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### TECHNOLOGY TRANSFER PHENOMENON AND ITS IMPACT ON SUSTAINABLE DEVELOPMENT

Manuela Tvaronavičienė<sup>1</sup>, Jūratė Černevičiūtė<sup>2</sup>

*Vilnius Gediminas Technical University, Saulėtekio av. 11, LT-10223 Vilnius, Lithuania*

*E-mails: <sup>1</sup>manuela.tvaronavicienne@vgtu.lt, <sup>2</sup>jurate.cerneviciute@vgtu.lt*

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**Abstract.** The aim of the presented paper is to examine how technology transfer is being approached in the latest scientific literature, and whether interrelations of technology transfer and sustainable development are being elaborated. Clusters in this context are perceived as networks (not necessarily proximate in geographic terms), which serve as technology transmitters. Efficiency of clusters is being addressed. The ultimate aim of the research is to develop framework, which would allow proceeding analysis of links between technology transfer phenomenon and sustainable development process.

**Keywords:** technology transfer, innovations, sustainable development

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**JEL Classifications:** O1, O3

## 1. Introduction

Sustainable development is research area, which embrace myriads of its facets e.g. (Lapinskienė et al. 2014; Scaringelli 2014; Travkina, Tvaronavičienė 2015). Naturally, factors, impacting sustainable development process can be analyzed from different perspectives and could be grouped into various driving forces e.g. entrepreneurial behavior (Caurkubule; Rubanovskis 2014; Dalati 2015, Šabasevičienė, Grybaitė 2014; Rasudeliūnienė et al. 2014; Figurska 2014), availability of innovative solutions (Grubicka, Matuska 2015; Ala-Juusela et al. 2015; Guruz, Scherer 2014; Cuneo et al. 2014; Barberis et al. 2014), sustainability of business (Garškaitė-Milvydienė 2014; Bonetto et al. 2014; Tvaronavičienė et al. 2014); business environment (Tunčikienė, Drejeris 2015).

Alas, impact of technology transfer phenomenon, level of its significance is for sustainable development phenomenon does not receive proper attention and remain comparatively unexplored (e.g. Iganatavičius et al. 2015)

This fact can be explained in the following way: both phenomena are multi-faceted therefore examination of links requires prior indication what is under investigation. Hence, on the one hand, it is necessary to specify, how sustainable development is being understood, what span (business unit, industry, cluster, regional or global) is being analyzed. On the other hand, technology transfer has got many dimensions and being analysed taking into account variety of actors with different characteristics, technologies in different industries of different complexity are being transferred, process of technology transfer is not necessarily equally beneficial for technology transferers and recipients, impact of technology transfer can be considered from different perspectives.

Hence, in order to formulate insights about interrelation between technology transfer and sustainable development, the paper is organized in the following way. At first, critical review of the very latest (2015-2014) literature on technology transfer is being provided. The second, the technology transfer evaluation approach, which could be instrumental of searching links with sustainable development phenomena suggested, sustainable development span, suitable for this type of analysis indicated. The third, insights will be provided.

### 1. Approaches towards technology transfer analysis

One of the latest papers on technology transfer belong to Varun Rai and Erik Funkhouser, published in Renewable and Sustainable Energy Reviews, 2015 September. Despite authors elaborate specifically low-carbon technology (LCT) transfer, their paper provides an approach to technology transfer process analysis, which can be adopted for technology transfer in any area. They organize synthesis of literature „under under three overarching themes: intellectual property rights; recipient country characteristics; and the role of international partnerships” ( Rai, Funkhouser 2015, p. 351).

Hence the authors analyze cases when technology is being transferred internationally, one country is transferer, another recipient. By choosing “overarching themes” they admit that intellectual property (IPR) and international partnership composition are the most important factors affecting technology transfer phenomenon. They provide schematically organized factors, among which, they focuss their attention IPR institution, recipient country and international partnership (network or cluster in the broader sense indicated above). Their schematically organized system of factors impacting technology transfer process is provided below (Fig. 1).

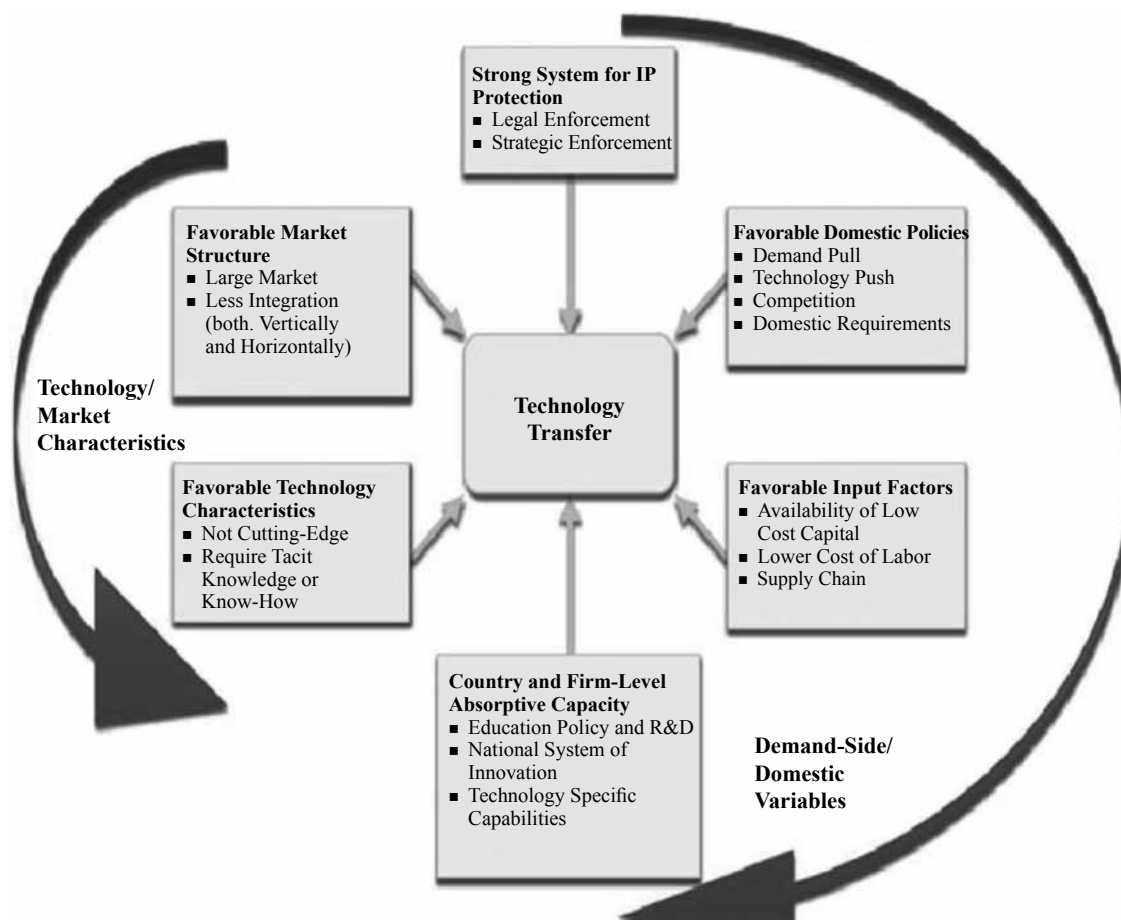


Fig. 1. Varun Rai, Erik Funkhouser

Factors that increase the likelihood of international technology transfer. Adapted from Rai et al. 2014 by Rai, Funkhouser 2015

Further in their paper the authors provide perception of international transfer (Fig. 2)

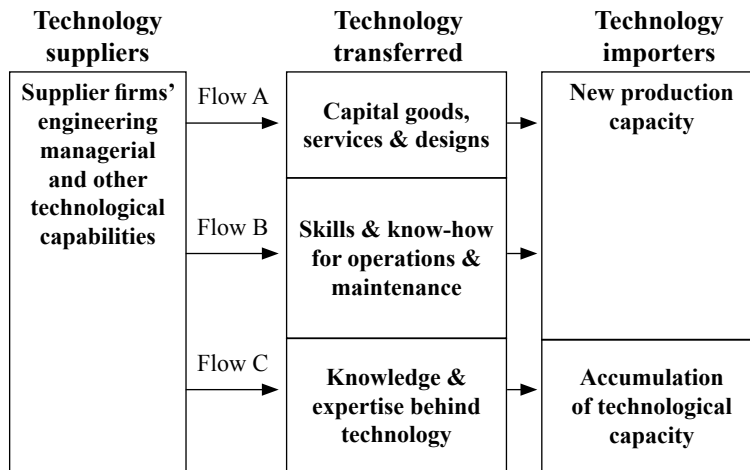


Fig. 2. The contents of international technology transfer (Rai, Funkhouser 2015)

If to evaluate the approach towards technology transfer analysis, it could be stated that it is very close to literature on impact of foreign direct investment (FDI) on economic development. In the strand of literature on FDI a lot of considerations about knowledge and know-how spillovers in case of one, more developed, country's investment into less developed country are found. In that context characteristics and institutions (including IPR institution) of recipient country are very important, as to some extent determine if those spillovers would take place. Elaborating related but at the same time different process – technology transfer phenomenon, it is needed to state rather firmly, that the latter is broader because embrace team level, companies level, industries, clusters, regional and only later on international level. Impact of FDI on sustainable development has been discussed a lot, while impact of technology transfer on sustainable development phenomenon remains an area open for further ongoing discussion.

The next approach toward technology transfer represents different focus. Here the authors tackle issues related to so called 'alliance of partners'. Here we can specify that meaning of allians of partners is very close, if not the same, as 'network of partners', which is engaged into technology transfer or 'cluster', if cluster is perceived in broader sense than just cooperating companies located in the same geographic area.

Hence Contractor and Woodley in their recent paper (Contractor, Woodley 2015) elaborate question of value sharing among alliance partners. Companies are cross-border partners, which act as technology providers and capture the higher share of returns. Value appropriation determinants, according the authors are: (1) technology and partner characteristics, (2) host nation mandates, (3) alliance structure and (4) other agreement provisions. Those determinant are reflected model summary depicted in Fig. 3. (Contractor, Woodley 2015).

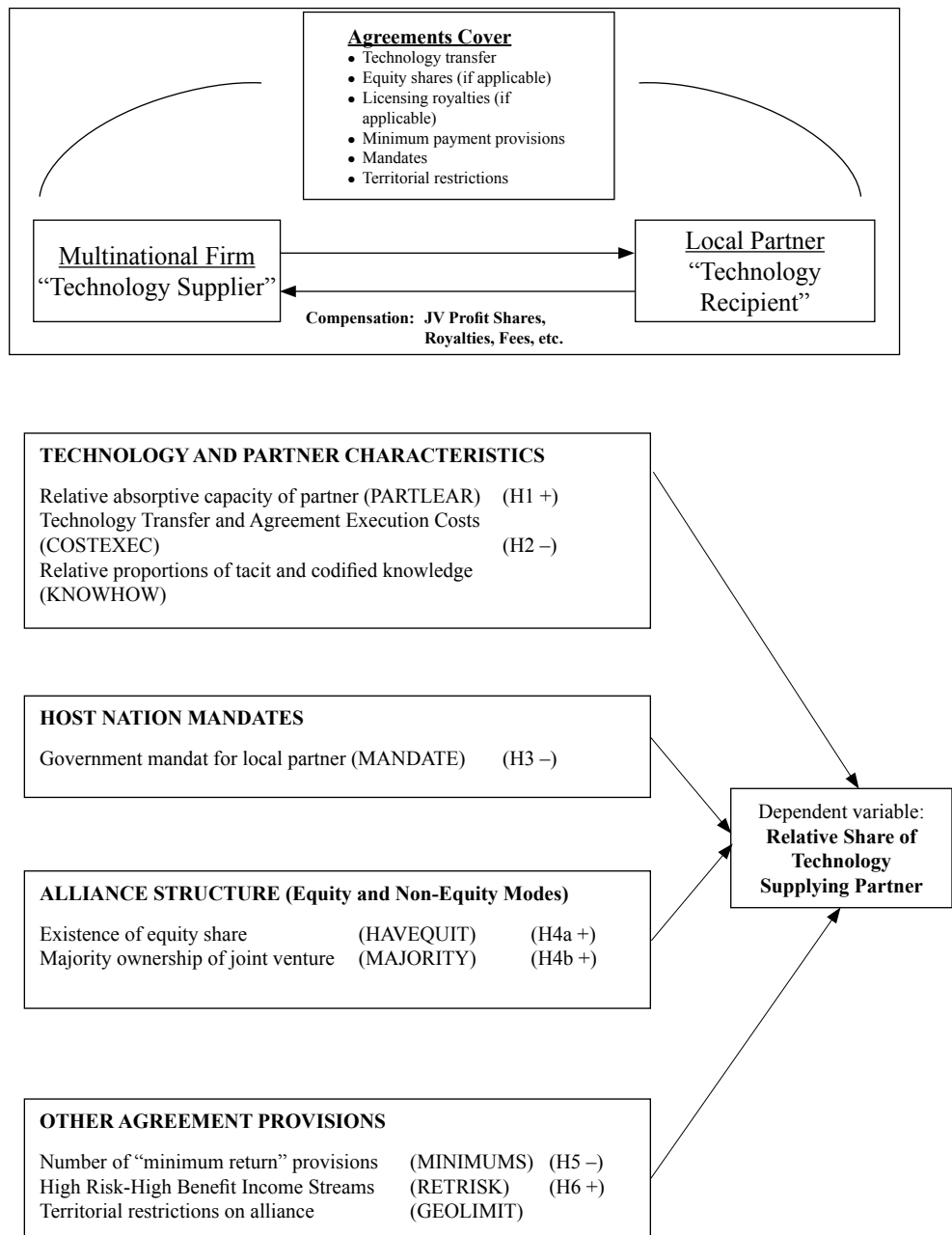


Fig. 3. Model summary (with hypothesized signs for coefficients, reflectin hypotheses presented below; i.e. H<sub>1</sub>...H<sub>6</sub>).  
 (Contractor, Woodley 2015).

**Hypothesis 1 (H1).**

*The poorer the technology recipient partner’s relative technical capabilities, compared to the technology providing partner, the greater will be the share of alliance value appropriated by the technology providing partner. (Note: The expected sign of the coefficient is positive because of the way the variable is constructed.)*

**Hypothesis 2 (H2).**

*There will be a negative relationship between the technology transfer and agreement execution costs borne by the technology provider and the share of net alliance value appropriated by them.*

**Hypothesis 3 (H3).**

*The presence of a government mandate, that foreign firms must accept a local partner, will have a negative effect on the share of overall returns from alliances accruing to technology providing firms based outside such nations.*

**Hypothesis 4a (H4a).**

*When investing in an alliance as an equity partner, the technology providing firm will receive a larger share of returns generated through the alliance, all else being equal.*

**Hypothesis 4b (H4b).**

*When the technology providing firm has a majority equity stake in the alliance, they will receive a larger share of returns generated through the alliance, all else being equal.*

**Hypothesis 5 (H5).**

*The presence in the alliance agreement of contractual minimum compensation or returns for the technology providing firm will lead to a lower overall share of alliance value appropriated by the technology providing firm.*

**Hypothesis 6 (H6).**

*A higher risk (i.e.: more volatile) 'portfolio' of compensation streams for the technology providing firm (as written into the agreement) will lead to a higher overall share of alliance value appropriated by the technology providing firm*

(Contractor, Woodley 2015)

Here let us recall the aim of provided research: our purpose is to compare approaches toward technology transfer analysis adopted by different authors in the most recent papers. The approach, just provided above again fall into research area very close to research area associated with foreign direct investments. The main difference among Contractor, Woodley 2015 and Rai, Funkhouser 2015 is focus: the formerly analyzed authors (Rai, Funkhouser 2015) considered **IPR** as main factor affecting technology transfer process, while latter authors (Rai, Funkhouser 2015) immersed **value appropriation nuances**. Despite the different focus direction both authors see technology transfer process as cross-border process, directed from stronger partner to weaker one. Again, let us put emphasis here, discussion spins on rather narrow case of technology transfer phenomenon. Here is appropriate to add one brief remark: the strand of literature on technology transfer, which is very similar or overlapping with FDI problematic is rather ample (e.g very recent paper of Newman *et al.* May 2015; Costantini *et al.*, October 2014)

**IPR** as factor, affecting technology transfer process is discussed rather frequently; e.g. as well very recent article Intarakumnerd; Charoenporn September 2015 could be mentioned here. One more significant difference, that authors analyze technology transfer between business and academia. Authors come to conclusion that **investigation of Thai** automotive industry does not allow to claim that the stronger patent regime has visible impact on technology transfer process between public research institutes and business companies.

Another strand of contemporary scientific literature on technology transfer is devoted to analysis of network characteristics. This new stand is well represented, or possibly introduced, by Kafouros and Wang 2015. The authors focus on configuration of technology transferring groups, the geographic dispersion and concentration. It is claimed that the ability and willingness to transfer technology depends on geographic configuration of networking business groups. In authors' words, they "develop the premise that the geographic configuration of a group's network of business units influences both the ability and willingness of a unit to transfer technological knowledge to other units and, thus, may result in different performance outcomes" (Kafouros, Wang 2015). Authors distinguish such network characteristics as "network breadth" and "network concentration". Authors define those characteristics in the following way: "*Network breadth* refers to the geographic dispersion of the units of a group within a country and can be measured by looking at the number of cities in which the group operates and the diversity of their locations country-wide. *Network concentration* captures the concentration of a group's business units in each given city. The higher the number of business units that a group has in a given city, the higher the level of *network concentration*. The two constructs therefore reflect differences in the geographic scope and scale of the operations of the groups" (Kafouros, Wang 2015) Fig. 4 summarizes the theoretical framework and hypotheses.

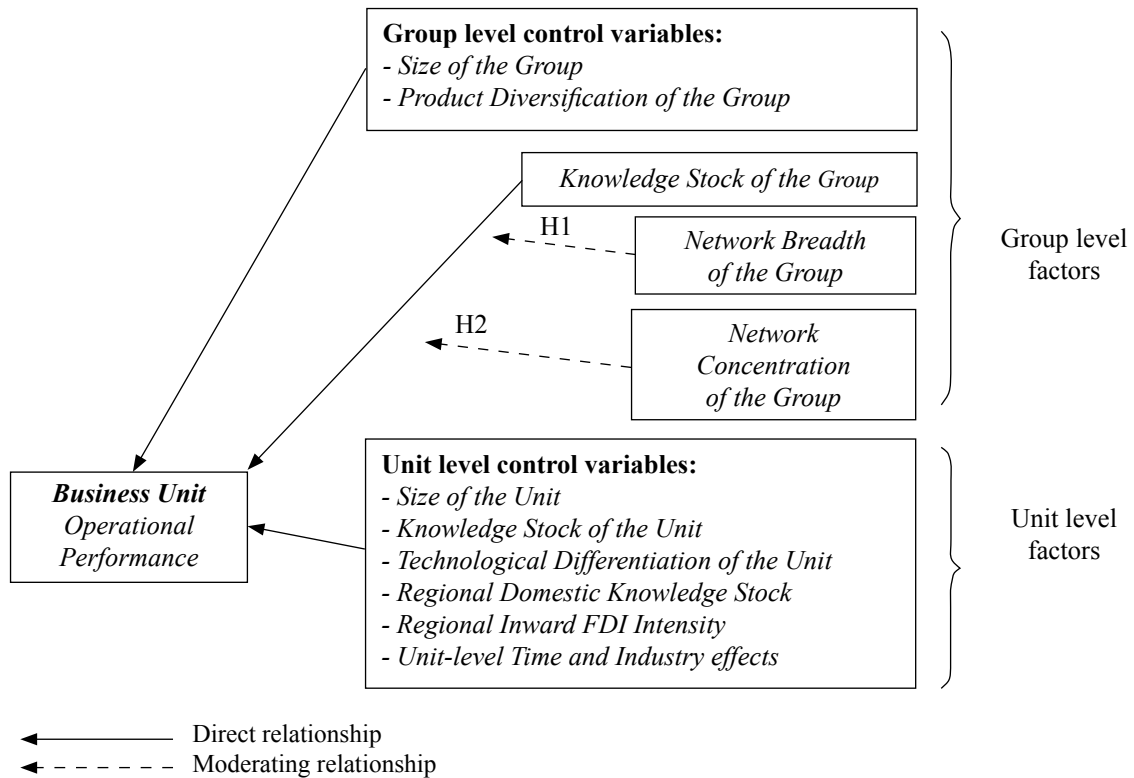


Fig. 4. Conceptual framework for analysis of networking technology transferring group characteristics (Kafouros, Wang 2015)

**Hypothesis 1.**

*The breadth of a group’s network of business units has a curvilinear moderating effect (taking an inverted U-shape) on the relationship between the group’s technological knowledge stock and its business units’ operational performance.*

**Hypothesis 2.**

*The concentration of a group’s network of business units has a curvilinear moderating effect (taking an inverted U-shape) on the relationship between the group’s technological knowledge stock and its business units’ operational performance.*

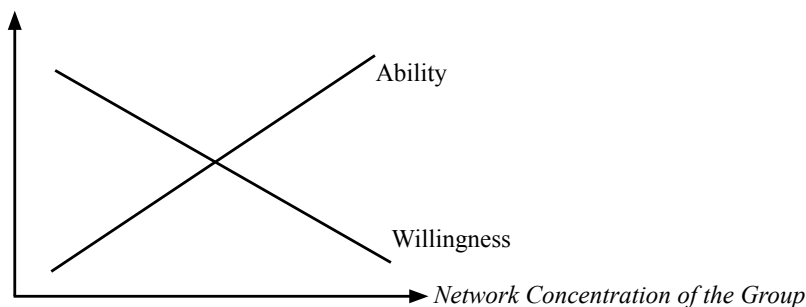


Fig. 5. Effects of network concentration on the ability and willingness to transfer technology (Kafouros, Wang 2015)

The authors arrive to the conclusions that besides such widely discussed factor as absorptive capacity of technology transfer ators, other factors such as configuration of alliance, or cluste, we can add, affect and even shape technolohy transfer process. Authors claim that due to the fact that some alliance members invest in similar products and technologies completion arises. Competition diminishes willingness to transfer knowledge, what natuarly diminishes efficiency of knowledge transfer. Authors provide interesting findings related to network **breath** and **concentration**. They point out that in emerging markets, which typically do not psses

strong technological capabilities, too big breath”makes the combination of diverse ideas and technologies less efficient, and can be detrimental for innovation and capability development. As the empirical findings confirm, network breadth has a curvilinear (inverted U-shape) moderating effect” (Kafouros, Wang 2015)

Concentration of companies in alliance affects efficiency of technology transfer in the following way: while big concentration increases potential or ability to transfer knowledge, it diminishes willingness to do so. Hence, according authors’ recommendations, it is necessary to control the concentration factors in order to have right trade-off between ability and willingness to transfer knowledge in order to have the highest possible technology transfer efficiency. Authors’ indicated that those findings contribute to research on innovation, clustering and agglomeration (Kafouros, Wang 2015).

Efficiency of technology transfer represents another rather autonomus research question embraced by broader technology transfer research area. Here we wanted to refer to latest paper of Bozeman *et al.* February 2015.

In this paper the authors update Bozeman’s Contingent Effectiveness Model of Technology Transfer published in year 2000. The authors indicate, that “the term “contingent” is key in both the original and revised model because of the assumption that technology transfer by definition includes multiple parties and these parties generally have multiple goals and, ergo multiple effectiveness criteria. Effectiveness is considered in terms of multiple criteria including (1) out-the-door (was anything transferred?), (2) market impact, (3) economic development, (4) political advantage, (5) development of scientific and technical human capital, and (6) opportunity cost considerations“ (Bozeman *et al.* 2015). The updated model incorporates so called *public value* (Fig.6)

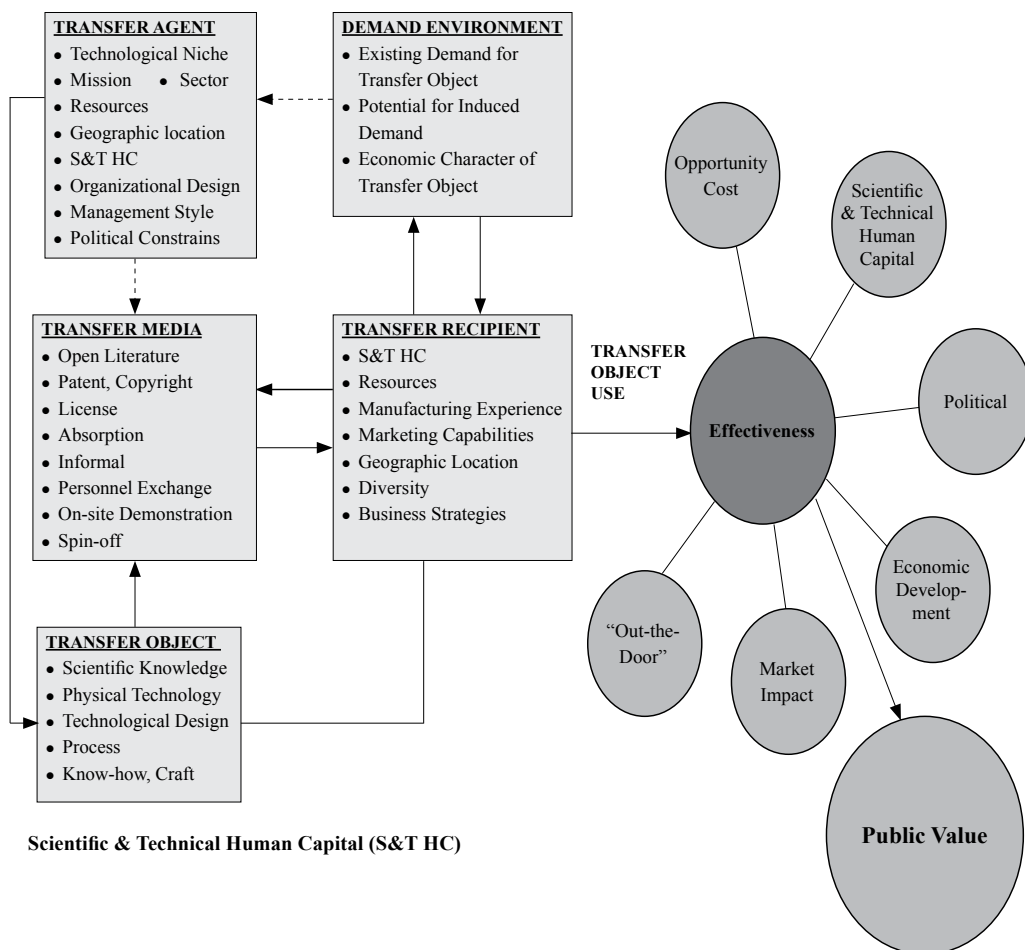


Fig. 6. Revised contingent effectiveness model of technology transfer (Bozeman *et al.* 2015)

In Table 1 authors describe their criteria of technology transfer effectiveness. Newly added *public value* criterion is being described as well (Bozeman *et al.* 2015)

**Table 1.** Technology transfer effectiveness criteria (Bozeman *et al.* 2015).

| Effectiveness criterion                | Key question                                                                                         | Theory base                                                                            | Major advantage and disadvantage                                                                                                                                                                           |
|----------------------------------------|------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| “Out-the-Door”                         | Was technology transferred?                                                                          | Atheoretical or classical organization theory                                          | Advantage: Does not hold transfer agent accountable for factors that may be beyond control.<br>Disadvantage: Encourages cynicism and focuses on activity rather than outcome                               |
| Market Impact                          | Did the transferred technology have an impact on the firm’s sales or profitability?                  | Microeconomics of the firm                                                             | Advantage: Focuses on a key feature of technology transfer.<br>Disadvantage: Ignores important public sector and nonprofit transfer; must accommodate market failure issues.                               |
| Economic Development                   | Did technology transfer efforts lead to regional economic development?                               | Regional science and public finance theory.                                            | Advantage: Appropriate to public sponsorship, focuses on results to taxpayer.<br>Disadvantage: Evaluation almost always requires unrealistic assumptions.                                                  |
| Political                              | Did the technology agent or recipient benefit politically from participation in technology transfer? | Political exchange theory, bureaucratic politics models                                | Advantage: Realistic.<br>Disadvantage: Does not yield to systematic evaluation.                                                                                                                            |
| Opportunity Cost                       | What was the impact of technology transfer on alternative uses of the resources?                     | Political economy, cost–benefit analysis, public choice                                | Advantage: Takes into account foregone opportunities, especially alternative uses for scientific and technical resources.<br>Disadvantage: Difficult to measure, entails dealing with the “counterfactual” |
| Scientific and Technical Human Capital | Did technology transfer activity lead to an increment in capacity to perform and use research?       | Social capital theory (sociology, political science), human capital theory (economics) | Advantage: Treats technology transfer and technical activity as an overhead investment.<br>Disadvantage: Not easy to equate inputs and outputs.                                                            |
| Public Value                           | Did technology transfer enhance collective good and broad, societally shared values?                 | Public interest theory, public value theory                                            | Advantage: Excellent and easily sanctioned criteria for public policy.<br>Disadvantage: Extremely difficult to measure systematically                                                                      |

Here we wanted to provide several comments on the latter approach towards technology transfer analysis. Differently than above presented authors, these scientists tackle technology transfer impact, which they name as “effectiveness“. Recall that above this paper presented approaches were very different by their focus. One group of authors focused technology transfer driving forces, such as IPR, what could be attributed to institutional factors, technology transfer participants (countries or companies) and value sharing among technology transferer and recipients (ability and willingness to participate in technology transfer). This, the very latter paper focuses on technology transfer outcomes. The author attempt to systemize and classify those outcomes. Despite the authors do not introduce sustainable development term, their insights already indicated some constituents of sustainable development phenomenon (economic development, political criteria of technology transfer effectiveness). Attempts to introduce additional rather tacit criterion *public value* signal of a need to for more extended framework, which could be used for technology transfer analysis.

To put in other way, we witness attempts to relate technology transfer and sustainable development constituents.

## 2. Technology transfer and sustainable development linkages

If to enter keywords of technology transfer and sustainable development it search of Science Direct powered by Elsevier, only one very recent paper pops out. This is article of Julian Blomke “Technology complexity, technology transfer mechanisms and sustainable development, Energy for Sustainable Development” (2014).



The paper is devoted to analysis of technology transfer processes resulting in climate change mitigation by reducing greenhouse gases. Author describes “the aspects which technology transfer mechanisms should integrate in order to ensure sustainable development induced by technology transfer”(Blomke 2014). The author looks at the technology transfer process from the cost-benefit analysis point of view. Complexity of technology is being considered, allowing naturally that more complex technology is respectively more costly. The authors’ consideration are the following: provides the following. “Let us assume for example that technology 1 and technology 3 cost the same (same mitigation effect per Euro invested), but the various components (e.g. wind blades, wind tower, PV solar glass, metal mounting structure of PV modules) have different technology complexity properties across the respective technology system (see also annex for a detailed rating of the technology components). Then, the technology, which has a higher amount of components ranked with lower complexity, in monetary terms, can bear a higher economic development potential. The reason is that components with lower complexity but high economic demand impact, can induce domestic demand for technology goods. The sum of the yellow bubbles, representing the investment of technology 1, is the same as the sum of the blue bubbles, making up the investment of technology 3 (Fig. 7)—each of the technologies summing up to 1 on the x-axis. Because the individual components of the technology 1 are ranked with lower complexity (below the complexity value of 2 on the y-axis), it is assumed that the domestic demand for technology goods could turn out to be higher. The reason for this is that it is more likely that components with lower complexity can be manufactured by domestic industries in developing countries. The potential domestic demand effect of technology 1 is higher than that of technology 3. Overall, technology 2 is more costly per mitigated unit of GHG. Thus, the sum of the grey bubbles is larger than the sum of the blue or yellow bubbles (2 instead of 1)“ (Blomke 2014).

Illustration: Climate Mitigation Technology for Sustainable Development

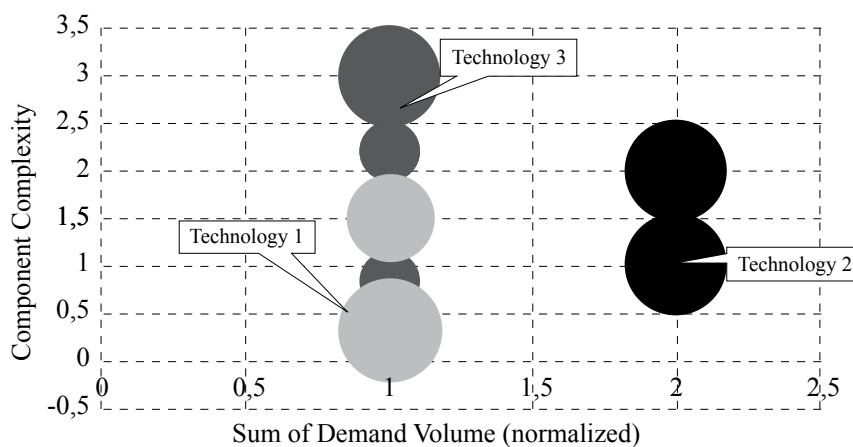


Fig. 7. Indexation of technologies and components (Blomke 2014).

## Conclusions

Analysis of the latest papers on technology transfer let us indicate that authors in this research area tackle rather different aspects of technology transfer phenomena. By many authors technology transfer is still associated with foreign direct investments, when more developed country transfer technology into less developed one. Some authors tackle impact of institutional environment (IPR regulations) on technology transfer process, other analyse relationships of technology transfer participants network (which we call clusters here). Effectiveness of technology transfer is being described (we would call that impact).

Impact of technology transfer on sustainable development is being analyzed only in the context of greenhouse gas effect mitigation. We claim that there is still gap in this research area in the field of structuring linkages between technology transfer and sustainable development. More specifically, impact of technology transfer should be described on all main constituents of sustainable development (economic, social, environmental) on

regional and, later, international level. Despite some attempts to work towards this direction, the more universal framework is still missing.

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