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THE ANALYSIS OF THE EFFECTS OF THE USE OF ICTS BY KNOWLEDGE WORKERS: EMPIRICAL EVIDENCE FROM MANUFACTURING ENTERPRISES IN POLAND AND IN GERMANY¹

Abstract

This article elaborates an existence of a positive effect of the use of a series of ICTs by knowledge workers on increasing the number of R&D projects in a manufacturing company. It focuses on the set of the knowledge workers, who use a series of ICTs (1) for searching data and information, (2) for sales and purchases, (3) for creating new ideas and products, (4) for analysing data and information in manufacturing companies and is based on a survey and data obtained from 62 Polish Manufacturing Enterprises from Lubuskie region and from 23 German Manufacturing Enterprises from Brandenburg region – also from 85 manufacturing enterprises from the region: „cross-border cooperation: Lubuskie/Poland and Brandenburg/Germany”. This article develops a framework to examine the main relationships between the use of a series of ICTs by knowledge workers and how it influences the increase of R&D projects in manufacturing companies and further discusses the research results.

Key words: knowledge workers, ICTs, manufacturing enterprises in Poland and in Germany.

ANALIZA EFEKTÓW STOSOWANIA INFORMATYCZNYCH TECHNOLOGII PRZEZ PRACOWNIKÓW WIEDZY: WYNIKI BADAŃ Z POLSKICH I NIEMIECKICH PRZEDSIĘBIORSTW PRODUKCYJNYCH

Streszczenie

W artykule pokazano istnienie pozytywnego wpływu użytkowania informatycznych technologii przez pracowników wiedzy na wzrost liczby realizowanych projektów badawczo-rozwojowych w przedsiębiorstwach produkcyjnych. Zdefiniowano zbiór pracowników wiedzy, którzy stosują technologie informatyczne odpowiednio dla celów: (1) poszukiwania danych i informacji, (2) dla celów sprzedaży i zakupu, (3) dla celów tworzenia nowych pomysłów i produktów, (4) dla celów analizy danych i informacji w przedsiębiorstwie produkcyjnym. Wyniki badań przedstawione w artykule opierają się na wynikach badań empirycznych uzyskanych z 62 polskich przedsiębiorstw produkcyjnych z województwa lubuskiego i z 23 przedsiębiorstw produkcyjnych z regionu Brandenburg – to jest z 85 przedsiębiorstw produkcyjnych z regionu transgranicznej współpracy polsko-niemieckiej: Lubuskie – Brandenburg. W artykule zdefiniowano relacje pomiędzy zastosowaniem informatycznych technologii przez pracowników wiedzy

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i zwiększeniem liczby realizowanych projektów badawczo-rozwojowych w przedsiębiorstwach produkcyjnych oraz przeprowadzono dyskusję wyników.

Key words: pracownicy wiedzy, informatyczne technologie, przedsiębiorstwa produkcyjne w Polsce i Niemczech.

Introduction

The use of ICTs by knowledge workers plays an important role in increasing the number of R&D projects within a manufacturing company. It is accepted, that an organization's information technology allows for the capture and distribution of information and also knowledge among workers and ensures the development of professional intellect within a company to much higher levels².

A company needs to develop systems to acquire and share knowledge among its workers. Vandaie (2008)³ stated that knowledge acquisition and knowledge storage may not contribute significantly to the success of a project. On the other hand Maurer (2010)⁴, pointed out that knowledge transfer may increase the success rates of R&D projects. In addition, the use of knowledge acquired from information technology systems implemented in a company in coordination with a project (cross project knowledge transfer) may have a positive effect on the outcome of a project⁵. Furthermore, Mourgues and Fischer (2008)⁶ argued that the acquisition of information during the realization of a project is a critical factor to its success. Moreover, Dai et al. (2005)⁷ stated that negative productivity of professional workers may be due to the poor quality of information they receive.

Knowledge workers can be defined as those workers in a company who use their knowledge, competency and skills to realize their work activities. Huber (2013)⁸ showed that good personal relationships might be useful for R&D activities.

The purpose of this paper is to examine the main relationships between the use of a series of ICTs by knowledge workers and how it influences on the completion of R&D projects in manufacturing companies. The research question is asked: does the use of a series of ICTs by

² J.B. Quinn, P. Anderson, S. Finkelstein. Managing professionals intellect: Making the most of the best. In: Klein, D.A. (eds.) *The strategic management of Intellectual Capital*, 1998, Butterworth-Heinemann.

³ R. Vandaie. The role of organizational knowledge management in successful ERP implementation projects. *Knowledge-Based Systems*, 2008, 21 (8), 920-926.

⁴ Maurer. How to build trust in inter-organizational projects: the impact of project staffing and project rewards on the formation of trust, knowledge acquisition and product innovation. *International Journal of Project Management*, 2010, 28 (7), 629-637.

⁵ J.G. Park, J. Lee. Knowledge sharing in information systems development projects: explicating the role of dependence and trust. *International Journal of Project Management*, 32(1), 153--1651 (2014)

G. Schuh, T. Drescher. Systematic leverage of technological assets: A case study for automated tissue engineering. *Journal of Engineering and Technology Management*, 2014, 32, 76-96.

⁶ Mourgues, M. Fischer. A Work Instruction Template for Cast-in-Place Concrete Construction Laborers: Center for Integrated Facility Engineering. 2008, Stanford University. Working Paper #109.

⁷ J. Dai, P.M. Goodrum, W.F. Maloney, C. Sayers. Analysis of Focus Group Data Regarding Construction Craft Workers' Perspective of the Factors Affecting Their Productivity. *American Society of Civil Engineers*, in: *Proceedings from the 2005 Construction Research Congress*, 2005, 1-10.

⁸ F. Huber. Knowledge-sourcing of R&D workers in different job positions: Contextualising external personal knowledge networks. *Research Policy*, 2013, 42(1), 167-179.

knowledge workers within a company is the source for creation and completion of R&D projects?

Based on this, the current study aims to promote the creation of new R&D projects within a manufacturing company whose knowledge workers are working with the use of a series of ICTs. This paper aims to make a contribution to the literature on the use of information technology in a manufacturing company. In this paper, the use of a series of ICTs knowledge workers in a manufacturing company is analysed according to Bigliardi, Dormio, and Galati, (2010)⁹ and is stated, that knowledge workers should use technologies which allow (1) to search data and information, (2) to sale and purchase, (3) to create new ideas and products, (4) to analyse data and information. Using survey data from 62 Polish Manufacturing Companies from Lubuskie region and from 23 German Manufacturing Companies from Brandenburg region analysed with a correlation approach, it is possible to show how the use of ICTs by knowledge workers is related to an increase in the number of R&D projects in the region: „cross-border cooperation: Lubuskie-Brandenburg”.

The remainder of this paper is organized as follows. Section 2 presents the theoretical background of the study. Section 3 describes the research methods. Section 4 explains the research methodology, discusses the results and provides a conclusion of the research. Section 5 summarizes the research results.

Theoretical framework and research model

According to Kathuria et al. (2010)¹⁰, manufacturing companies should improve their existing production systems with well-known manufacturing practices, they should also use information technology. Burgelman¹¹ stated that technology may influence the R&D activities of a company. Internal technology exploitation focuses on the use of technology for the company itself. Based on the ideas of Ihde (1993)¹² and Irrgang (2006)¹³, that implemented technology in a company can help to increase the innovation level of an enterprise, the following area of the use of ICTs that can be exploited by knowledge workers are identified: (1) for searching data and information, (2) for sales and purchases, (3) for creation new ideas and products, (4) for analysing data and information. The purpose of the use of the technology for searching data and information is to perform business processes in an acceptable manner¹⁴. The use of ICTs for sales and purchases is a natural consequence of the evolution of ICT and mobile in-

⁹ A. Bigliardi, A.I. Dormio, F. Galati. ICTs and knowledge management: An Italian case study of a construction company. *Measuring Business Excellence*, 2010, 14(3), 16–29.

¹⁰ R. Kathuria, S. Porth, N. Kathuria, T. Kohli. Competitive priorities and strategic consensus in emerging economies: evidence from India. *International Journal of Operations & Production Management*, 2010, 30 (8), 879-896.

¹¹ R.A. Burgelman, C. Christensen, S. C. Wheelwright. Integrating technology and strategy: a general management perspective. In: R.A. Burgelman, C. Christensen, S. C. Wheelwright (eds.) *Strategic Management of Technology and Innovation*, 2004, McGraw-Hill, New York, 208.

¹² Ihde. *Philosophy of Technology. An introduction*. 1993, New York.

¹³ B. Irrgang. *Technologietransfer transkulturell. Komparative Hermeneutik von Technik in Europa, Indien und China*. 2006, Frankfurt.

¹⁴ W. Stevenson. *Production/operation management*. 1993, Homewood: Irwin.

dustries¹⁵. The use of ICTs for creation new ideas and products is used in the detailed design stage of a project in a manufacturing company. The use of ICTs for analysing data and information allow to provide production activities from the order launch to the finished goods¹⁶. The use of technology facilitates the provision of information and knowledge transfer among workers within a company¹⁷. It can be observed that 20% of Polish manufacturing companies exploit the use of an ERP system for their workers¹⁸ and 30% of German manufacturing companies¹⁹. These information technologies are a natural medium for information and knowledge transfer, so a major contribution of this study is that it proposes the exploitation of the use of ICTs by knowledge workers which can efficiently support the realization of R&D projects in a manufacturing company. According to the results of the literature study, it is possible to define the following research model (Fig. 1):

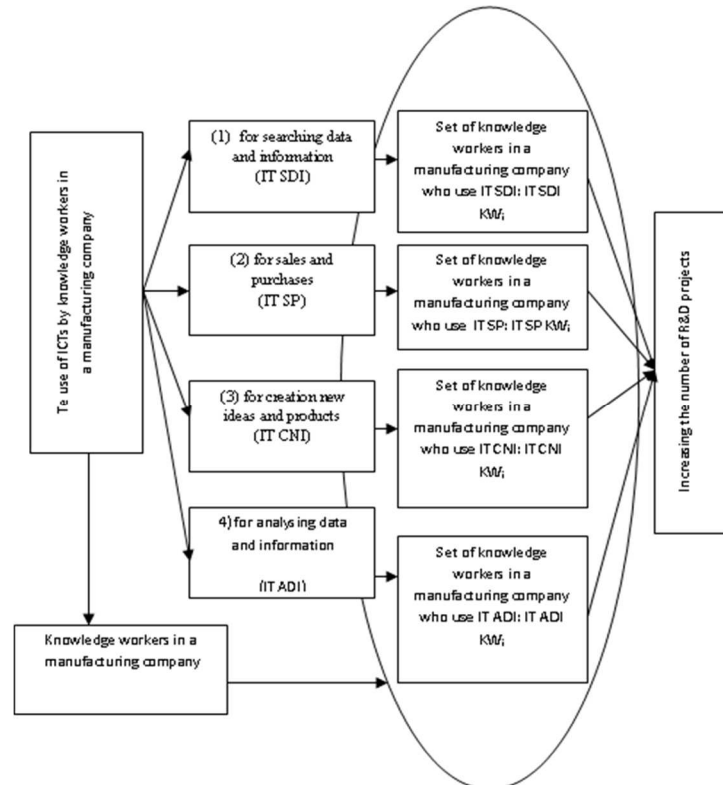


Fig. 1. A conceptual model.

¹⁵ R. Phaal, E. O'Sullivan, M. Routley, F. Prober. A framework for mapping industrial emergence. *Technological Forecasting and Social Change*, 2011, 78 (2), 217-230.

E. Shin, H. Choo, K. Beom. Socio-technical dynamics in the development of next generation mobile network: translation beyond 3G. *Technological Forecasting and Social Change*, 2011, 75(9), 1406-1415.

¹⁶ MESA International: MES Explained: a High Level Vision. White Paper. 1997, 6 (1), 997.

¹⁷ A. Abecker, A. Bernardi, K. Hinkelmann, O. Kuhn, M. Sintek. Context-aware, proactive delivery of task-specific information: the knowmore project. *Information Systems Frontiers*, 2000, 2 (3), 253-276.

¹⁸ Information Society in Poland – statistical analysis. 2013, Warsaw, Poland.

¹⁹ Information Society in Germany – statistical analysis, 2013. Germany.

This study posits that there will be an increase in the number of R&D projects in a manufacturing company in which ICTs are appropriately implemented and used by knowledge workers. In order to facilitate the description of the defined relationships, the use of the information technology among knowledge workers in manufacturing enterprises should be organized in a standardized way as a set of indicators, shown as follows:

$$\text{IT KW} = \{\text{IT SDI KW}_1, \dots, \text{IT SDI KW}_n\}; \{\text{IT SP KW}_1, \dots, \text{IT SP KW}_m\}; \{\text{IT CNI KW}_1, \dots, \text{IT CNI KW}_k\}; \{\text{IT ADI KW}_1, \dots, \text{IT ADI KW}_l\}.$$

where $n, m, k, l \in \mathbb{N}$ and:

IT KW_i - the i -th IT KW are the indicators which describe the significance of the use of ICTs by selected knowledge workers in Polish/German manufacturing companies which were surveyed.

- IT SDI KW_i - the i -th IT SDI KW are the indicators which describe the significance of the use of information technology by knowledge workers for searching data and information.
- IT SP KW_i - the i -th IT SP KW are the indicators which describe the significance of the use of information technology by knowledge workers for sales and purchases.
- IT CNI KW_i - the i -th IT CNI KW are the indicators which describe the significance of the use of information technology by knowledge workers for the creation of new ideas and products.
- IT ADI KW_i - the i -th IT ADI KW are the indicators which describe the significance of the use of information technology by knowledge workers for analysing data and information.

Each IT KW_i is associated with an increase in the number of R&D projects in a manufacturing company and therefore a base of the indicators can be defined as:

$$\text{RDP} = \{\text{RDP}_1, \dots, \text{RDP}_p\}.$$

where $p \in \mathbb{N}$ and:

RDP_i is the i -th RDP are the indicators which describe the significance of the increase of R&D projects in a Polish/German manufacturing company (from the study).

So, the conceptual model posits, from the preceding argument, that knowledge workers use the implemented forms of information technology and this enables the creation of an increased number of new research and development projects.

Research design and methods

In order to test the influence of the use of ICTs by knowledge on the increase in the number of R&D projects, survey data were collected from 62 Polish Manufacturing Enterprises from

Lubuskie region and from 23 German Manufacturing Enterprises from Brandenburg region that had seen the implementation of ICTs between January to September, 2014 (Polish Enterprises), between November 2015 to January 2016 (German Enterprises) (see Table 1). So, the data were collected from 85 manufacturing enterprises from the region: „cross-border cooperation: Lubuskie/Poland and Brandenburg/Germany”, where the profile of companies as “construction” and “automotive” was defined.

Tab. 1. Profile of companies and respondents

| | Items | Frequency/ Polish Manufacturing Enterprises (N=62) | Frequency/ German Manufacturing Enterprises (N=23) |
|--------------------|--------------------------|--|--|
| | Construction | 24 (39%) | 5 (22%) |
| | Automotive | 30 (48%) | 15 (65%) |
| | Others | 8 (13%) | 3 (13%) |
| Respondents | Managers | 51 (82%) | 20 (87%) |
| | Chief executive officers | 11 (18%) | 3 (13%) |

Researches were intentionally carried out in the region Lubuskie/Poland and Brandenburg/Germany, because these regions are a special joint cross-border area. The research results from Polish and German Manufacturing Companies focused on the region: „cross-border cooperation” could be a good recommendation for improving the cooperation between German and Polish companies. The analyzed group of companies, also 85 manufacturing companies from the sector “automotive” and “construction” constitutes about 20% of those enterprises in the region: „cross-border cooperation”.

The Polish and German manufacturing companies used in the study were approached in the form of the direct meetings, an e-mail survey and phone survey. The well-known disadvantage of self-reported data from a single respondent was acknowledged during this process. In order to define knowledge workers for the purposes of this study, the procedure of the determination of knowledge workers from Patalas-Maliszewska and Krebs (2015)²⁰ was adopted. Therefore, this study only considered the responses of managers and CEOs, because the research is focused mainly on that set of knowledge workers in the company. This chosen group was further analysed on the basis that they had been identified as knowledge workers in those Polish and German manufacturing companies.

The use of ICTs by knowledge workers includes five key items which describe a firm’s ability to engage in internal R&D activities²¹:

²⁰ J. Patalas-Maliszewska, I. Krebs. Decision model for the use of the application for knowledge transfer support in manufacturing enterprises. In: Business Information Systems Workshops: BIS 2015 International Workshops. W. Abramowicz (eds.) LNBIP, 2015, 228, 48-55. Cham Heidelberg: Springer International Publishing Switzerland.

²¹ R.R. Nelson (eds.). National Innovation Systems: A Comparative Analysis. 1993, Oxford, Oxford University Press.

- IT KW-factor1: I do not use the ICTs in my organization at all.
- IT KW -factor2: I use the ICTs in my organization infrequently.
- IT KW -factor3: I use the ICTs in my organization regularly
- IT KW-factor4: I use the ICTs in my organization frequently.
- IT KW-factor5: I use the ICTs in my organization very frequently.

Increasing the number of R&D projects also includes five items²²:

- RDP-factor1: I know that in my organization internal interaction among knowledge workers is not very important for firm innovativeness as described by the factor: an increase in the number of R&D projects.
- RDP-factor2: I know that in my organization internal interaction among knowledge workers is not important for firm innovativeness as described by the factor: an increase in the number of R&D projects.
- RDP-factor3: I know that in my organization internal interaction among knowledge workers is marginally important for firm innovativeness as described by the factor: an increase in the number of R&D projects.
- RDP-factor4: I know that in my organization internal interaction among knowledge workers is important for firm innovativeness as described by the factor: an increase in the number of R&D projects.
- RDP-factor5: I know that in my organization internal interaction among knowledge workers is very important for firm innovativeness as described by the factor: an increase in the number of R&D projects.

For all items that were measured, a five-point Likert scale was adopted in which: 1- strongly disagree and 5 – strongly agree.

Analysis

The research model was analysed using a correlation approach in order to estimate the use of ICTs by knowledge workers and its associated influence on the number of R&D projects in Polish and in German manufacturing companies. A moderated correlation approach, using Statistica ver.10.0, was used to test the defined hypothesis. The data were carefully examined with respect to linearity, equality of variance and normality. No significant deviations were detected. Table 2 presents descriptive correlations for the main variables.

²² B-A. Lundvall (eds.). National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. 1992, London: Pinter Publishers.

Tab. 2. Research results

| Construct/Item: IT KW-factor1/ IT KW-factor2/ IT KW- factor3/ IT KW-factor4/ IT KW-factor5 RDP-factor1/ RDP-factor2/ RDP-factor3/ RDP-factor4/ RDP-factor5 | Correlation | r² | t | p |
|---|--------------------|----------------------|----------|-------------|
| Polish manufacturing companies: IT SDI KW _i /RDP | 0.5595 | 0.3130 | 5.4418 | 0.0000 |
| German manufacturing companies: IT SDI KW _i /RDP | -0.0838 | 0.0070 | -0.3855 | 0.7037 2 |
| Polish manufacturing companies: IT SP KW _i /RDP | -0.0532 | 0.0028 | -0.4299 | 0.6686 |
| German manufacturing companies: IT SP KW _i /RDP | 0.3308 | 0.1094 | 1.6065 | 0.1230 |
| Polish manufacturing companies: IT CNI KW _i /RDP | 0.1815 | 0.0329 | 1.4881 | 0.1415 |
| German manufacturing companies: IT CNI KW _i /RDP | 0.1399 | 0.0196 | 0.6477 | 0.5241 |
| Polish manufacturing companies: IT ADI KW _i /RDP | 0.3053 | 0.0931 | 2.5845 | 0.0120 |
| German manufacturing companies: IT ADI KW _i /RDP | 0.3765 | 0.1418 | 4.3960 | 0.0000 |

Table 2 presents descriptive correlations for the main variables. This includes the results of the correlation analyses which estimate the effect of the use of ICTs by knowledge workers in a company and its effects on increasing the number of R&D projects in a company. The primary interaction of the use of information technology by knowledge workers for searching data and information makes a significant contribution to the increase in the number of R&D projects (corr = 0.5595) only in Polish Manufacturing Enterprises. Unfortunately in German Manufacturing Enterprises this relationship is negative (corr = -0.0839). The second relationship between the use of ICTs for sales and purchases by knowledge workers and its effects on the increase of R&D projects is negative alternately in Polish Companies (corr = -0.0532) and positive in German Enterprises (corr = 0.3308). The third interaction of the use of ICTs for creation new ideas and products is not expressed also in Polish (corr = 0.1815) and German Companies (corr = 0.1310). The research model posits a positive relationship between the use of ICTs for analysing data and information and an increase in the number of R&D projects and this is supported by the data from Polish Companies (corr = 0.3053) and also supported by the data from German Companies (corr = 0.3765).

Using survey data the research model was tested as an elaboration of the research question concerning the relationship between the use of information technology by knowledge workers and an increase in the number of R&D projects.

The empirical results from German Manufacturing Companies also show that the use of ICTs by knowledge workers for sales and purchases (IT SP) is positively associated with a growth of the number of R&D projects and based on results from Polish Manufacturing Companies –negatively.

Moreover the results show that if knowledge workers use the ICTs for searching data and information (IT SDI), then the number of new R&D project should also increase in a company – based on the results from Polish companies and the number of new R&D project will be not increase – based on the results from German companies.

So, the similar research results from German and Polish Manufacturing Enterprises was obtained only for the use of ICTs for analysing data and information by knowledge workers (IT ADI) and for the use of ICTs for the creation of new ideas and products (IT CNI). It was also found that the use of IT ADI and of IT CNI by knowledge workers has a positive influence on increasing the number of R&D projects, based on the research results from Polish and German Companies, also in a special joint cross-border area: Lubuskie/Poland and Brandenburg/Germany.

To determine the nature of significant interactions between the use of ICTs for analysing data and information, and any associated influence on the number of new R&D projects, the study tests the research model using regression analyses which estimate this effect. The number of new R&D projects clearly increases when knowledge workers make use of an IT ADI. Therefore, a potential RDB model (increasing the innovativeness of a firm as described by the factor: increasing the number of R&D projects) for manufacturing companies in the joint cross-border area: Lubuskie/Poland and Brandenburg/Germany can be formulated:

$$RDP = 3.9267 + 0.0156 IT ADI KW_i$$

where:

RDB - increasing the innovativeness of a firm as described by the factor: increasing the number of R&D projects and IT ADI KW_i – the use of ICTs for analysing data and information by knowledge workers in a manufacturing company.

This finding can help to clarify that the choice of appropriate information technology may influence the innovativeness of a firm. A theoretical model was developed and tested; however, it was evident that the use of information technology for analysing data and information can play an important role in the creation of new R&D projects in a company.

Discussion and conclusion

In this paper, it was found that the use of ICTs for analysing data and information in a manufacturing company may positively influence an increase in the number of R&D projects. In previous work²³, a novel concept and theoretical AKT model was proposed for the selection

²³ J. Patalas-Maliszewska, I. Krebs. Decision model for the use of the application for knowledge transfer support in manufacturing enterprises. In: Business Information Systems Workshops: BIS 2015 International Workshops. W. Abramowicz (eds.) LNBIP, 2015, 228, 48-55. Cham Heidelberg: Springer International Publishing Switzerland.

of knowledge workers in a manufacturing company. Based on a worker's specific characteristics, a decision model was made for the use of an application for knowledge transfer support (AKT) which indicated that the most important employee who transfers knowledge within an organization, should be an employee with a high-level of work experience. In this work, the AKT decision model is extended in order to discover the role of ICTs which is used by knowledge workers within a manufacturing company. Discovering the significance of the use of information technology by knowledge workers involves two stages: identifying knowledge workers within a company is stage I, and identifying the influence on an increase in the number of R&D projects is stage II. It can be concluded that adapting the RDB model in a manufacturing company can play a role in increasing the innovativeness of a firm as expressed by the number of R&D projects.

So, the research results indicate, in accordance with the views of Maurer²⁴ and Burgelman²⁵, that the use of ICTs by workers may influence R&D activities in a company. The research is focused on those workers who can be classified as knowledge workers, and it was found that communication among knowledge workers supported by the use of technology can influence the innovation level of an enterprise (according to Ihde²⁶ and to Irrgang²⁷).

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²⁵ R.A. Burgelman, C. Christensen, S. C. Wheelwright. Integrating technology and strategy: a general management perspective. In: R.A. Burgelman, C. Christensen, S. C. Wheelwright (eds.) *Strategic Management of Technology and Innovation*, 2004, McGraw-Hill, New York, 208.

²⁶ Ihde. *Philosophy of Technology. An introduction*. 1993, New York.

²⁷ B. Irrgang. *Technologietransfer transkulturell. Komparative Hermeneutik von Technik in Europa, Indien und China*. 2006, Frankfurt.

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