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Vertical and horizontal technology transfer and firm innovativeness[1]

*Karina Sachpazidu-Wójcicka**

The paper discusses the relationship between vertical and horizontal technology transfer and firms innovativeness. The main aim of the survey is to determine the relationship between vertical and horizontal technology transfer and innovativeness in surveyed enterprises, what has been investigated empirically. The specific objectives of the article relate to examining which specific dimensions of vertical and horizontal technology transfer influence firms innovativeness positively and which are the most important channels of vertical and horizontal technology transfer in firms innovativeness. The study is based on a survey on firms (n = 100) located in Poland. Data was collected during 100 interviews with managers of randomly selected companies. The article first establishes the research framework, then deduces the research hypotheses and finally describes the analysis tools, sample structure and statistical methods. The study uses a soft modelling method which allows for measuring and analysis of the relationships among unobserved variables (latent variables) – vertical technology transfer, horizontal technology transfer and innovativeness. The surveys have determined positive relationship between both vertical and horizontal technology transfer and innovativeness of the research sample. A strong direct effect on the innovativeness of the firms surveyed has different channels in the case of horizontal and vertical technology transfer, considering the importance of the entity (firm or scientific unit) the technology is transferred from. These findings suggest that measurement of both vertical and horizontal technology transfer and their channels should be developed further as they are important factors for firms innovativeness and competitiveness.

Keywords: innovativeness, vertical technology transfer, horizontal technology transfer.

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Poziomy i pionowy transfer technologii a innowacyjność przedsiębiorstw

Głównym celem autorki jest określenie zależności między pionowym i poziomym transferem technologii a innowacyjnością wybranych w ramach badania przedsiębiorstw. Szczegółowe cele artykułu dotyczą określenia, które z wymiarów pionowego i poziomego transferu technologii wpływają pozytywnie na innowacyjność firm, a które spośród kanałów transferu technologii są najistotniejsze dla innowacyjności w badanych przedsiębiorstwach. Badanie oparte zostało na próbie (n = 100) przedsiębiorstw zlokalizowanych na terenie Polski. Dane empiryczne zebrane zostały podczas 100 wywiadów przeprowadzonych z wybranymi losowo menedżerami przedsiębiorstw. W pierwszej części artykułu ustanowione zostały ramy, a następnie hipotezy badawcze, aby w dalszej części określić narzędzia badawcze, strukturę próby badawczej i metody statystyczne. W ramach badania zastosowane zostało modelowanie miękkie, które

* **Karina Sachpazidu-Wójcicka** – PhD, University of Bialystok, Faculty of Economics and Management. *Correspondence address:* ul. Warszawska 63, 15-062 Białystok, e-mail: sachpazidu@uwb.edu.pl, ORCID: 0000-0003-2654-499X.

umożliwia pomiar oraz analizę związków między zmiennymi nieobserwowalnymi (zmiennymi ukrytymi) – pionowym transferem technologii, poziomym transferem technologii i innowacyjnością. Przeprowadzona analiza wskazała na silny związek zarówno między pionowym, jak i poziomym transferem technologii a innowacyjnością w badanej próbie przedsiębiorstw. Istnieje silny bezpośredni wpływ wybranych kanałów transferu technologii – różnych kanałów w przypadku pionowego i poziomego transferu technologii w zależności od podmiotu (przedsiębiorstwo czy jednostka naukowa), z jakiego technologia jest transferowana na innowacyjność badanych firm. Uzyskane wyniki sugerują, że pomiar pionowego i poziomego transferu technologii, jak również specyfika poszczególnych kanałów powinny być dalej zgłębiane, jako że stanowią one ważny element w uzyskiwaniu wyższego poziomu innowacyjności przed firmy, co również przekłada się na ich konkurencyjność.

Słowa kluczowe: innowacyjność, poziomy transfer technologii, pionowy transfer technologii.

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1. Introduction

Innovation is a key source of knowledge-based competitive advantage (Huarng, 2015). The role of technology in life keeps increasing and to analyze the effects of various types of technology on the activity of enterprises should be an interesting, pertinent, modern-day subject. According to Ch. Freeman (1972), innovation is any kind of novelty which becomes the subject of trade for the first time and firms that do not innovate find it hard to survive. One of the keys to success in any organization has been identified in terms of taking advantage of and applying for knowledge acquired from technology transfer (TT) in strengthening the company's capability (Gilbert and Cordey-Hayes, 1996). Firms that acquire technology and make an effective use of it are able to compete in domestic and international markets (Lynn, Skov and Abel, 1999). Enterprises have to consider the process of innovation in the sense of social change as well as in the realm of business (Kim and Huang, 2011). The ability to gain and apply developmental technology can improve the mean performance level which in turn maximizes the competitive advantage of the firm (Gilbert and Cordey-Hayes, 1996). Intense global competition and rapid technological change have transformed the current competitive environment (Prahalad, 1998). There is an increased pressure on enterprises to advance knowledge and new technologies in a constant basis in order to ensure their long-term prosperity and survival (Steele, 1989).

Innovativeness in the economic dimension refers to the ability of enterprises to continuously acquire and use in practice the results of scientific research, research and development, new concepts as well as ideas and inventions (Oslo Manual, 2005). In market conditions a company can obtain innovation from external sources rather than through involving in its own research and development (R&D) activities. When the acquisition and implementation of technology from external sources is accompanied by research and development, the internal technology process is observed.

Practitioners consider innovation as a tool to improve the paths of growth available to their firms, and use branding to survive the competition they face in the market (Gupta and Malhotra, 2013). Companies that rely on imitation of technological resources are able to achieve a sustainable competitive advantage (Bettis and Hitt, 1995; Teece, 1977). One of the key success factors of the organization becomes the use of transferred knowledge in increasing a company's competitive ability (Gilbert and Cordey-Hayes, 1996). Innovation transfer can contribute significantly to the achievement of competitive advantage (Sazali et al., 2009). Only the firms strong enough to have sufficient research and development activity, as well as financial resources, are able to innovate according to and based on their own resources. Therefore, these ways of acquiring innovativeness are usually beyond the reach of most companies. Usually firms, especially smaller ones, have modest financial resources and poor human capital. On the other hand, internal research and development (R&D) activity is usually risky and thus out of reach of most firms. In that situation, companies can lean towards the purchase of finished material and well-proven technologies. Therefore, to achieve innovativeness, modern enterprises are obliged to use the opportunities offered by the technology transfer – both vertical and horizontal.

The most important contribution of this article is to extend the analysis of the relationship between horizontal and vertical technology transfer and innovativeness of firms. Under the survey, specific vertical and horizontal technology transfer channels are characterized and empirically investigated under conditions of indirect influence on innovativeness and the direct influence and role for vertical and horizontal technology transfer. The article is organized into five sections. Following the introduction, theoretical background conceptual model with hypotheses is presented. The third section is dedicated to research method and the fourth to results. Conclusions are presented in the fifth section.

2. Theoretical background

Firms have many ways of exploiting their technological assets for profitability and growth. While internal exploitation of technological assets, through designing, developing, manufacturing, and selling products and processes remains important, interest in their external exploitation through technology transfer has intensified over the recent years (Ramanathan, 2011).

According to Chakrabarti (1973), transfer of technology is a general transfer of information between science, technology and its current use. Diffusion and technology transfer must be understood as essentially phenomenological issues. Technology is information, and is relevant only to an extent to which people can put it into practice and use it to achieve values (Eveland, 1986). It is common to assume that the cost of transferring the innovation to other firms is much lower so that the marginal cost of successive application is trivial compared to the average cost of research, development and application (Teece, 1977). Keller (2009) sets up a complex mechanism by which technology transfer takes place both at intra and inter industry level.

The literature identifies several channels through which technology can occur and increased competition from foreign affiliates may force local competitors to improve their efficiency (Glass and Saggi, 2002).

In some situations technology transfer may be confined to relocating and exchanging of personnel (Osman-Gani, 1999). Labor turnover can benefit local firms by attracting skilled workers trained in multinationals (Fosfouri et al., 2001).

The term technology transfer can be defined as the process of movement of technology from one entity to another (Souder et al., 1990). The movement may involve physical assets, know-how, and technical knowledge (Bozeman, 2000). Technology transfer can be understood as a movement of a specific set of capabilities (Lundquist, 2003). Hayami and Ruttan (1971) and Mansfield (1975) refer to material transfer, design transfer and capacity transfer. The first one refers to the transfer of a new material or product, while design transfer corresponds to the transfer of designs and blueprints that can facilitate the manufacturing of the material or product by the transferee. Capacity transfer involves the transfer of know-why and know-how to adapt and modifies the material or product to suit various requirements.

The concept of technology transfer is also applied to determine the movement of technology from laboratories to industry, from developed to developing countries or from one application to another sphere of activity. The movement may concern physical assets, know-how and technical knowledge. In some cases technology transfer may be related to the transfer and exchange of personnel or the movement of a specific set of skills. In that sense, technology is considered information and technology transfer is defined as the use of information. Technology transfer is a movement of knowledge, skills, methods of organization, value and capital from the point of production to the place of its adaptation and application (Lunguis, 2003).

The purpose of the flow of new knowledge from research institutions to enterprises is usually technical innovation, while the goal of the flow between companies is mainly the diffusion of innovation.

According to the OECD (1997), technology transfer can be divided into:

- transfer between companies;
- transfer to companies from the public R&D sector, including universities.

According to Masfield (1982), one of the fundamental processes that influence the economic performance of nations and firms is technology transfer. Vertical technology transfer occurs when information is transmitted from basic research to applied research, from applied research to development, and from development to production. Such transfers occur in both directions, and the form of the information changes as it moves along this dimension. Horizontal transfer of technology occurs when technology used in one place, organization, or context is transferred and used in another place, organization, or context (Masfield, 1982). According to this division, technology transfer is the division due to the plane in which it occurs. According to this division, we distinguish vertical and horizontal technology transfer. Technology transfer levels are the process of transfer of new technological knowledge to industrial production or the flow of information or knowledge from the level of basic and applied research to the level of production. Technology transfer in this approach can take place horizontally in any direction. The form of information transmitted changes as it is transferred as part of the horizontal technology transfer. We talk about the horizontal transfer of technology when technology used in one place or organization, meaning is transferred and then used in another place or organization.

In the case of the creation of knowledge by the subjects of the research and development sphere, the results of activities of scientific entities in the form of inventions and technical projects are transferred to the enterprise, which then use them in their production. The policy of the donor and the possibilities of using the new technology by the recipient determine the course of vertical technology transfer.

According to literature (Mansfield, 1982; Languis, 2003; Ramanathen, 2011), TT forms differ depending on whether we have to deal with vertical or horizontal transfer of technology. The basic technology flow channels within the vertical TT are as follows:
- contract research, ordered by enterprises;
- licenses for inventions;
- utility models;
- know-how;
- scientific and technical consulting;
- flow of technical staff, training;
- spin-off firms;
- information in scientific publications;

In turn, the basic channels of horizontal technology transfer are:
- licenses for inventions;
- utility models;
- know-how;
- automation means, technological lines;
- industrial cooperation;
- technical services;
- joint research projects.

Innovation strategies exploiting external flows of knowledge represent a new source of competitive advantage for companies (Gassmann et al., 2010). Limited resources may incentivize firms to rely on less expensive and less risky alternatives than internal R&D (Dahlander and Gann, 2010). Firms rely heavily on external knowledge for innovation (Ortega-Argilés et al., 2009). According to Un et al. (2010) research, there is an interaction effect among external R&D collaborations including universities, suppliers, customers, and competitors on a firm's product innovation. Engaging external entities such as suppliers and customers in the innovation process can facilitate innovation (Von Hippel, 1998). To become more competitive and innovative, firms need to expose to external knowledge. Thus, the research attempts to examine whether firms can gain innovativeness from both vertical and horizontal technology transfer. In line with this, the first hypothesis was put forth:

H1. Vertical and Horizontal technology transfer relate positively to firm innovativeness.

Due to the fact that horizontal and vertical technology transfer mostly occur through similar channels, it is important to understand whether in the case of a difference in the technology donor (firm or scientific unit) there is any difference in the influence of the same type of technology channel on innovativeness and if all the channels influence the innovativeness in the same strength. In line with this second hypothesis was proposed:

H2. Firm innovativeness is influenced by the same vertical and horizontal technology transfer channels.

3. Research method[2]

Analysis and evaluation of innovativeness of enterprises is quite complex and raises a lot of doubts. Based on the literature in the field of innovation it can be concluded that sources of innovation in enterprises are widely reported (Rogers, 1998; Utterback and Abernathy, 1975; Mayer and Blaas, 2002), with a detailed approach to the subject of technology transfer and its place in the innovation process, and the relative configuration of technology transfer and innovativeness.

For this purpose, a research model defining the relationship between vertical and horizontal technology transfer and innovativeness of firms has been developed. The statistic model was based on substantive criteria, both knowledge and experience in research on technology transfer. All indicators such as vertical, horizontal technology transfer as well as innovativeness are more complex and do not have one definition and unambiguous measurement, hence their definition as hidden variables makes it possible to measure them. For this purpose the survey uses the method of soft modelling (Wold, 1980; 1982) which allows user to examine links between variables which are not directly observable – latent variables. The values of the variables cannot be directly gauged as there is the lack of a widely accepted definition or method of their measurement. The soft model consists of two sub-models: an internal one (structural model) and an external one (measurement model) (Skrodzka, 2018).

The internal model describes dependencies between latent variables implied by the assummed theoretical model (Skrodzka, 2018). The internal sub model can be expressed as (Rogowski, 1990; Skrodzka, 2018):

$$\boldsymbol{\Xi}_{\mathbf{end}} = \boldsymbol{\Xi}_{\mathbf{end}}\,\mathbf{B} + \boldsymbol{\Xi}_{\mathbf{egz}}\mathbf{C} + \mathbf{V}, \qquad (1)$$

where

$\mathbf{B} = [b_{ij}]$ – n-square matrix with a diagonal of zeroes,

$\mathbf{C} = [c_{ij}]$ – $((k - n) \times n)$ – dimensional matrix of structural parameters associated with endogenous and predetermined variables, respectively,

$\mathbf{V} = [v_j]$ – n-dimensional vector of random components with expected values equal to zero and finite variances,

$\boldsymbol{\Xi}_{\mathbf{end}} = [\xi_1, \ldots, \xi_n]$ – n-dimensional row vector of unlagged endogenous variables,

$\boldsymbol{\Xi}_{\mathbf{egz}} = [\xi_{n+1}, \ldots, \xi_k]$ – $(k - n)$-dimensional row vector of predetermined theoretical variables.

Latent variables in external model are defined by means of observable variables (indicators). The indicators allow for indirect observation of the latent variables and are selected on the basis of a theory or the researcher's intuition. A latent variable can be defined inductively: the approach is based on the assumption that indicators form latent variables (formative indicators), or deductively, based on the premise that indicators reflect their theoretical notions (reflective indicators). In the deductive approach, a latent variable is a starting point in the search for empirical data (the variable precedes a given indicator). In the inductive approach, it is indicators that precede the latent variable which they form. Under both approaches, latent variables are estimated as weighted sums of their indicators (Skrodzka, 2018). Indicators should have different statistical properties – a lack of correlation in the case of the inductive definition and high correlation in the case of the deductive definition (Wold, 1982; Skrodzka, 2018).

The formal notation of external relations is (Rogowski, 1990; Skrodzka, 2018):

$$\underset{j=1,\ldots,k}{\forall}\ \underset{t=1,\ldots,T}{\forall}\ \xi_{tj} = \sum_i w_{ij} x_{tij}. \qquad (2)$$

It is assumed that each latent variable is a weighted sum of its indicators. For each reflective indicator, the relation measuring the strength of reflection is given (Rogowski, 1990; Skrodzka, 2018):

$$\underset{j=1,\ldots,k}{\forall}\ \underset{t=1,\ldots,T}{\forall}\ \xi_{tj}\ x_{tij} = \pi_{ij0} + \pi_{ij}\xi_{tj} + \mu_{tij}, \qquad (3)$$

where:

ξ_{tj} – t-th values of variables, respectively, ξ_j and i-th indicator of this variable,

w_{ij} – weight associated with x_{ij}, when defining ξ_j,

π_{ij} – factor loading measuring the strength of reflection of the latent variable ξ_j by its i-th indicator,

μ_{tij} – random component with expected values equal to zero.

The estimation of soft model parameters is performed by means of the partial least squares method – PLS (Lomhmöller, 1989; Esposito Vinzi et al., 2010). The quality of the model is assessed using coefficients of determination – R^2. The significance of the parameters is analyzed by means of standard deviations, calculated with the help of the Tukey's test. In the case of the external model, estimators of factor loadings are treated as the degree of fit between each indicator and the latent variable which they define. The prognostic quality of the model is assessed by Stone-Geisser test (S-G). The test measures the accuracy of a prognosis performed on the basis of the model in juxtaposition to a trivial prognosis. The tests statistics take values from the range of $(-\infty,1>$. For an ideal model, the value of the test equals 1 (prognoses are accurate in comparison with trivial prognoses). If the value is equal to zero, the quality of the model's prognosis is, on the average, identical to the quality of a trivial prognosis. Negative values indicate low quality of the model (worse predictive value of the model compared to a trivial prognosis). By applying the PLS method, an estimation of values of the latent variables is made. They can be treated as values of synthetic measures and can be used to produce a linear ordering of the studied objects. These values depend not only on external relationships, but also on the relationships among the latent values assumed in the internal model. This means that the cognitive process is not only dependent on the definition of a given notion, but also on its theoretical description (Skrodzka, 2018).

Specification of the model

The model used for development of the survey objective contained the following equation:

$$\text{INNO} = \alpha_1\text{VTT} + \alpha_2\text{HTT} + \nu, \quad (4)$$

where INNO – innovativeness, VTT – vertical technology transfer, HTT – horizontal technology transfer, α_1, α_2 – structural parameters of the model, ν – random component.

The latent variables INNO, HTT and VTT are defined by means of observable variables on the basis of the deductive approach, *i.e*. the latent variable, as a theoretical concept, serves as a starting point to identify empirical data (Skrodzka, 2018).

Using the available domestic and international literature, primary sets of indicators of the variables VTT, HTT and INNO were developed. The model consists of three latent variables (Skrodzka, 2018). Each of the variables has been defined using a set of indicators (Table 1, Table 2, Table 3).

From the statistical point of view, the following considerations were taken into account: variability of indicator values (coefficient of variation above 10%) and an analysis of the quality of the estimated model (an *ex post* analysis) (Skrodzka, 2018).

The INNO – innovativeness latent variable, is defined by ten indicators (Table 1). The innovativeness is understood as the innovation in product, process, marketing and organization. The assumptions in the field of innovation within the article are based on the Oslo Methodology in the field of innovation, which perceives innovativeness as the introduction of new or significantly changed products, processes or solutions in the field of marketing and organization (Oslo Manual, 2005).

For each type of innovation specific indicators where specified. For a level of innovativeness, the number of innovations implemented by the company as well as their novelty are important.

Table 1. Indicators of innovativeness

Symbol of indicator	Indicator
INN01	Introducing new or improved products by the firm to the market
INN02	The novelty level of new or improved products introduced to the market
INN03	The number of new or improved products introduced to the market
INN04	New or significantly improved technology processes used in the firm
INN05	The novelty level of new or improved processes used in the firm
INN06	The number of new or improved processes implemented in the firm
INN07	Implementation of a marketing method not used so far in the firm
INN08	Characteristics of a new marketing method implemented in the firm
INN09	Implementation of organizational method in the principles of operation adopted by the firm
INN010	Characteristics of a new organizational method implemented in the firm

Source: author's own elaboration.

Technology transfer is a term describing a very wide range of activities, depending on the scope of activities to be covered by the transfer or from entities involved in it. For the purposes of this article, technology transfer is seen as the process of transferring technology from a technology donor to its recipient. Horizontal technology transfer takes place from research units belonging to the research and development sphere, *i.e.* the entirety of institutions and people involved in creative work undertaken to increase the knowledge base and to find new applications for it. Vertical technology transfer takes place between companies within selected channels.

The VTT latent variable is defined by nine indicators (Table 2). As the vertical technology transfer describes the transfer of technology from firm to the firm, all the indicators describe the move of technology from a company to the company (to the surveyed sample).

Table 2. Indicators of vertical technology transfer

Symbol of indicator	Indicator
VTT1	Patent purchase
VTT2	Purchase of the right to use a non-patented invention
VTT3	Purchase of a license
VTT4	Purchase of designs or utility models
VTT5	The use of scientific and technical consultancy services
VTT6	Employment of highly specialized employees
VTT7	Commission of research services
VTT8	External training
VTT9	Cooperation in developing technologies with another company

Source: author's own elaboration.

The HTT latent variable is defined by ten indicators (Table 3). As the horizontal technology transfer describes the transfer of technology from scientific unit to the company, all the indicators describe the move of technology from a scientific unit to the company (to the surveyed sample).

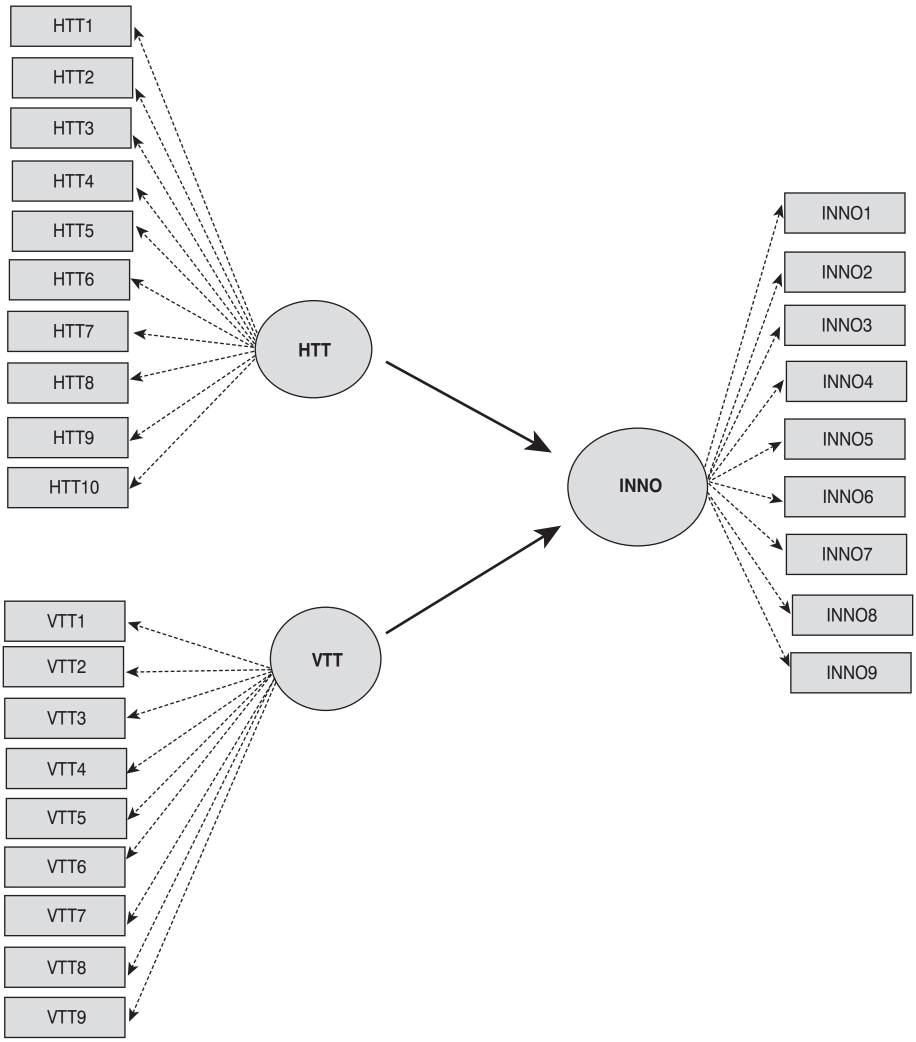
Table 3. Indicators of horizontal technology transfer

Symbol of indicator	Indicator
HTT1	Patents purchase
HTT2	The right to use a non-patented invention purchase
HTT3	License Purchase
HTT4	Know-how
HTT5	Purchase of designs or utility models
HTT6	The use of scientific and technical consultancy services
HTT7	Employment of highly specialized employees
HTT8	Commission of research services
HTT9	External training
HTT10	Cooperation in developing technologies with scientific unit

Source: author's own elaboration.

A schematic diagram of the soft model, taking into consideration both the internal and external relationships, is presented in Figure 1.

Figure 1. Soft model of internal and external relationships



Source: author's own elaboration.

The model was estimated using the PLS method, which enables simultaneous estimation of the external model parameters (weights and factor loadings) and the internal model parameters (structural parameters). The estimation was conducted with the help of PLS software (Skrodzka, 2018).

The survey adopted a variant of partial studies. The study included stratification of the population before the draw test. This ensured that the special features included in the group of firms are represented in the sample and reflect the actual proportions of individuals with the same characteristics in the population of firms (Fowler, 1995). The units of study were managers of the highest level of randomly selected enterprises. The samples for the study had to meet the following criteria of the company activity – manufacturing and firm size <250 employees. Based on applied research tool – direct questionnaire – pilot study in the group of 10 firms was conducted to determine the difficulty in understanding the structure of the questions and answers. The study was carried out in 2017–2018 by CATI interviews in Poland. During the study 100 valid interviews were collected.

4. Results

The relative share of a given indicator in the estimated value of a hidden variable is represented by individual weights (Table 4). Factor loadings are coefficients of correlation between latent variables and indicators. This indicates the degree and direction of the variation of the indicator reflecting the variability of the latent variable. When the latent variable is determined inductively, the order of the indicators is performed according to weight. In the survey, deductive approach was applied where factor loadings are interpreted (Skrodzka, 2018). According to that π_{ij} factor accepts values (Nowak, 1990):

- $|\pi_{ij}| < 0,2$ – no correlation;
- $0,2 \leq |\pi_{ij}| < 0,4$ – weak correlation;
- $0,4 \leq |\pi_{ij}| < 0,7$ – moderate correlation;
- $0,7 \leq |\pi_{ij}| < 0,9$ – strong correlation;
- $|\pi_{ij}| \geq 0,9$ – very strong correlation.

In terms of estimated parameters the results consist with the assumptions. The stimulants have positive estimations of weights and factor loadings. The destimulants have negative estimations of weights and factor loadings. According to '2s' principle, all parameters are statistically significant (Skrodzka, 2018).

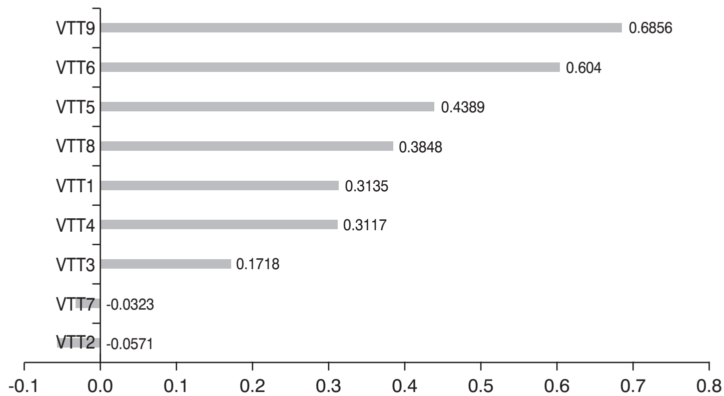
Table 4. Estimations of external relationships parameters in the soft model

Symbol of indicator	Weight	Standard deviation	Factor loading	Standard deviation
VTT **latent variable**				
VTT1	0.3178	0.0277	0.3135	0.0287
VTT2	–0.1324	0.0405	–0.0571	0.0383
VTT3	0.0511	0.0382	0.1718	0.0402
VTT4	0.2158	0.0203	0.3117	0.0231
VTT5	0.3073	0.0319	0.4389	0.0282
VTT6	0.4188	0.0222	0.6040	0.0307
VTT7	–0.1651	0.0221	–0.0323	0.0272
VTT8	0.1851	0.0070	0.3848	0.0100
VTT9	0.5139	0.0168	0.6856	0.0136
HTT **latent variable**				
HTT1	–0.0230	0.0218	0.0657	0.0217
HTT2	–0.0155	0.0129	0.0587	0.0139
HTT3	0.2049	0.0176	0.4439	0.0199
HTT4	0.0529	0.0174	0.0563	0.0160
HTT5	0.0304	0.0342	0.3084	0.0413
HTT6	0.3069	0.0165	0.6556	0.0157
HTT7	0.1313	0.0295	0.2119	0.0296
HTT8	0.3250	0.0097	0.5792	0.0175
HTT9	0.2783	0.0250	0.4888	0.0278
HTT10	0.4597	0.0192	0.7524	0.0120
INN **latent variable**				
INN01	0.2427	0.0046	0.8471	0.0213
INN02	0.2271	0.0152	0.8087	0.0139
INN03	0.2009	0.0135	0.7380	0.0291
INN04	0.1974	0.0185	0.6814	0.0278
INN05	0.1184	0.0168	0.5871	0.0468
INN06	0.0787	0.0126	0.4673	0.0478
INN07	0.1136	0.0223	0.4668	0.0520
INN08	0.1136	0.0216	0.4734	0.0372
INN09	0.1292	0.0212	0.4447	0.0314
INN010	0.1224	0.0261	0.4698	0.0327

Source: author's own elaboration.

The indicators reflect VTT latent variable with varying strength (Figure 2). There is no correlation of variable with one indicator – purchase of a license (VTT3). Variables commission of research services (VTT7) and purchase of the right to use a non-patented invention (VTT2) are destimulants. The variable is weakly correlated with indicators external training (VTT8), patent purchase (VTT1) and designs or utility models purchase (VTT4). The most important and correlated indicators are cooperation in developing technology with another company (VTT9) and employment of highly specialized employees (VTT6).

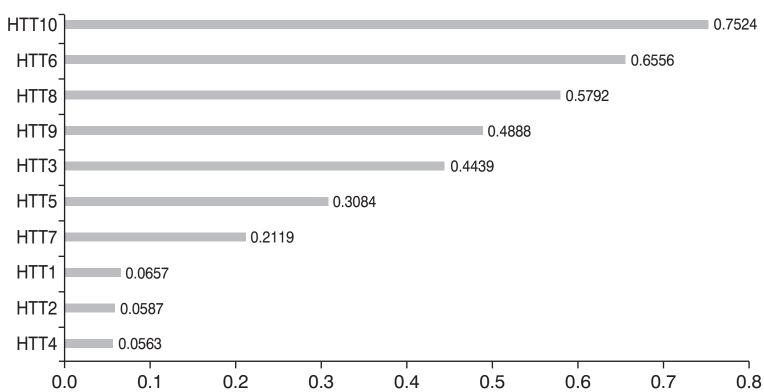
Figure 2. Estimations of factor loadings of VTT latent variable



Source: author's own elaboration.

The indicator cooperation in developing technology with scientific unit (HTT10) most strongly reflects the variable of horizontal technology transfer (Figure 3). The variable is also reflected by indicator the use of scientific and technical consultancy services (HTT6) and commission of research services (HTT8). There is a moderate correlation of external training (HTT9) and license purchasing (HTT3) indicator with variable. One indicator employment of highly specialized employees (HTT7) is weakly related with variable and two indicators the right to use a non-patented invention purchase (HTT2) and Patents purchase (HTT1) are no correlated with variable.

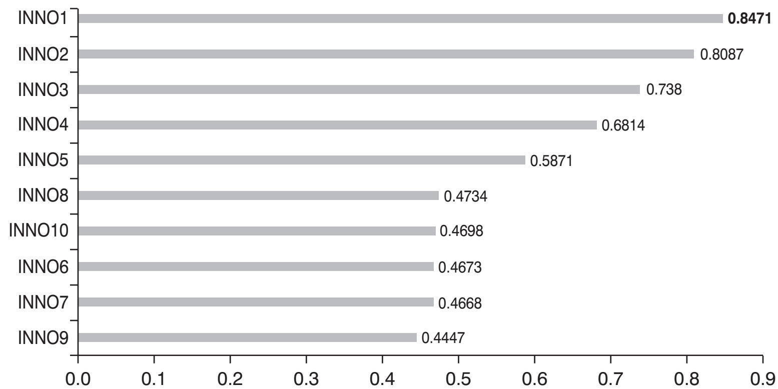
Figure 3. Estimations of factor loadings of HTT latent Variable



Source: author's own elaboration.

All indicators are correlated to the variable (Figure 4). The indicators introducing new or improved products to the market (INNO1), the number of new or improved products introduced to the market (INNO3) and the novelty level of new or improved products (INNO2) are strongly correlated with innovativeness variable. All the other rest indicators (INNO4, INNO5, INNO6, INNO7, INNO8, INNO9, INNO10) are moderately correlated with the variable.

Figure 4. Estimations of factor loadings of INNO latent Variable



Source: author's own elaboration.

The following equation illustrates the outcomes of the internal model estimation:

$$INN = \underset{(0.0124)^{*}}{0.3811}VTT + \underset{(0.0167)^{**}}{0.3725}HTT + \underset{(0.0278)^{***}}{0.7170} \quad R^2 = 0.3489$$

Standard deviations (*,**,***) were calculated by means of the Tukey's test. The structural parameters are statistically significant ('2s' rule). The value of the coefficient of determination R^2 justifies the conclusion that the independent variables VTT and HTT both determine the variability of the dependent variable INNO. The values of the Stone-Geisser test, which verifies the soft model in terms of its predictive usefulness (Table 5) are positive, which proves the model's high prognostic quality (Skrodzka, 2018). The indicator the number of new or improved processes implemented in the firm (INN6) has the weakest predictive power, while introducing new or improved products to the market (INNO1) is the strongest one.

The estimation of the internal model parameters indicates a positive and significant correlation between vertical and horizontal technology transfer and innovativeness in the surveyed firm population.

Table 5. Values of the Stone-Geisser test

Symbol of indicator	Value of S-G test
INN01	0.2572
INN02	0.2224
INN03	0.1702
INN04	0.1650
INN05	0.0535
INN06	0.0224
INN07	0.0346
INN08	0.0413
INN09	0.0631
INN010	0.0562
General value	0.1234

Source: author's own elaboration.

In order hypothesis H1. vertical and horizontal technology transfer relate positively to firm innovativeness was statistically verified??. The revised model is statistically significant. Model results indicate a significant correlation and positive impact of vertical and horizontal technology transfer on innovativeness in the surveyed group of firms. First hypothesis has been verified positively. In order of verification?? of hypothesis H2. firm innovativeness is influenced by the same vertical and horizontal technology transfer channels was statistically verified. Model results indicate that in the case of vertical and horizontal technology transfer not the same channels influence the innovativeness of surveyed firms sample.

5. Conclusions

This study aims to contribute to the innovation literature by untangling the relationship among the level of innovativeness, transfer of technology and channels through which vertical and horizontal technology transfer occurs in firms. It was also important to define which of VTT and HTT channels influence innovativeness of the surveyed firms.

Regarding its methodology, this survey is one of the first studies to examine the relationship between vertical and horizontal technology transfer and innovativeness of firms based on individual-level data and according to theory. The study uses a soft modelling method which allows for measuring and analysis of the relationships among unobserved variables (latent variables) – vertical technology transfer, horizontal technology transfer and firm innovativeness. The survey has determined positive relationship between both vertical and horizontal technology transfer and innovativeness of the research sample. A strong direct effect on surveyed firms innovativeness have different channels in the case of horizontal and vertical technology transfer, considering it is important from which entity (firm or scientific unit) the technology is transferred. The value of the coefficient of determination R^2 justifies the conclusion that the independent variables VTT and HTT both determined the variability of the dependent variable INNO. The estimation of the internal model parameters indicates a positive and significant correlation between vertical and horizontal technology transfer and innovativeness in the firm population under survey. Both vertical and horizontal technology transfers influence the level of innovativeness of the companies surveyed. For innovativeness in the case of vertical technology transfer, the most important and correlated indicators are cooperation in developing technology with another company and employment of highly specialized employees from other companies. From horizontal technology transfer, the most important for firms innovativeness is cooperation in developing technology with a scientific unit. The model showed that from horizontal technology transfer, the employment of highly specialized employees from scientific units is not so important for firms innovativeness.

On the basis of the survey findings obtained, recommendations regarding vertical and horizontal transfer to firms can be formulated. As both VTT and HTT have positive influence on firm innovativeness, enterprises should more actively engage in transfer activities. Firms should be especially interested in cooperation in developing technologies in cooperation with other companies, firms and scientific units. It is also important for firms innovativeness to employ highly specialized employees, with technology experience gained in other enterprises.

Obviously, further research in the future is needed. The most important points to the future analysis are detailed vertical and horizontal technology transfer aspects and their influence on firms innovativeness and competitiveness.

Endnotes

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