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The Impact of Human Capital on the Changes of Export Structure in the Process of Narrowing of the Technological Gap

Abstract. *The aim of this paper is to present the research results on the impact of human capital's accumulation at the level of higher education on changes in export structure of Poland's economy which result from an increase in learning productivity of a country and technological progress. The period between 1993 and 2015 was under consideration. The research was carried out with the help of the methods of Pearson's linear correlation analysis and Spearman's rank corelation analysis. The results confirm the importance of human capital as a factor affecting the level of learning productivity of the Polish economy and demonstrate its role as a determinant of the reallocation of export structure towards more technologically intensive commodities. Development of human capital at the level of higher education in Poland thus contributes to building the endogenous advantages based on knowledge, and giving higher income from exports, which later can be reinvested in further strengthening these advantages, eg. through innovative activities.*

Keywords: *human capital, export, competetivenness, Poland*

Introduction

Accumulation of human capital resources should lead to the improvement of learning productivity of an economy, which is reflected in an increase in technological complexity of a country's export structure. As a result there is a rise in profits from the sales of goods of a given country abroad, and thus there is welfare. This welfare growth results from the implementation of technological progress by more and more educated, and better-paid employee capital. Thus we

deal with the development of endogenous specialization of a national economy which, in this case, is the result of investing in human capital development. The deepening of this endogenous advantage requires, however, planned long-term actions, which will bring visible accumulated effects only after some time. The investments in human capital development discussed in this paper lead, in the long run, to, among others, beneficial changes in a country's production structure in the form of a growing share of processed goods that involve higher contribution of human capital and technology.

The main objective of the paper is to present the research results on the impact of human capital's accumulation at the level of higher education on changes in export structure of Poland's economy which result from an increase in learning productivity of a country and technological progress. The paper consists of the following parts: first, the author presents theoretical assumptions on which is based the methodology of empirical research. The next part discusses the materials and research methods. The part that follows discusses the research results and how they compare with the author's previous findings. The paper ends with conclusions.

1. Human capital and technological change

According to R. Nelson and P. Romer technological change is a very complex phenomenon and that is why it is extremely difficult to fully comprehend the processes that contribute to its occurrence. As a result particular researchers focus on an analysis of selected elements and relationships leading to technological progress [Nelson & Romer 1996: 14]. This explains why there are so many various ways of demonstrating it through the size of differences in selected criteria that are used to assess a country's technological level. Very often one can find different types of productivity indicators e.g. national or domestic product per capita, which is also, as recommended in the subject literature, a measure of learning productivity of an economy. The author discusses various kinds of international trade structure depending on the analyzed determinants of the occurrence of technological gap or activities aimed at decreasing the gap.

Countries develop human capital mainly thanks to investments in education and innovativeness, strengthening, at the same time, endogenous advantages in international trade, the source of which is technological change. In light of new theories of trade and endogenous growth the changes in international trade may be the result of the process of country learning. The very international trade is one of the factors stimulating the learning process and the diffusion of technology, thus contributing to an increasing productivity of an economy. The development of endogenous advantage in international trade, the source of which is accumulation

of knowledge as a result of the learning process, is staggered and requires appropriate human capital quality. Endogenous character of technological progress manifests itself in different rates of welfare growth of particular economies due to, among others, differences in dynamics of human capital investment.

One of the main sources of human capital development that this paper discusses is formal education, the other ones being e.g. learning by doing, or learning by mimicking, or learning by doing innovation. All of these forms of learning and knowledge accumulation are mutually complimentary in the process of human capital development. It is necessary to remember that only part of human capital skills is shaped through education at school or university. We also acquire important skills in family environment, which determine, to a large extent, a young person's attitude toward education and knowledge-assigned meaning. We also learn by mimicking other people in the workplace and by sharing knowledge with them in the process of cooperation. We also learn by imitating social groups in which we function (e.g. peers) [Krugman 1985: 35-49; Yang & Borland 1991: 460-482; Nelson & Romer 1996: 14; Durkin 1997: 401-411; Parente 2001: 50; Jerbashian, Slobodyan & Vourvachaki 2015: 167-170; Zhang 2015: 59-60].

The pace of technological progress depends on learning productivity of an economy. The higher the potential of knowledge absorption by people, the higher the productivity is. A country's learning productivity is dependent on the efficiency of employee capital in the absorption of knowledge from different sources including technology. And it is not only about the acquisition and absorption of knowledge, but, first of all, it is about its implementation in different types of activity, which leads to technological change. Undoubtedly the ability to absorb knowledge depends on human capital quality including employees' qualifications and skills that could be acquired and developed, as highlighted above, in the process of education. A higher level of employees' education should, at least by definition, increase the potential of knowledge absorption. It manifests itself in the fact that more people are able to understand and implement technologically more advanced improvements. Thus the accumulation of human capital plays an essential role in the absorption of new technologies including those coming from abroad and being transferred, among others, via international trade, direct investment, scientist exchange or patents [Lejour, Steen & Timmer 2000: 220-222; Hoffmann 2003: 435; Mingyong, Shuijun & Qun 2006: 300-320; Teixeira & Fortuna 2006: 1-31; Bhattacharya & Raychaudhuri 2004: 23-56; Soukiazis & Antunes 2012: 6].

Thus one can state that the accumulation of human capital through education increases the chance of the technological change occurrence in economy. The visible effect is the evolution of the character of a given economy's comparative advantage in the direction of goods that require higher qualifications and higher technological complexity. In this way education leading to beneficial changes in

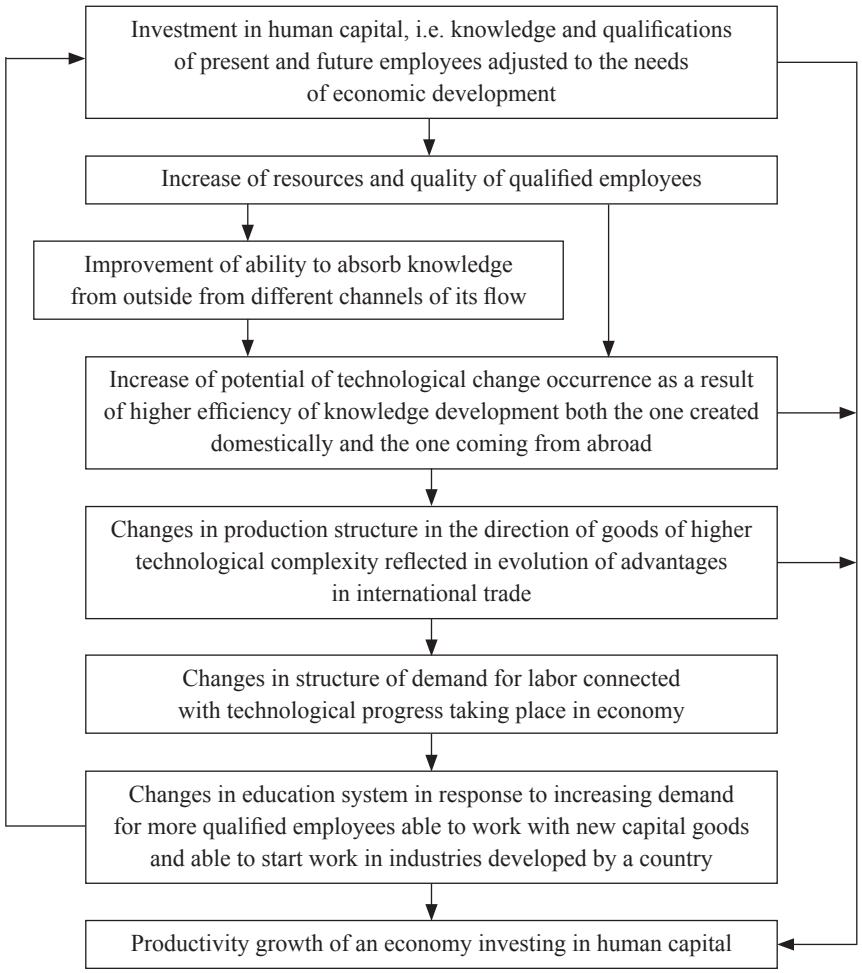

Figure 1. Impact of investment in human capital on the change of character of an economy's comparative advantage

Source: Majewska-Bator 2010, p. 155.

the structure of qualification and production reallocation in the direction of higher added value goods brings about an increase in export profits. To sum it up, bigger investments in the development of efficiently working education system increase, in the long run, supply of better quality human capital, which results in higher production of technologically more complex goods at the cost of smaller share of labor-intensive goods, and low-processed goods. The above mentioned relationships are synthetically illustrated in Figure 1.

2. Materials and research methods

The focus of this paper is on indicators regarding Poland's economy as a whole, which are the so-called indirect measures of a given phenomenon. The research period included the years 1993-2015. However, in the case of the study on the impact of higher education indicators on the changes in Poland's exports structure, the research period was a bit shorter because the data about export structure were available from 1995. The study was carried out with the help of the methods of Pearson's linear correlation analysis and Spearman's rank correlation analysis for the relationships of Gross Domestic Product per capita (GDP pc), exports per capita (EXP pc) and Poland's exports share in the global market and export groups differentiated from the adopted human capital indicators. The decision to choose Spearman's rank correlation analysis and Pearson's linear correlation analysis was made after the analysis of similar subject studies conducted by other authors.

The author used a time-lag study method as regards changes in export structure and indicators of learning productivity of an economy against human capital indicators. Thus exogenous variables of human capital, that is the higher education indicator in a year t_0, show the causes of the explained phenomenon of GDP pc growth, EXP pc and Poland's EXP share in global exports and a given group of Poland's exports in a year t_{+1} and t_{+2}.

The variables expressed in absolute values were log transformed. The log transformation method is not used for percentage variables because it does not standardize results. It is necessary to emphasize that the research results should be interpreted as a possible approximation of the occurrence of variables included in the study and the correlation between them.

In order to assess human capital resources of a given country one often uses different types of indicators for the level and structure of a society's education, which later are correlated with productivity variables [Majewska 2013: 174-176]. Among them are this study's indirect measures of human capital quality. These indirect measures are higher education indicators. The data regarding the indicators of human capital quality come from a Central Statistical Office annual report entitled "Szkoły wyższe i ich finanse" [Higher Education Institutions and Their Finances].

The first indirect measure of human capital quality is the number of higher education institutions' graduates with the division into the ones from technical higher education institutions and the ones from economic higher education institutions. They are indirect indicators of technical knowledge because they concern education in the area of exact sciences, economic sciences and engineering. For technical knowledge is the ability to design activities and processes that add up to the realization and completion of certain actions or creation of certain objects. It

Table 1. Education structure of univeristies' graduates by division into selected types of universities in 1993-2014

Year	Number of graduates in total	Graduates of technical universities			Graduates of economic universities		
		Total	% share in number of graduates in total	Growth rate	Total	% share in number of graduates in total	Growth rate
1993	64201	10593	16.50	–	4366	6.80	–
1994	69758	11092	15.90	4.71	5162	7.40	18.23
1995	88330	14329	16.22	29.18	8525	9.65	65.15
1996	115120	17472	15.18	21.93	13463	11.69	57.92
1997	145509	23663	16.26	35.43	19931	13.70	48.04
1998	174004	29173	16.77	23.29	30264	17.39	51.84
1999	214570	34233	15.95	17.34	44103	20.55	45.73
2000	260314	41311	15.87	20.68	65930	25.33	49.49
2001	303074	44713	14.75	8.24	82581	27.25	25.26
2002	342138	51973	15.19	16.24	93583	27.35	13.32
2003	364834	56158	15.39	8.05	99250	27.20	6.06
2004	382851	57069	14.91	1.62	100010	26.12	0.77
2005	391465	56298	14.38	–1.35	94867	24.23	–5.14
2006	393968	55 696	14.14	–1.07	87965	22.33	–7.28
2007	410107	55209	13.46	–0.87	94025	22.93	6.89
2008	420942	53398	12.69	–3.28	86469	20.54	–8.04
2009	439749	52606	11.96	–1.48	86173	19.60	–0.34
2010	478916	59282	12.38	12.69	88425	18.46	2.61
2011	497533	74494	14.97	25.66	86322	17.35	–2.38
2012	485246	77155	15.90	3.57	77170	15.90	–10.60
2013	455206	78248	17.19	1.42	69355	15.24	–10.13
2014	424564	78436	18.47	0.24	62466	14.71	–9.93

Source: own study and calculations based on Central Statistical Office data [Higher Education Institutions and Their Finances].

includes a description of technological features and parameters, and construction principles or the sequence of actions or ways of conduct that enable to accomplish a given task. Thus technical knowledge includes applied knowledge, that is, knowledge that deals with the ways different objects function or can be used. The basis for the development of technical knowledge is scientific knowledge. As a result of scientific knowledge development there appears e.g. a patent which later is implemented and then constitutes technical knowledge [Jantoń-Drozdowska & Majewska-Bator 2011: 262-264].

Data presented in Table 2 show that in the analyzed period of 22 years, that is between 1993 and 2014 there was a rise of 561.3% in the number of gradu-

Table 2. Structure of doctoral degrees awarded in Poland be by division into selected types of universities in 1993-2014

Year	Total number of degrees	Doctoral degrees awarded at technical universities			Doctoral degrees awarded at economic universities		
		Total	% share in the total number of degrees	Growth rate	Total	% share in the total number of degrees	Growth rate
1993	1749	359	20.53	–	61	3.49	–
1994	1339	195	14.56	–45.68	25	1.87	–59.02
1995	2112	371	17.57	90.26	73	3.46	192.00
1996	2218	436	19.66	17.52	75	3.38	2.74
1997	2356	462	19.61	5.96	92	3.90	22.67
1998	3172	633	19.96	37.01	116	3.66	26.09
1999	3724	669	17.96	5.69	135	3.63	16.38
2000	4138	726	17.54	8.52	154	3.72	14.07
2001	4111	780	18.97	7.44	172	4.18	11.69
2002	5105	973	19.06	24.74	194	3.80	12.79
2003	5090	1001	19.67	2.88	248	4.87	27.84
2004	5314	1057	19.89	5.59	255	4.80	2.82
2005	5496	1 073	19.52	1.51	290	5.28	13.73
2006	5667	1 160	20.47	8.11	297	5.24	2.41
2007	5226	1 104	21.13	–4.83	281	5.38	–5.39
2008	4941	1114	22.55	0.91	249	5.04	–11.39
2009	4 659	901	19.34	–19.12	260	5.58	4.42
2010	4 449	872	19.60	–3.22	202	4.54	–22.31
2011	4 938	910	18.43	4.36	215	4.35	6.44
2012	5153	925	17.95	1.65	183	3.55	–14.88
2013	5610	977	17.42	5.62	236	4.21	28.96
2014	5278	975	18.47	–0.20	221	4.19	–6.36

Source: own study and calculations based on Central Statistical Office data [Higher Education Institutions and Their Finances].

ates in Poland, with a 640.5% increase at technical universities and 1330.7% at universities of economics. In 1993 Poland's total percentage share of graduates of technical universities and economic universities in the total number of graduates was 23.3% and 22 years later it increased to 33.2%. Although the number of technical universities' graduates was still on the rise in the years 1993-2004, their percentage share in the total number of graduates did not rise. It was 2011 that saw a reversal of declining percentage share of technical universities' graduates in the total number of graduates. However, the percentage share of economic universities' graduates in the total number of graduates kept going up in the years 1993-2003, and then it started going down. As a result in 2013 it was

lower than the share of technical universities' graduates in the total number of graduates.

Then data presented in Figure 1 show that the number of people acquiring technical knowledge in Poland is still too low, especially in comparison to those countries that experienced the so-called economic miracles e.g. Asian Tigers. It is a worrisome phenomenon because in this situation in the future it will be difficult to achieve a faster pace of technological progress and enhance Poland's welfare. The reason for that will be a shortage of well-qualified human capital

The other indirect measure of human capital quality is doctoral degrees that can be treated as indictors of potential development towards the creation of specialist scientific knowledge. In this case the author analyzed the impact of doctoral degrees awarded at technical and economic universities on the indicators of learning productivity of an economy and selected export groups. The data in Table 2 demonstrate that in the analyzed period of 22 years the number of doctoral degrees awarded at higher education institutions in Poland rose by 201.8%, with a 171.6% rise at technical universities and 262.3% rise at economic universities.

Yet the percentage share of doctoral degrees awarded at technical universities in the total number of degrees fell by 2.1%, at economic universities it rose by only 0.7%. The majority of doctoral degrees at technical universities were awarded in the years 2003-2008. At that time the number of doctoral degrees was above 1000. As it comes to doctoral degrees awarded at economic universities their number, beginning in 2003, was above 200, with the exception of 2012. One can then state that the number of doctoral degrees awarded at technical and economic universities leveled off in the last years covered by this analysis.

By contrast, as an indicator of Polish economy's learning productivity the author adopted two indicators, which according to research methods of this phenomenon, are frequently used. The two indicators are GDP pc and EXP pc of Poland. It is assumed that along with a increasing level of knowledge of a particular type of activity there is a drop in required input necessary for achieving a given outcome, which is the result of different types of learning. The third indicator of learning productivity of an economy adopted by the author is share of Poland's exports in global exports. This indicator should increase along with the acquisition of experience in international trade. Exporters adjusting their products to global consumer needs learn and become, at the same time, more competitive. Moreover, they expand their sales markets. If the consumers come from countries with a more diversified and technologically advanced demand structure, we deal with supply technicization of the exporter's country. It means a rise in production value of a given economy due to larger contents of knowledge in manufactured commodities. As a result there is a growth in GDP pc and EXP pc, that is welfare. As it comes to EXP pc it was computed by dividing Poland's total exports value by the size of population reported by UNCTAD. The data on GDP pc, and Polish

Table 3. Changes in the level of learning productivity of Poland's economy in GDP pc, EXP pc in USD at current prices and Poland's exports share in global exports in % in the years 1993-2014

Year	GDP pc	Growth rate of GDP pc	EXP pc	Growth rate of EXP pc	EXP in total as % of global exports
1993	2457	1.77	367	–2.71	0.374
1994	2827	15.06	447	21.71	0.399
1995	3623	28.18	593	32.67	0.442
1996	4082	12.67	633	6.73	0.452
1997	4096	0.35	667	5.41	0.460
1998	4511	10.11	732	9.72	0.512
1999	4382	–2.85	710	–3.00	0.478
2000	4477	2.17	825	16.13	0.492
2001	4982	11.28	936	13.45	0.581
2002	5190	4.17	1070	14.30	0.633
2003	5687	9.57	1398	30.72	0.708
2004	6632	16.63	1952	39.58	0.814
2005	7968	20.13	2325	19.15	0.852
2006	8987	12.80	2879	23.81	0.913
2007	11227	24.92	3640	26.44	1.000
2008	13883	23.65	4425	21.55	1.056
2009	11428	–17.68	3541	–19.97	1.087
2010	12479	9.20	4141	16.94	1.044
2011	13725	9.98	4889	18.08	1.029
2012	12986	–5.39	4801	–1.80	1.002
2013	13760	5.96	5308	10.55	1.082
2014	14319	4.06	5700	7.40	1.159

Source: own study based on UNCTAD data http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx [access: 30.08.2015].

exports in total, and share of Poland's exports in global exports come from the UNCTAD statistics.

Data in Table 3 show that in the years 1993-2014 Poland's GDP pc rose by 482.8%, EXP pc by 1453.1%, and Poland's EXP share in global exports grew by 0.8 percentage points. In the analyzed period of 22 years, 1995 and 2007-2008 saw the highest growth of GDP pc. EXP pc increased the fastest in the years 1995-1995 and 2003-2008. In 2007 Poland's exports share in global exports reached 1%.

Yet the current level of GDP pc and EXP pc in comparison to other developed countries is relatively low and rises too slowly. The reason for that may be, among others, the character of Poland's comparative advantages. This process is well illustrated in Table 4 which presents leaders of GDP pc and profits from exports per inhabitant. The advantage of the majority of the world countries except for, e.g. Arabic countries as regards the level of income from exports just results from pro-

Table 4. Leaders of GDP pc and EXP pc in USD at current prices in 2014

Position	Country	GDP pc	Country	EXP pc
1.	Luxembourg	116248	Singapore	74418
2.	Norway	98211	Qatar	58333
3.	Qatar	92118	Belgium	42072
4.	Switzerland	87443	United Arab Emirates	41272
5.	Australia	62414	Holland	39879
6.	Denmark	60724	Switzerland	37728
7.	Sweden	59130	Luxembourg	34575
8.	Singapore	54593	Norway	28087
9.	San Marino	54346	Kuwait	27794
10.	United States	53702	Ireland	25434
11.	Ireland	52602	Brunei	25177
12.	Holland	51481	Faroe Islands	23387
13.	Austria	51155	Austria	20929
14.	Iceland	50484	Denmark	19637
15.	Canada	50294	Germany	18533

Source: own study and calculations based on UNCTAD data: http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx [access: 30.08.2015].

duction reallocation towards industries with more technological contents thanks to governments' well-thought and long-term activities. This issue was a research subject for, among others, researchers dealing with countries' development paths, and researchers dealing with theories of endogenous development and new theories of trade [e.g. Majewska-Bator 2010: 93-99; Jantoń-Drozdowska & Majewska 2013: 284-288].

In order to illustrate the impact of indicators of human capital quality on the changes in economy's comparative advantages as a criterion for segmentation of export structure of processed goods, the author adopted a rate of qualification and technology contents. Data on Poland's international trade structure come again from UNCTAD statistics. Table 5 presents evolution of Poland's export structure segmented by level of qualification and technology contents. The data show that in the years 1995-2015 there was a clear fall in the share of material-intensive and labor-intensive products, and with low qualification and technology contents in favor of a rise in the share of medium and high qualification and technology products.

The above-mentioned positive changes in Poland's export structure that took place in the years 1995-2015 do not mean, however, that Poland has significant comparative advantages in trade of products with higher qualification and technology contents. That it is so can be seen from Table 6 which presents indicators of specialization in international trade (IST). The indicators come from UNCTAD

Table 5. Changes in Poland's export structure of processed goods in % in the years 1995-2015

Year	Material- and labor-intensive products		Products with low qualification and technology contents		Products with medium qualification and technology contents		Products with high qualification and technology contents	
	Share %	GR	Share %	GR	Share %	GR	Share %	GR
1995	38.18	–	22.62	–	23.58	–	15.62	–
1996	37.37	8.92	21.18	4.18	25.31	19.44	16.15	15.05
1997	37.31	3.34	17.02	–16.85	27.40	12.07	18.26	17.02
1998	34.89	8.56	19.71	34.47	29.05	23.07	16.34	3.86
1999	35.03	–2.89	18.20	–10.67	31.53	4.99	15.24	–9.77
2000	30.86	3.88	16.92	9.59	36.31	35.78	15.91	23.12
2001	29.79	11.19	18.87	28.48	35.95	14.05	15.38	11.33
2002	28.53	10.59	18.72	14.52	37.16	19.32	15.59	17.05
2003	27.60	27.46	17.83	25.51	38.93	38.07	15.63	32.11
2004	24.44	21.31	18.00	38.30	42.33	48.94	15.23	33.49
2005	22.87	9.76	16.58	8.07	44.35	22.90	16.20	24.74
2006	20.73	11.93	15.99	19.03	45.39	26.38	17.89	36.31
2007	19.78	22.80	16.36	31.71	45.35	28.60	18.51	33.19
2008	18.31	14.14	16.45	24.03	44.37	20.64	20.87	39.10
2009	18.82	–18.38	13.47	–35.00	43.61	–21.94	24.10	–8.32
2010	18.56	12.74	13.06	10.80	42.58	11.60	25.80	22.36
2011	18.69	18.79	15.08	36.20	43.06	19.26	23.18	5.96
2012	18.82	–5.65	14.81	–7.95	42.24	–8.06	24.13	–2.41
2013	18.90	14.25	14.87	14.23	41.93	12.91	24.30	14.52
2014	19.49	9.84	14.44	3.46	41.22	4.73	24.85	8.95
2015	19.14	–9.65	14.08	–10.26	41.47	–7.43	25.31	–6.28

Source: own calculations based on UNCTAD data: http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx [access: 30.08.2015].

statistics. The value of specialization indicator (IST) comes in between –1 and 1. The positive value of the indicator shows that a country specializes in production of a certain commodity, the negative value shows just the opposite. These indicators are calculated according to the following formula:

$$IST = \frac{x_j^i - M_j^i}{x_j^i + M_j^i},$$

where i stands for a given group of products, j refers to a specific country, X means exports, and M imports of products.

On the basis of these indicators it can be stated that Poland has the highest indicator of specialization in trade of material-intensive and labor-intensive

products, and the lowest in products with high qualification and technology contents for which the IST has negative values. However, there is a rise in the level of specialization in products with medium qualification and technology contents. Additionally, the negative IST indicator for products with high qualification and technology contents is declining.

Yeti t is necessary to note that in comparison with other economies of lower labor costs and economically less developed, the current level of Poland's specialization in material-intensive and labor-intensive products may turn out to be insufficient in order to maintain competitiveness in this respect in international markets. Thus it is necessary to put more emphasis on the strengthening of the country's endogenous advantages based on intellectual capital development [Jantoń-Drozdowska & Majewska 2016: 115-116].

Table 6. Changes in indicators of specialization in Poland's international trade in the years 1995-2015

Year	Material- and labor-intensive products	Products with low qualification and technology contents	Products with medium qualification and technology contents	Products with high qualification and technology contents
1995	0.148	0.264	–0.331	–0.479
1996	0.103	0.169	–0.398	–0.508
1997	0.070	0.011	–0.435	–0.509
1998	0.048	0.064	–0.416	–0.536
1999	0.061	0.036	–0.370	–0.582
2000	0.093	0.035	–0.212	–0.545
2001	0.113	0.075	–0.156	–0.506
2002	0.115	0.032	–0.126	–0.473
2003	0.150	–0.002	–0.095	–0.429
2004	0.151	–0.017	–0.029	–0.415
2005	0.174	0.001	0.039	–0.380
2006	0.159	–0.017	0.047	–0.332
2007	0.145	–0.043	0.032	–0.312
2008	0.117	–0.027	0.017	–0.283
2009	0.132	–0.004	0.082	–0.215
2010	0.139	–0.055	0.081	–0.205
2011	0.143	–0.011	0.081	–0.215
2012	0.184	0.003	0.106	–0.189
2013	0.199	0.012	0.110	–0.167
2014	0.184	–0.003	0.095	–0.157
2015	0.173	0.003	0.089	–0.140

Source: own study based on UNCTAD data: http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx [access: 30.08.2015].

3. Discussion of research results

Table 7 shows the level of the Pearson linear correlation coefficients and Spearman's rank correlation coefficients that were calculated for the dependence between higher education indicators and GDP pc, Poland's EXP pc in USD and Poland's export share in global exports in % in the years 1993-2015. All the correlation coefficients, both Pearson's linear correlation and Spearman's rank correlation, turned out to be statistically significant. Their values prove the significance of human capital development for the improvement of learning productivity of Poland's economy, which is reflected in increasing welfare.

Moreover, for the equation taking into account one-year and two-year delay of GDP pc, Poland's EXP pc and Poland's export share in global exports against higher education indicators, the strength of correlation relationship does not diminish. What is more, in case of doctoral degrees, that is specialist knowledge, the strength of correlation relationship clearly goes up over time. It brought about the leveling-off of initial difference between the impact of knowledge acquired at a master's degree level and knowledge acquired in the process of PhD dissertation development. In the previous studies relating to the years 1995-2006 but not taking into account Poland's export share in global exports, the correlation coefficient values showed that more specialist knowledge acquired at a doctoral degree level has a stronger impact on GDP pc and EXP pc growth than knowledge acquired at a master's degree level.

In this study as well as in the previous studies one can see a stronger relationship between the number of technical universities' graduates in Poland and changes in GDP pc and EXP pc than in the case of economic universities' graduates. The same applies to Poland's export share in global exports. This type of situation does not occur in the case of doctoral degrees as the strength of correlation relationship for both their total number and the doctoral degrees awarded at technical and economic universities was similar.

The comparison of the above mentioned results with the ones conducted in earlier studies for the period of 1995-2006 indicates a diminishing significance of the analyzed education indicators for the rise of learning productivity, thus welfare. It relates, to a larger extent, to doctoral degrees. This can be caused by the fact that when the knowledge gap decreases, the very quantitative rise in resources of educated human capital is not enough. It is necessary to put more emphasis on the quality of education and doctoral degrees. The reason for that could be a drain of young and talented scientists by foreign universities and research institutes which offer better working conditions and development opportunities [see: Majewska-Bator, 2010: 287-290, 376].

Table 7. Results of Pearson's linear correlation and Spearman's rank correlation analysis for the relationship between high er education indicators and GDP pc, Poland's EXP pc in USD at current prices and Poland's export share in global exports in % in the years 1995-2015

Number of cases: $t_0 - 22$, $t_1 - 22$, $t_2 - 21$	GDP pc_{t_0}	EXP pc_{t_0}	EXP sh_{t_0}	GDP pc_{t+1}	EXP pc_{t+1}	Share EXP $t+1$	GDP pc_{t+2}	EXP pc_{t+2}	Share EXP $t+2$
Pearson's correlation									
Analyzed period	1993-2014			1993-2015			1993-2015		
Number of higher education institutions' graduates	0.88*	0.88*	0.86*	0.88*	0.90*	0.88*	0.89*	0.92*	0.91*
Number of technical universities' graduates	0.87*	0.87*	0.84*	0.86*	0.88*	0.87*	0.85*	0.89*	0.89*
Number of economic universities' graduates	0.75*	0.74*	0.71*	0.76*	0.78*	0.74*	0.78*	0.82*	0.80*
Number of awarded doctoral degrees	0.80*	0.80*	0.78*	0.79*	0.82*	0.81*	0.81*	0.84*	0.86*
Number of doctoral degrees awarded at technical universities	0.78*	0.78*	0.76*	0.77*	0.79*	0.79*	0.80*	0.83*	0.83*
Number of doctoral degrees awarded at economic universities	0.78*	0.78*	0.77*	0.78*	0.80*	0.79*	0.80*	0.83*	0.83*
Spearman's rank correlation									
Analyzed period	1993-2014			1993-2015			1993-2015		
Number of higher education institutions' graduates	0.95*	0.96*	0.94*	0.96*	0.97*	0.93*	0.97*	0.99*	0.95*
Number of technical universities' graduates	0.90*	0.93*	0.87*	0.91*	0.94*	0.89*	0.90*	0.92*	0.90*
Number of economic universities' graduates	0.57*	0.57*	0.57*	0.66*	0.58*	0.57*	0.68*	0.63*	0.64*
Number of awarded doctoral degrees	0.76*	0.78*	0.74*	0.80*	0.80*	0.80*	0.81*	0.78*	0.85*
Number of doctoral degrees awarded at technical universities	0.75*	0.74*	0.72*	0.77*	0.72*	0.78*	0.80*	0.73*	0.82*
Number of doctoral degrees awarded at economic universities	0.74*	0.73*	0.77*	0.78*	0.73*	0.77*	0.83*	0.76*	0.80*

* statistically significant coefficient at the level $\alpha = 0{,}05$.

Source: own calculations.

The character of correlation relationships presented in Table 8 shows that the higher the indirect measures of human capital in Poland, the lower the export share of material-intensive and labor-intensive products, and those with low qualification and technology contents, and the higher the export share of products with

Table 8. Results of correlation analysis for relationships between higher education indicators and the level of export shares of products with intensive-material and intensive-labor, low qualification and technology, medium qualification and technology, and high qualification and technology contents in % in the years 1995-2015

	Number of university graduates			Number of doctoral degrees awarded		
	Total	Technical universities	Economic universities	Total	At technical universities	At economic universities
Pearson's correlation						
Number of cases: 20						
EXPIMLP t_0	–0.93*	–0.89*	–0.78*	–0.85*	–0.85*	–0.86*
EXPLQT t_0	–0.83*	–0.80*	–0.67*	–0.67*	–0.65*	0.68*
EXPMQT t_0	0.96*	0.91*	0.91*	0.94*	0.95*	0.96*
EXPHQT t_0	0.57*	0.57*	0.28	0.35	0.32	0.33
Number of cases: 21						
EXPIMLP t_1	–0.95*	–0.92*	–0.84*	–0.88*	–0.86*	–0.86*
EXPLQT t_1	–0.83*	–0.80*	–0.71*	–0.76*	–0.77*	–0.77*
EXPMQT t_1	0.96*	0.93*	0.95*	0.95*	0.95*	0.95*
EXPHQT t_1	0.60*	0.58*	0.37	0.44*	0.42	0.44*
Number of cases: 21						
EXPIMLP t_2	–0.97*	–0.94*	–0.91*	–0.93*	–0.91*	–0.91*
EXPLQT t_2	–0.83*	–0.81*	–0.75*	–0.77*	–0.77*	–0.78*
EXPMQT t_2	0.96*	0.95*	0.97*	0.97*	0.96*	0.95*
EXPHQT t_2	0.64*	0.60*	0.46*	0.52*	0.51*	0.52*
Spearman's rank correlation						
Number of cases: 20						
EXPIMLP t_0	–0.96*	–0.79*	–0.51*	–0.58*	–0.63*	–0.66*
EXPLQT t_0	–0.89*	–0.76*	–0.30	–0.54*	–0.46*	–0.57*
EXPMQT t_0	0.76*	0.64*	0.73*	0.75*	0.85*	0.92*
EXPHQT t_0	0.73*	0.57*	–0.05	0.27	0.20	0.26
Number of cases: 21						
EXPIMLP t_1	–0.93*	–0.77*	–0.63*	–0.65*	–0.70*	–0.77*
EXPLQT t_1	–0.88*	–0.76*	–0.41	–0.63*	–0.62*	–0.68*
EXPMQT t_1	0.70*	0.69*	0.88*	0.81*	0.90*	0.95*
EXPHQT t_1	0.76*	0.60*	0.09	0.44*	0.36	0.44*
Number of cases: 21						
EXPIMLP t_2	–0.90*	–0.79*	–0.72*	–0.79*	–0.85*	–0.89*
EXPLQT t_2	–0.88*	–0.82*	–0.62*	–0.71*	–0.75*	–0.74*
EXPMQT t_2	0.68*	0.74*	0.96*	0.88*	0.92*	0.96*
EXPHQT t_2	0.77*	0.68*	0.32	0.51*	0.53*	0.54*

* statistically significant coefficient $\alpha = 0{,}05$.

EXPIMLP – export share of intensive-material and intensive-labor products; EXPLQT – export share of products with low qualification and technology contents; EXPMQT – export share of medium qualification and technology contents; EXPHQT – export share of high qualification and technology contents.

Source: own calculations.

medium and high qualification and technology contents. The strength of correlation relationships increases for the balance with a one-year and two-year time delay in export structure in relation to the growth or drop in the level of indirect measures of human capital quality. As one can see, the results are in line with the above mentioned theoretical considerations. According to them human capital development should lead to positive changes in export structure, and thus to exports resulting in higher added value of manufactured goods.

The level of the received correlation coefficients indicates differences in the strength of the impact of particular higher education indicators on changes in the analyzed export structure. A stronger correlation relationship occurred for the total number of university graduates and the number of technical universities' graduates rather than for the number of economic universities' graduates. As regards the number of awarded doctoral degrees the strength of correlation relationship is similar for these three indirect indicators of human capital quality no matter what group of trade is taken into consideration.

Moreover, for the exports of products with high qualification and technology contents the value of Pearson's linear correlation and Spearman's rank correlation rises over time, becoming statistically significant for all the analyzed indirect indicators of human capital quality in the balance taking into consideration a two-year time delay in the case of Pearson's linear correlation.

The research results show that what is essential in building comparative advantages in international trade is both knowledge acquired at technical universities and at economic universities. For these two types of knowledge are complimentary to each other as regards the expansion of companies on international markets. The former one is used more for modernization and enhancement of technological complexity of products, the latter one for winning sales markets and later maintaining them, and better management of business activity.

Conclusions

The study results for Poland presented in this paper prove the significance of human capital as a factor affecting the level of learning productivity of Poland's economy and point to its role as determinants of reallocation export structure toward technologically more advanced goods. Thus Poland's human capital development at a higher education level contributes to building endogenous advantages based on knowledge and providing higher income from exports, which later can be reinvested in further strengthening of these advantages, e.g, through innovative activities. It may result in an increase, in the long term, in Poland's so far relatively low income from exports per capita.

Thus human capital is the factor enhancing competitiveness of Poland's export structure, whose source is not only lower production costs but, to a larger extent, development of different types of knowledge thanks to better qualified workers. This kind of situation stimulates Poland's shift on the country's development route to an knowledge-based economy associated with welfare. However, for the process to move on over time, it is necessary, in the first place, to attend to the maintaining and growth of education quality not only at a higher education level. It is also necessary to create working conditions for young people and senior workers who want to develop specialist scientific knowledge.

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Oddziaływanie kapitału ludzkiego na zmiany w strukturze eksportu w procesie zmniejszania luki technologicznej

Streszczenie. *Głównym celem opracowania jest prezentacja wyników badań dotyczących oddziaływania akumulacji kapitału ludzkiego poprzez edukację na poziomie szkolnictwa wyższego na zmiany w strukturze eksportu Polski, które wynikają ze wzrostu produktywności uczenia się gospodarki i postępu technologicznego. Okres badawczy stanowiły lata 1993-2015. Badania przeprowadzono metodą korelacji liniowej Pearsona i porządku rang Spearmana. Wyniki badań potwierdzają znaczenie kapitału ludzkiego jako czynnika oddziałującego na poziom produktywności uczenia się gospodarki Polski i wskazują na jego rolę jako determinanty realokacji struktury eksportu w stronę dóbr bardziej intensywnych technologicznie. Rozwój kapitału ludzkiego na poziomie szkolnictwa wyższego w Polsce przyczynia się zatem do budowania endogenicznych przewag opartych na wiedzy i dających wyższe dochody z eksportu, które później można reinwestować w dalsze umacnianie tych przewag, np. w drodze działalności innowacyjnej.*

Słowa kluczowe: *kapitał ludzki, eksport, konkurencyjność, Polska*