic growth in both groups of countries (Krugman, 1979).

Intensive empirical research is being carried out in all of the areas mentioned. One line of research concentrates on the diffusion of technology embodied in imported products. Coe and Helpman (1995) estimated that the return on investment in research and development in the G7 countries is an additional 30% higher (compared with domestic rates of return) as a result of increased TFP abroad. The transfer of embodied technical knowledge proved to be negatively correlated with a country's size and level of development. In small countries, the impact of foreign technical knowledge on TFP was markedly greater than that of domestic knowledge. Similarly, Keller (2000, 2002) showed that, although the positive influence on productivity decreases as the distance between innovator and imitator increases, the significance of the distance factor has been consistently declining over the past three decades. It can therefore be concluded that foreign research and development activity is constantly growing in importance relative to domestic R&D. The diffusion of technology via the trade channel becomes more intense as a greater proportion of total imports is accounted for by imports from a specific technology leader. Xu and Wang (2000) consider only capital goods in their studies, instead of total imports of manufactures, obtaining markedly better indicators of model fit. Their results also confirm the significant positive impact of foreign technical knowledge, embodied in the form of imported capital goods, on domestic TFP.

The second line of research focuses on foreign direct investment (FDI) as a channel of diffusion of technical knowledge. Although theoretically FDI is undertaken in order to retain control over a production technology which is specific to the firm, which suggests the possibility of a spill-over effect in the host country, various authors have obtained differing results. Xu and Wang (2000) showed that outward FDI enables the gaining of access to foreign technical knowledge, but they were not able to confirm the hypothesis that inward FDI is a significant channel for the diffusion of technology. The expected impact of activity by foreign investors in the domain of technology transfer was successfully confirmed by Xu (2000) with the use of data relating to the activity of American MNEs abroad. However, the result was unambiguously positive only in relation to developed countries. In the case of less developed countries, no significant increases in productivity were recorded.

Keller (2002) draws attention to a third channel for the diffusion of technical knowledge – communication links – which has not been sufficiently appreciated in the aforementioned lines of research. He also proposes that all three channels ought to be analysed simultaneously. In his cross-industry research in the G7 countries, he shows that more than half of spill-over effects can be ascribed to imports, with the remainder divided equally between FDI and interpersonal communication.

The present paper contributes to the first of the aforementioned lines of empirical research. Its purpose is to provide deeper knowledge about the relationship between imports of technology embodied in capital goods and productivity in a market economy which has been functioning for somewhat less than two decades. Because the inflow of foreign technology played a very significant role in the transformation of the Polish economy, much space has been devoted to it in the Polish literature. However attention is focused much more often on the transfer of technology via the FDI channel. This is because that FDI is seen as the route by which the country receives the most advanced technologies, associated with a whole package of accompanying components, for example in the form of foreign specialists and modern methods of organization and management. Therefore, in contrast to what is found in the worldwide literature, the diffusion of technology embodied in imports remains unappreciated and relatively poorly documented.

To analyze the impact of foreign technology shocks transferred to Poland through imports, as in Xu and Wang, we decided to concentrate on capital goods instead of all manufactures. As a proxy for imports of capital goods we use imports of machinery and equipment. According to Keller's (2000) findings we concentrated on imports from the main trading partner – European Union with 15 member states as before May 1st, 2004 (henceforth EU15).

An important issue is the method of measuring openness to the inflow of technology in the form of imported products. In many empirical studies (e.g. Trefler, 2004; Schor, 2004), indicators of tariffs reduction are used for this purpose. Dollar and Kraay

(2002) prove, however, that tariff reductions have little correlation with observed trade volumes. Karacaovali (2008) shows, both theoretically and empirically, that trade policy cannot be treated as exogenous to productivity and concludes, that without accounting for the endogeneity bias the positive effect of liberalization on productivity remains underestimated. Bearing in mind, that the average level of tariffs rarely reflects the effective scale of protection, it seems more justified to use a measure of trade openness related to trade directly. In our paper we use the rate of import penetration. The quality of imported products is measured in terms of the price-to-weight ratio. Inspired by Alcorta (2000) we assume that technological progress may either cause the miniaturisation of machinery equipment or enhance the efficiency without visible changes in machinery appearance. In both cases price-to-weight ratio growths, as the machinery weigh less and/or prices increase.

The reminder of the paper is organized as follows. In section 2 we describe the trade and productivity data used in our investigation. In section 3 we specify regression equation and report the main empirical findings. Section 4 is devoted to policy implications. In section 4 we conclude.

2. Data

In the paper we analyze the impact of foreign technology shocks transferred to Poland through imports of machinery and equipment. To test a hypothesis of diffusion of technology embedded in physical capital, we study the reaction (with impulse response functions) of sectoral residuals constructed for Polish manufacturing to changes in two indicators able to capture technology shocks abroad – price/weight ratio in imports and import penetration indicator.

Price to weight ratio was obtained from Eurostat foreign trade database Comext. We used data on Polish imports from EU15, which accounts for more than ⅔ Polish total imports. Since we research machines and equipment trade only, we focus on imports in group 84 in Combined Nomenclature – "Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof."[1] The group at 8-digit level comprises 1716 types of machines and equipment used in production processes. The group does not include electrical equipment that is a part of CN group 85. We collected quarterly data from the period 1995-2008 on value, quantity, and weight in Poland-EU15 trade.

All types of machinery were aggregated to 40 machinery groups following Statistical Classification of Economic Activities in the European Community (NACE) at 6-digit level (see appendix 1). We chose the items from Comext database falling into groups 28-31 of the NACE classification comprising various machinery manufacturing (equivalent to

[1] Commission Regulation (EC) No 1214/2007 of 20 September 2007 amending Annex I to Council Regulation (EEC) No 2658/87 on the tariff and statistical nomenclature and on the Common Customs Tariff.

group 333 of NAICS). Because of this and several classifications' inconsistencies, we were forced to drop 273 items from CN group 84 constituting 14% of total import value of the group 84.

Our input machinery groups were translated into output NACE sectors with the help of EndUse classification and I-O Commodity Use matrices also obtained from Eurostat. We used sectors inside the heading C – "Manufacturing". To provide accordance with Polish statistical classification of economic activities (PKD), finally, 18 sectors were specified with the total being the 19th output category (see appendix 1).

Price to weight ratios were then calculated from CN8 data as value/quantity/weight ratio for all 1443 types of machinery imported to Poland in 1995-2008. After aggregation to the aforementioned 40 input categories and allocation to output sectors with the use of I-O coefficients, we were able to produce series representing sectoral shocks to the quality of imported machinery. Namely, we ascribed as such shocks changes in price-to-weight ratio.

Import penetration indicator was also computed using CN8 import data as well as the data on capital accumulation acquired from Polish statistical office (GUS) for all output sectors in the studied period. Specifically, we calculated separate ratios of imported machinery value and the value of investment in machinery and equipment for all sectors, also taking into consideration the data on the liquidation of physical capital in studied sectors (for detailed formulas see appendix 2).

Our output indicators, sectoral residuals, were calculated in a standard manner, as the difference between the output growth and the growth rates of input production factors. Capital was represented by previously described investments in machinery and equipment, and labour input was depicted as the number of hours worked.

All time series were seasonally adjusted using H-P filtering procedure (with λ=1600) and corrected for inflation using data from GUS. Import data were recalculated to Polish zloty, using EURPLN and ECUPLN rates from Polish central bank (NBP) database. The series were changed into logs and tested for stationarity with Augmented Dickey-Fuller test. Since the results, overall, tend to suggest non-stationarity in log levels of the variables but stationarity in their log first differences, we proceed by contending that the variables belong to the I(1) process.

2. Results

The main calculation in the paper is a simple VAR model of the form:

$$TFP_{s,t} = \sum_{i=1}^{q} (qual_{s,t-i} + pene_{s,t-i}) + \varepsilon_t \tag{1}$$

where *TFP* represents sectoral Solow residuals, *qual* stands for price to weight ratio and *pene* for import penetration indicator described above. The subscript *s* indicates that the calculation was performed for all 19 output sectors.

With the support of Schwartz-Bayesian criterion, we decided to follow VAR(4) with the exception of total manufacturing where VAR(2) was used and "Petroleum and coal products manufacturing" in which case VAR(6) was found to be more useful. Table 1 presents the results of VAR computations.

The main findings stemming from the table are that both indicators are generally more statistically significant at lags of 3 or 4 quarters. 15 coefficients of both indicators lagged 4 quarters are significant at minimum the 10% level, while only 5 with the lag of 1 quarter. Import penetration indicator can be seen as, overall, more significant and therefore more promising in explaining foreign technology shocks. It is evident that for several sectors none of the indicators is significant (e.g. in manufacturing of tobacco, textile products, leather products, chemicals, plastic and rubber and metal processing). These sectors represent traditional industries in which capital input consist mainly of supplies and materials.

In the case of food & beverages – also a traditional industry – the fraction of machinery and equipment in capital input is much more important.

TABLE 1. VAR results for Polish manufacturing sectors.

	Quality – price to weight ratio				Import penetration indicator			
	L.1	**L.2**	**L.3**	**L.4**	**L.1**	**L.2**	**L.3**	**L.4**
Total manufacturing VAR(2)	0.026	-0.041	-	-	-0.122 (**)	0.110 (**)	-	-
Food & beverages manufacturing	-0.003	-0.164	0.297 (***)	-0.145 (**)	0.038	0.034	-0.167 (***)	0.073 (*)
Tobacco manufacturing	-0.015	-0.038	0.046	0.010	-0.034	0.036	0.002	-0.012
Textile mills & Textile product mills	0.013	0.005	-0.003	0.006	-0.046	0.007	0.011	-0.003
Apparel manufacturing	0.039 (*)	0.009	-0.244 (**)	0.051 (**)	0.008	0.036	0.051 (**)	-0.374 (***)
Leather and allied product manufacturing	0.004	0.076 (*)	-0.062	0.038	-0.070	0.006	-0.073	0.120 (*)
Wood product & Furniture manufacturing	0.109	-0.299 (*)	0.384 (**)	-0.226 (**)	0.003	-0.001	-0.342 (**)	0.236 (**)
Paper product manufacturing	0.034	-0.109 (*)	0.112 (*)	-0.050	0.021	-0.039 (*)	0.129 (*)	0.007
Printing and related support activities	-0.028	0.067 (**)	-0.009	0.016	0.040	-0.087	0.240 (**)	-0.331 (**)
Petroleum and coal products manufacturing VAR(6)	-0.031	-0.465 (*)	0.128	0.176	-0.118	0.230	-0.024	-0.077
L.5	-0.431 (*)				-0.346 (***)			
L.6					0.213 (**)			
Chemical manufacturing	0.122	0.191	-0.771	0.700	0.304	-0.674	-0.07	0.442
Plastics and rubber products manufacturing	-0.212	0.240	-0.445	0.441	-0.108	0.158	-0.096	-0.030
Non-metallic mineral product manufacturing	0.509	-1.167 (**)	1.268 (**)	-0.396	-0.218 (*)	0.674 (***)	-0.589 (***)	0.142
Metal production and processing	-0.112	0.038	0.173	-0.094	0.085	-0.131	-0.092	0.126
Metal product manufacturing	0.197	-0.348	0.527 (**)	-0.342 (**)	-0.147	0.384 (**)	-0.478 (***)	0.246 (**)
Computer and peripheral equipment & Electric equipment manufacturing	0.015	-0.253 (**)	-0.418 (***)	0.337 (**)	-0.60 (***)	0.069 (**)	0.087 (**)	-0.123 (***)
Machinery manufacturing	0.127 (**)	-0.081	-0.007	0.037	-0.340 (**)	0.724 (**)	-1.261 (***)	-0.625 (***)
Motor vehicle manufacturing	0.077	-0.100	0.056	-0.005	0.020	-0.307 (**)	0.330 (**)	0.230 (*)
Other transportation equipment manufacturing	-0.034	0.046	-0.039	-0.004	-0.003	0.437 (*)	-0.718 (***)	0.303 (**)
	L.1	**L.2**	**L.3**	**L.4**	**L.1**	**L.2**	**L.3**	**L.4**
	Quality – price to weight ratio				**Import penetration indicator**			

Calculations using gretlw32 GNU software.
Note: Significance at 1 (***), 5 (**) and 10 (*) levels.

Tobacco manufacturing is similar to food and beverages in this regard, but this is the only sector in which the output significantly diminished over the studied period. In more advanced sectors (e.g. manufacturing of machinery, computers, electric equipment, motor vehicles and other transportation equipment) coefficients are generally statistically significant.

VAR model can be used to test Granger causality among the variables of the model and also that an endogenous variable can be treated as exogenous. We used chi-square (Wald) statistics to assess if price to weight ratio and import penetration indicators Granger-cause sectoral residuals. The results are presented in Table 2.

The majority of sector residuals are Granger-caused by foreign technology shock indicators. Similar to Table 1, manufacturing of textiles, leather, chemicals, plastic and rubber and metal are independent from the changes in shocks indicators. Import penetration again seems to be more promising in explaining changes in productivity. It is worth noting that aggregated data describing total manufacturing show weaker causality than sector specific data.

The results of Table 2 enabled us to analyze the impulse response functions that provide information to study the dynamic behaviour of a variable due to a random shock or innovation in other variables. The impulse response traces the effect on current and future values of the endogenous variables of one standard deviation shock to the variables. To identify innovations in each of the variables and the dynamic responses to such innovations, variance-covariance matrix of the VAR was factorized using the Choleski decomposition method.

TABLE 2. Chi-square statistics for Polish manufacturing sectors.

Excluded Sector	quality – price/weight	import penetration	Both variables
Total manufacturing	2.298	6.241 (**)	7.850 (*)
Food & beverages manufacturing	27.340 (***)	59.297 (***)	71.519 (***)
Tobacco manufacturing	27.247 (***)	18.639 (***)	45.882 (***)
Textile mills & Textile product mills	4.279	4.338	10.654
Apparel manufacturing	13.240 (***)	22.356 (***)	35.925 (***)
Leather and allied product manufacturing	6.634	3.818	10.846
Wood product & Furniture manufacturing	35.713 (***)	26.309 (***)	50.950 (***)
Paper product manufacturing	4.867	43.431 (***)	48.530 (***)
Printing and related support activities	0.981	10.933 (**)	12.344
Petroleum and coal products manufacturing	22.555 (***)	16.387 (***)	44.439 (***)
Chemical manufacturing	0.871	3.221	4.310
Plastics and rubber products manufacturing	5.893	5.872	12.549
Non-metallic mineral product manufacturing	11.192 (**)	38.55 (***)	54.980 (***)
Metal production and processing	3.924	4.387	7.520
Metal product manufacturing	9.752 (**)	20.762 (***)	26.921 (***)
Computer and peripheral equipment & Electric equipment manufacturing	36.057 (***)	67.184 (***)	80.846 (***)
Machinery manufacturing	9.662 (**)	61.470 (***)	72.988 (***)
Motor vehicle manufacturing	3.928	22.846 (***)	26.815 (***)
Other transportation equipment manufacturing	6.219	25.696 (***)	29.174 (***)

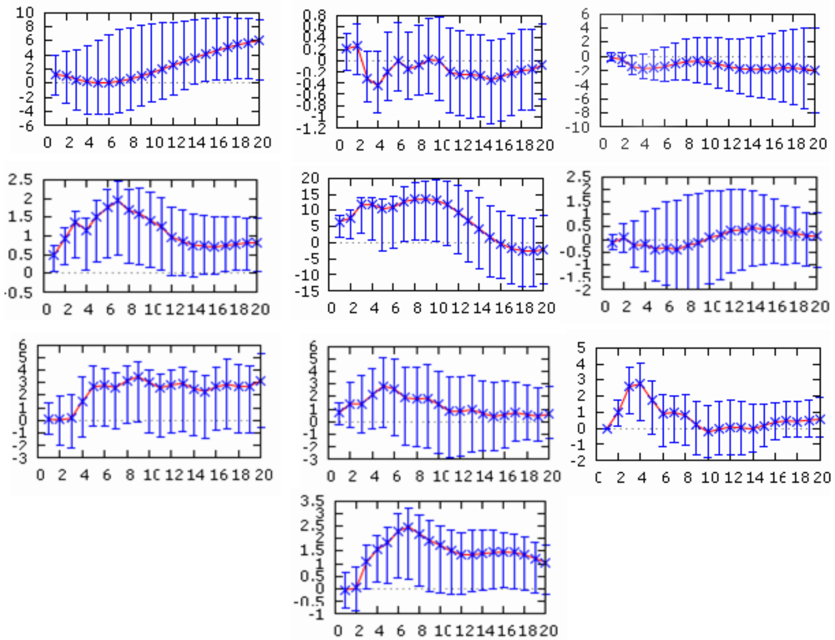
Calculations using gretlw32 GNU software.
Note: Significance at 1 (***), 5 (**) and 10 (*) levels.

Figure 1 illustrates the dynamic response of the target variables (residuals) to a one standard deviation shock in price to weight ratio. The presented data are only for sectors in which Granger-causality was identified.

The response functions are presented in 20-quarter horizon with bootstrap confidence intervals. In all cases, with the exception of tobacco manufacturing, the response is positive – the productivity levels in Polish manufacturing sectors increase in the effect of leaps in price to weight ratio. The response in most cases is permanent in 5-year perspective. Only in the case of traditional sectors –impact of a technology shocks is temporary. In addition in some of these sectors as manufacturing of food & beverages and petroleum and coal products manufacturing the initial change of productivity is negative and the augmentation of productivity is postponed. It is worth noting that in mining the so-called time-to-build, that is the time needed to install new machinery, is especially long and in farming machinery acquisitions as well as field yield are highly dependent on seasons and short term yield forecasts. Finally the case of tobacco manufacturing in fig. 1 is inconclusive with the residual oscillating around zero.

Figure 2 presents impulse response functions of sectoral residuals to impulse in the form of a onetime one standard deviation shock in import penetration indicator. There were 14 cases in which causality was identified.

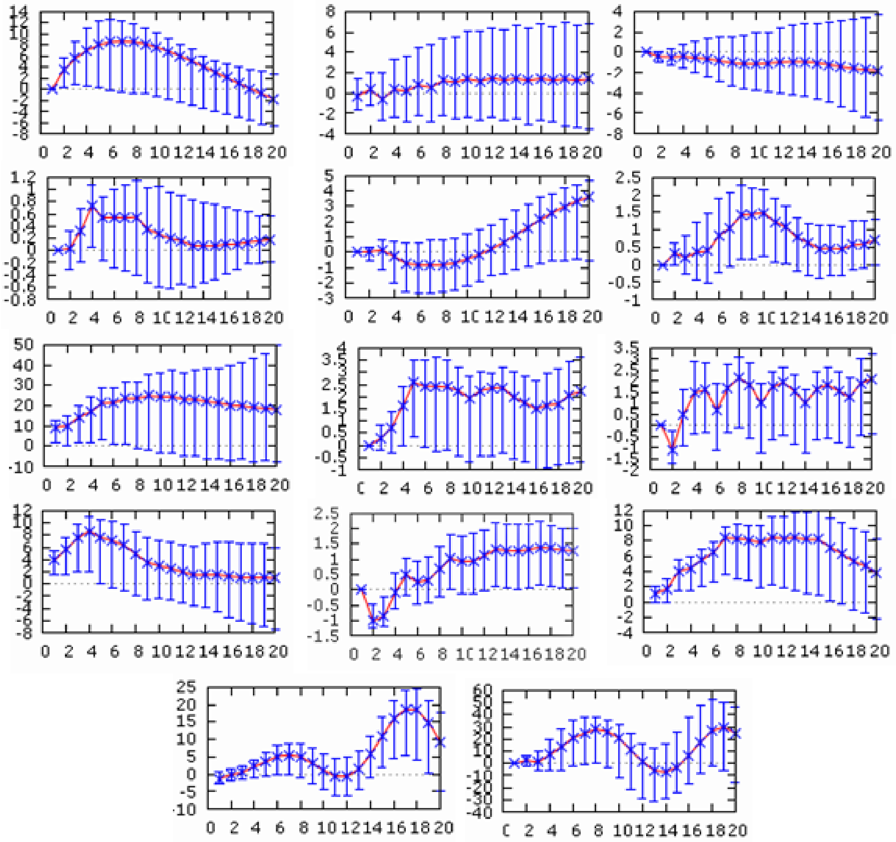
FIGURE 1. IRFs of several Polish manufacturing sectors residuals. Impulse: Price/weight ratio.



Calculations using gretlw32 GNU software.

The sectors are presented as follows:
upper row – Manufacturing, Food&Bev., Tobacco
middle row – Apparel, Wood&Furniture, Petroleum&Coal
lower rows: Non-metallic minerals, Metal products, Electric Equip., Machinery

FIGURE 2. IRFs of several Polish manufacturing sectors residuals. Impulse: import penetration.



Calculations using gretlw32 GNU software.

The sectors are presented as follows:

1st row – Manufacturing, Food&Bev., Tobacco
2nd row – Apparel, Wood&Furniture, Paper
3rd row – Printing, Petroleum&Coal, Non-metallic minerals
4th row – Metal products, Electric Equip., Machinery
5th row – Motor, Transport

Onetime, random shock to import penetration indicator causes the increase of sector residuals. The effects are, similarly to shock in price/weight ratio, positive and permanent in most cases. The exception is again tobacco manufacturing where the effect of technology shock is inconclusive for sector's productivity and manufacturing of textiles and metal products in which the effect of a leap in import penetration is temporary. In many sectors the impulse response function is cyclical – productivity drops and rises several times.

Table 3 presents sectoral results in a more compacted form – sectors were grouped according to OECD classification into sectors using high, medium or low production technology.

TABLE 3. Average rates of growth of Polish manufacturing sectors' indicators in 1995q1-2008q4, by technology level.

Sectors / Indicators	High and medium-high tech	Medium-low tech	Low tech	Manufactu-ring
Machinery import	3.23	3.04	1.42	2.53
Production	1.56	1.67	-0.03	1.12
Price to weight ratio	2.54	0.28	1.72	2.18
Machinery value	0.13	0.56	0.38	0.35
Hours worked	-0.19	-0.09	-0.69	-0.46
Residual value	1.61	1.20	0.29	1.23
Import penetration = growth rate	3.10	2.48	1.04	2.17
Import penetration – value (manufacturing = 1)	1.86	0.76	0.84	1.00

Productivity levels measured with the use of residual value increase in all sectors groups – the rate of growth of residual is the highest in high and medium-high technology sectors. It is due to increases in production levels with decreasing use of labor (hours worked) and relatively modest augmentation of physical capital use. In medium-low tech production rose faster but the use of production factors was also increasing substantially. This group of sectors consists mainly of heavy industry in which machinery value is especially high comparing to other sectors and which was modernized in Poland during the studied period. It is worth noting that although import of machinery from UE15 was growing relatively fast, import penetration indicator remained the lowest of all product groups what reflects a great number of non-modernized machinery in heavy industry. Additionally the quality of machinery was augmenting at the slowest pace. Productivity of low-tech traditional sectors is, as expected, the lowest. The sectors were transformed into less labor-intensive but production levels did not grow substantially. The average growth rate for a whole group of sectors is -0.03, but some of the ssectors noted increases of production (as wood & furniture, paper, food & beverages manufacturing) while the production of the others (as textile, apparel, leather products manufacturing and mostly tobacco manufacturing) decreased sharply. Diminishing production levels of apparel-related manufacturing is connected with growing imports of cheap clothes from Asia and, on the other side, second-hand clothes from Western Europe.

Import penetration indicator is the highest in high-tech sectors. The rate of growth of the indicator as well as machinery import value are also uppermost. The rate of growth of physical capital use is, however, the lowest. This reflects the phenomenon of high rate of replacing previous generations of machinery with the new ones as in these sectors product life-cycles are especially short. This is also evidenced by the highest rate of increase of machinery quality.

In low-tech sectors, the rate of growth of price to weight ratio is higher than in medium-low tech group. The effect results from fast increasing quality of machinery used in Polish tobacco manufacturing which is classified by OECD as a low-tech industry and, on the other side, low rate of growth of machinery quality in manufacturing of nonmetallic minerals and metals in Poland which OECD ascribes to medium-low tech sectors.

It is also worth noting that the rate of growth of price to weight ratio in all sectors groups accelerated sharply in 2004. In the period of 2004-2008 the value was increasing at 4% quarterly while in the period of 1995-2003 at the pace of 0.7% quarterly. Only in high-tech sectors the rate of growth of price to weight ratio of imported machinery spurred up earlier – the rate was high in 1998-2000 and 2004-2008. The decrease in the period 2000-2002 was connected with the recession in Poland and bursting the dotcom bubble.

4. Policy implications

The results presented in previous section indicate that import of machinery of better quality has a positive impact on productivity of Polish manufacturing sectors. This offers interesting implications for innovation policy in a less developed country, which is, first to enhance modernization of existing stock of physical capital and then, when the manufacturers become more internationally competitive, to intensify R&D.

It is worth noting that acquisition of new machinery or knowledge embedded in software is one of most important types of innovative activities – the others are:

- running intramural R&D,
- acquisition of research results subcontracted from other entities – eg. extramural R&D,
- acquisition of ready-to-use technological solutions (patents, know-how, licenses or companies with attractive knowledge assets).
- on-the-job training or coaching in order to develop new production processes or product enhancements.

CIS-4 survey in 2004[2] confirmed that the majority (75%) of innovative enterprises in the EU27 obtain new machinery

[2] CIS-4 stands for Community Innovation Survey – a series of most comprehensive cyclical study of innovative companies in European Union run by national statistical offices throughout the European Union and in Norway and Iceland. The harmonized surveys are designed to give information on the innovativeness of different sectors and regions. See: "Science, technology and innovation in Europe. Edition 2008", Office for

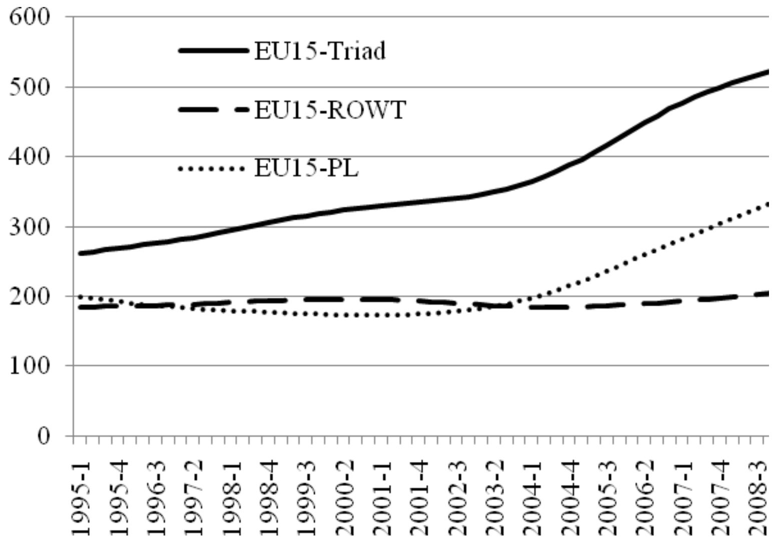
and software. Intramural R&D is conducted by 52% of companies and 49% obtains technological solutions from their employees. Extramural R&D and acquisition of ready-to-use solutions are rarer and declared by 23% and 22% of enterprises.

In Poland the advantage of new machinery acquisitions are even more pronounced – 82.3% of sums spent on innovative activity is used to finance new equipment purchases. On intramural R&D 7.6% of the total is spent and the rest is used for extramural R&D (4.3%) and acquiring ready-to-use knowledge (5.8%).

The effect of spending on modernization of machinery park of Polish companies can be seen in the figure 3. The quality of machinery imported from developed countries represented by EU15 is increasing in 2004-2008. The quality of equipment exported by EU15 manufacturers to The Triad countries is rising during the whole studied period, while the price to weight ratio remains stable for the machinery exported to the other countries. Although the quality of machinery exported to The Triad is also accelerating after 2004, the rate of growth of the price to weight ratio is slightly faster in case of Polish companies import. The machinery quality gap between Poland and developed countries is closing.

Official Publications of the European Communities, Luxembourg, http://epp.eurostat.ec.europa.eu.

FIGURE 3. Price to quality ratio of machinery exported by EU-15 manufacturers to The Triad countries, Poland and the Rest of the World in 1995-2008.



The chronological coincidence of the acceleration of increases in imported machinery quality of Polish companies with the date of the accession to the European Union is not accidental. Before 2004 Poland was using pre-accession funds which, only to the limited extent, were connected with direct aid to physical capital modernization. Within The Improvement of the Competitiveness of Enterprises Operational Programme (ICE OP) from 2004 to 2009, when the period of qualification of expenses was closed, Polish incumbents were assigned 6.2 bln PLN in forms of subventions, credits, guarantees and enrichment of business environment with incubators, clusters or technology parks.

Evaluation of ICE OP from 2008 revealed that the incumbents valued highly the influence of the program for their innovativeness although the opinions on different activities within the program varied. The highest notes were given to supporting in purchasing new machinery and equipment – over 70% enterprises pointed this as the most innovativeness-enhancing activity.

4. Conclusion

This paper examines foreign trade as a channel for technology diffusion to Poland using data on imports of machines (group 84CN) from EU15 countries over the period 1995-2008. To gauge the productivity change led by better input availability we have regressed TFP on the import penetration and price-to-weight ratios for 18 NACE2 sectors. Then we Granger-tested our model for causality.

Obtained results confirm that foreign technology embodied in capital goods trade has a positive impact productivity, with an effect which is strongly differentiated (in value and in time horizon) across industries. In the cases of five sectors import penetration does not explain the variance in TFP level. These sectors represent traditional industries in which capital input consist mainly of supplies and materials.

Price-to-weight ratios display significant coefficients in smaller number of sectors than import penetration, revealing weaker linkages between the quality of imported machines and gains in total factor productivity. It should be noted however, that price/weight ratios were not estimated with satisfactory precision because of poor quality of the statistical data on quantity and weight of imported machines. Nonetheless, our estimates are at least suggestive about positive effects of foreign technology shock for a country's productivity, especially as far as more technically advanced sectors are concerned.

In the light of our research modernization of stock of physical capital through enhancing machinery imports from developed countries may be a recommended instrument of innovation policy. Such policy allows for catching-up and Poland, although the policy was active only for relatively short period of time, is a good example of its effectives. However, the policy does not allow for leapfrogging so it must be combined with R&D enhancing instruments. In the period 2007-2013 such policy is to be implemented in Poland. The open question remains if such policy, in the light of still existing gap of innovativeness and competitiveness of Polish companies is not premature.

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Appendix1: Input and output sectors

TABLE A1. Input machinery types

NAICS	Machinery type	Share [%]
333111	Farm machinery and equipment manufacturing	3.34
333120	Construction machinery manufacturing	4.96
333130	Mining and oil and gas field machinery manufacturing	0.67
333210	Woodworking machinery manufacturing	2.23
333220	Plastics and rubber industry machinery manufacturing	2.73
333291	Paper products machinery manufacturing	1.83
333292	Textiles mills and textile products machinery manufacturing	1.36
333293	Printing machinery manufacturing	2.98
333294	Food. beverage machinery manufacturing	2.65
333295	Semiconductor machinery manufacturing	0.14
333298	Other industrial machinery manufacturing	0.72
333311	Vending. commercial. industrial. and office machinery manufacturing	0.82
333315	Photographic and photocopying equipment manufacturing	0.02
333319	Other commercial and service industry machinery manufacturing	0.21
333411	Air purification and ventilation equipment manufacturing	0.85
333414	Heating equipment (except warm air furnaces) manufacturing	1.85
333415	Air conditioning. refrigeration. and warm air heating equipment manufacturing	4.02
333511	Industrial mold manufacturing	1.38
333512	Metal cutting and forming machine tool manufacturing	4.65
333514	Special tool. die. jig. and fixture manufacturing	0.03
333515	Cutting tool and machine tool accessory manufacturing	0.17
333516	Rolling mill and other metalworking machinery manufacturing	0.41
333611	Turbine and turbine generator set units manufacturing	0.50
333612	Speed changer. industrial high-speed drive. and gear manufacturing	0.47
333613	Mechanical power transmission equipment manufacturing	1.16
333618	Other engine equipment manufacturing	13.28
333911	Pump and pumping equipment manufacturing	2.91
333912	Air and gas compressor manufacturing	2.84
333920	Material handling equipment manufacturing	5.23
333991	Power-driven handtool manufacturing	1.13
333993	Packaging machinery manufacturing	3.27
333994	Industrial process furnace and oven manufacturing	0.56
333995	Fluid power process machinery	0.51
333999	Other general purpose machinery manufacturing	12.62
333999.1	Apparel machinery manufacturing	0.34
333999.2	Leather products machinery manufacturing	0.14
333999.3	Tobacco machinery manufacturing	0.16
334111	Electronic computer manufacturing	5.33
334112	Computer storage device manufacturing	2.07
334113	Computer terminals and other computer peripheral equipment manufacturing	9.45

TABLE A2. Output sectors

Sector	NACE	Share [%]
Manufacturing	**3**	**100**
Food & beverage manufacturing	10+11	20.9
Tobacco manufacturing	12	0.4
Textile	13	1.2
Apparel manufacturing	14	0.9
Leather and allied product manufacturing	15	0.4
Wood product manufacturing + Furniture + Other	16+31+32	7,1
Paper	17	2,5
Printing and related support activities	18	2,8
Petroleum and coal products manufacturing	19	7,1
Chemicals	20	6,4
Plastics and rubber products manufacturing	22	5,6
Nonmetallic mineral product manufacturing	23	5,2
Metal	24	4,3
Metal products	25	7.6
Computer and peripheral equipment manufacturing + Electric equipment	26+27	8.1
Machinery	28	7.3
Motor	29	10.2
Other transportation	30	2.3

Appendix 2: Calculation of indices

Price to weight ratio

$$pw_{jT} = \frac{pw_{jt}}{pw_{j0}}$$

– a fixed-base index of price to weight ratios of j output sectors of Polish manufacturing;

$$pw_{jt} = \sum_{\kappa} \overline{pw}_{\kappa jt}$$

– a sum of weight averages of price to weight ratios of input sectors κ to output sectors j;

$$\overline{pw}_{\kappa jt} = pw_{\kappa T} \cdot \frac{v_{\kappa j}}{v_{jt}}$$

where

$$pw_{\kappa T} = \frac{pw_{\kappa t}}{pw_{\kappa 0}}$$

– a fixed-base index of price to weight ratios in input sectors κ;

$$v_{\kappa j} = v_{\kappa} \cdot C_{\kappa j}$$

– where v_{κ} represents value of imports of input sector κ and $C_{\kappa j}$ is an Input-Output coefficient of imports from κ destined to sectors j, which total imports is noted as v_{jt}.

Each κ sector's price to weight ratio $pw_{\kappa t}$ is a weighted average of price to weight ratios of all individual CN8 code machinery that belong to κ - $pw_{\kappa t} = \sum_{i \in \kappa} \overline{pw}_i$.

Import penetration index

$$pene_{jT} = \frac{pene_{jt}}{pene_{j0}}$$

– a fixed-base index of a ratio of the value of imported machinery in a sector j to the value of investments in machinery in this sector. Investment in machinery was calculated as net accumulation during each period t.

where:

$$pene_{jt} = \frac{v_{jt}}{I_{jt}}$$