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EVALUATION OF EFFICIENCY OF THE INTERNATIONAL TECHNOLOGY TRANSFER PROCESSES

The aim of this paper is to set the task of evaluating and optimizing the processes of international technology transfer. This paper analyzes the main approaches to assessing the effectiveness of technology transfer and the proposed architectural approach to solving this problem.

Keywords: international technology transfer, model, estimation, efficiency.

Целью данной работы является постановка задачи оценки и оптимизации процессов международного трансфера технологий. В работе проанализированы основные подходы к оценке эффективности трансфера технологий и предложен авторский подход к решению этой задачи.

Ключевые слова: международный трансфер технологий, модель, эффективность, оценка.

International technology transfer (ITT) is a comprehensive term covering mechanisms for shifting information across borders and its effective diffusion into recipient economies[5; 6]. Thus, it refers to numerous complex processes, ranging from innovation and international marketing of technology to its absorption and imitation. Included in these processes are technology, trade, and investment policies that can affect the terms of access to knowledge. Policy making in this area is especially complex and needs careful consideration, both by individual countries and at the multilateral level.

ITT is a comprehensive term covering mechanisms for shifting information across borders and its effective diffusion into recipient economies. Technology transfer is an area of interest not just to business, economists, and technologists but also to other disciplines (Zhao and Reisman, 1992), so it has multidisciplinary base.

For economists, as argued by Mansfield (1975), the focus is on economic growth and achievement of economic goals. However, from the perspective of business and technologists the main focus of technology transfer is to improve the competitive advantage of firms through the enhancement of customer value (Ramanathan, 2001). It is envisaged that, through the improvement of competitive advantage, a firm and its partners collaborating in the technology transfer will gain financial and other strategic benefits.

In the initial ITT equilibrium between two countries, the terms of trade settle somewhere within the range set by the comparative cost ratios in the two countries, ratios that would reflect autarky prices: a_i denote the labor cost of producing the i^{th} commodity at home, a_i* the labor cost per unit produced abroad.

The sizes of the two labor forces relative to productivities are such that in the trading equilibrium the terms of trade settle at a value strictly between the autarky ratios so that each country is completely specialized in the commodity in which it possesses a comparative advantage.

The two production blocks in Figure 1 illustrate a two-country equilibrium. The origin for the home country's production block is shown by *0* in the southeast corner, and the origin for the foreign country is denoted by *0** in the northwest corner. The offer curve for the home country is 0_TCH, and that for the foreign country is 0_TC*F. As illustrated, import demand in each country is elastic, but that is not necessary (although we assume the market equilibrium is stable). Equilibrium terms of trade are shown by the slope of the λ-ray from the trading origin, 0_T.

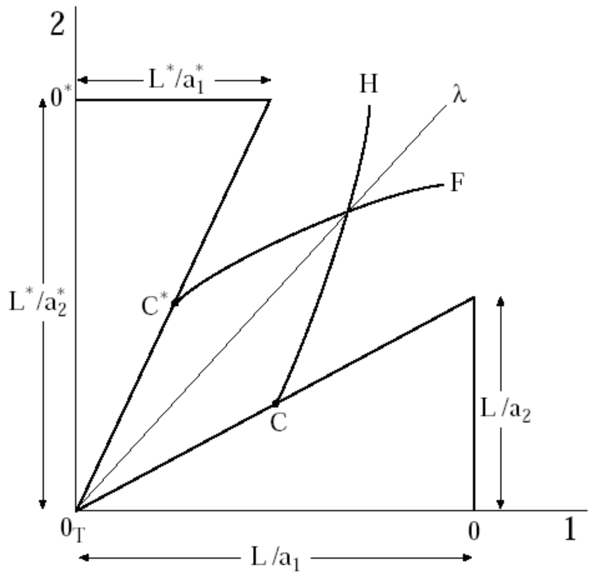

Figure 1 – Initial state

The effects of ITT are divided into two base components:

- technology transfer from national companies;
- technology transfer from foreign companies (companies with direct investments and importers).

In each of them there are three levels of technological excellence:

– entire industry;

– technological direction where there is a world-class design;

– separate technology with the world level, but relative to the industry in which the country is lagging behind the world level (eg, biotechnology).

Traditional approach assesses technology transfer as a knowledge transfer between research laboratories and industry and is influenced by four main components[**3**]:

a) level of collectivization or/and globalization;

b) availability of new facts (knowledge);

c) personnel skills and abilities to adapt, use, improve and innovate;

d) availability of advanced machines and equipment.

The results indicated that culture, physical environment, and geographical location all have significant effects on technology transfer; necessary accommodations for these adapting factors then become vital to the success of technology transfer and will strongly facilitate the effectiveness of the technology. We will check this hypothesis in the Ukrainian conditions.

Despite the importance of qualitative criteria, we believe that it is necessary to develop criteria for evaluating the economic efficiency of the processes of ITT.

The priority for us is a turn-based assessment of the stages of transfer (the life cycle of a transfer), as it allows you to:

1) to forecast technological development;
2) realistically assess the existing capacity;
3) to produce "dynamic" technology assessment.

The "Life Cycle Approach for Planning and Implementing a Technology Transfer Project" (Table 1) is based on the stage-gate structure developed by Jagoda and Ramanathan (2005) for developing a systematic approach for planning and managing ITT.

We propose to use a matrix to assess the potential effectiveness of technologies for making decisions about appropriateness of transfer. The matrix has the next form (figure 2).

Table 1 – The Life Cycle Approach for Planning and Implementing Technology Transfer

Stage	*Gate*
Stage 1: Identifying CVD enhancing technologies	Gate 1: Confirming identified technologies
Stage 2: Focused technology search	Gate 2: Technology and supplier selection
Stage 3: Negotiation	Gate 3: Finalizing and approving the TT agreement
Stage 4: Preparing a TT project implementation plan	Gate 4: Approving the implementation plan
Stage 5: Implementing technology transfer	Gate 5: Implementation audit
Stage 6: Technology transfer impact assessment	Gate 6: Developing guidelines for a new project

Y-axis represents the characteristics of the technology compared to existing in the country, the x-axis shows the results of implementing the technology.

As a result, we can consider the following main situations:

(3) *progressive technology transfer*: advanced technology – high efficiency: situation of high technology transfer, leading to significant social and economic benefits in the recipient country (transfer of efficiency);

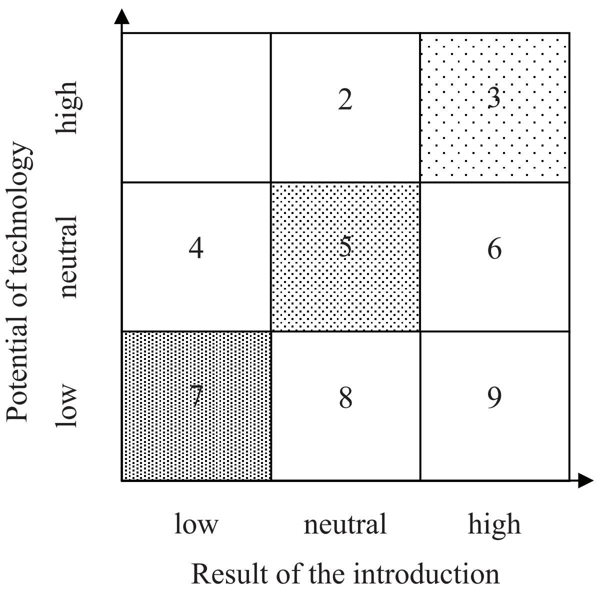

Figure 2 – Evaluation of international technology transfer

(5) *neutral technology transfer*: same technology – similar result: a situation when foreign technology is transferred, similar to the existing scientific and technical base of the state (the situation of poor communication and ineffective internal technology transfer);

(7) *regressive technology transfer*: backward technology – a poor outcome: a situation when the transfer doesn`t fulfill its basic function and leads to a qualitative technological development of countries (the situation considered in the hypothesis of "pollution haven" when implemented transfer of environmentally hazardous technologies in developing countries riches in a variety of productive resources).

It should be noted that the achievement of the situation (3) requires a considerable effort, since the use of foreign technology provides for a "technological gap" due to the fact that the successful technology use is the availability of the necessary related technologies at the same level (for example – the role of engineering in support of all other sectors of national economy). It results that "innovation chain transfer" situation, when, together with major technology updates the entire process chain in the recipient country. Otherwise technology can not bring effect, pledged by international agreement.

The "Two Gap" Theory [1] describes constraints limiting a developing country's ability to gain technology. First, developing countries are unable to save enough capital to create and maintain their own technological base to promote growth. Second, the cost of importing technology far exceeds export revenues.

Review and analysis of other situations (figure 1) reveals a problem or an adjustment of innovation policy.

Processes for ITT we can offer the following formula of it's efficiency:

$$E = \sum_{i=1}^{m} s_i \sum_{j=1}^{n} \left(m_i \cdot N_j\right), \qquad (1)$$

s_j – technology transfer coefficient of the stage of innovation i; m_i – coefficient of the efficiency of the innovative process of creating of additional value of stage *i*; N_j – amount of innovation product *j* which was made on the basis of technology at the stage *i*.

Estimation of value added can be done as:

$$E_{AV} = \max(AV) = \max \sum_{i=1}^{N} AV_i \,, \qquad (2)$$

where *AV* is criteria for additional value in sectors.

According to this ITT processes should be aimed at maximizing the value added.

IL is criteria for innovational level of ITT and is an indicator of science-intensive sectors, we can use the index of knowledge-intensity sectors, calculated as the ratio of expenditure on science and technology purchase through international technological exchange (import) to the volume of industrial production in the industry in the area.

Consider a single multinational firm owning a technology that may be transferred to a recipient location through FDI or licensing with an unaffiliated firm. These options incur a fixed transfer cost of the following form:

$$F^j = P^j + C^j(k) \qquad (3)$$

where $j = L, F$ denotes licensing or FDI.

Fixed costs are comprised of two distinctive components:

1) production-related costs, denoted P, such as investment in equipment, altering production lines, and establishing distribution channels. While these differ between FDI and licensing contracts, they are independent of the strength of intellectual property rights, indexed by k;

2) costs of contractual elements transferring knowledge, denoted C.

So $\frac{dC^j(k)}{dk} < 0$ for j = F, L, where an increase in k indicates a more rigorous patent regime. However, it is also plausible that the rate at which these contractual costs decline with k is faster for licensing contracts: $\left|\frac{dC^F(k)}{dk}\right| < \left|\frac{dC^L(k)}{dk}\right|$.

Patent transfer counts between priority office and duplicate office are extracted from the PATSTAT database while trade data between countries comes from the UN COMTRADE database. Trade and patent transfers are collected for the period from 1988 to 2005 where there is data available for approximately 50 countries.

To substantiate the use of patent data as a measure of technological transfer, we would expect trade and patent flows to be strongly positively correlated as indeed they are found to be (Table 2). Firstly, each export-import pair (1988-2005) is correlated at 0.69. Aggregating over time for each export-import pair gives a correlation of 0.74. And finally, when aggregating trade and patent data for each exporter (regardless of who imports) gives a correlation of 0.88.

Technological transfer occurs through many channels, although trade, foreign-direct investment and licensing are the most important. Using this approach and taking into account the multifactor process of international technology transfer, we propose to identify the factors using correlation graph, which will take into account factors like socio-economic development, and the factors of the national innovation system. A result can be obtained for each individual country assessments of factors that will continue to develop a set of economic and mathematical models for solving control problems.

As a result of multiple linear regression, this method that determines the objective of transforming-in each set of variables that affect the existed opposite set indicators. Canonical analysis allows to identify and assess the interdependence between the integral “entrance” and integrated “solution” without destroying the possible relationships of latent variables in each set.

$$a_1x_1 + a_2x_2 + \ldots + a_nx_n \leftrightarrow b_1y_1 + b_2y_2 + \ldots + b_my_m \qquad (4)$$

Table 2. Correlations between trade values and counts of duplicate patent applications [2]

Correlation between trade flows and duplicate patenting	Full sample	Sub-sample excl. outliers
Base dataset – all country pairs and all years (1988-2005), *corr (exports, patents)*	0.47	0.69
For each country pair, aggregate over time, *corr (exports, patents)*	0.52	0.74
For each exporter country, aggregate across partner countries, *corr (exports, outgoing patents)*	0.76	0.87
For each importer country, aggregate across partner countries, *corr (imports, incoming patents)*	0.71	0.76

a_i – canonical weight and the second variable of the first group (“input” set of indicators), reflecting its contribution to the linear combination of variables that are integral “out” set of indicators; b_k – canonical weight of variable k of the second group (“initial” set of indicators), reflecting its contribution to the linear combination of variables that are integral “way out”; ↔ – sign means a stochastic relationship between linear combinations of the two sets of variables.

These canonical weight should be used for assembly of integrated indicators “input” and “output”. However, as the output variables differ greatly before the procedure to apply their rolls, the value indicators must first normalize.

The next stage of performance analysis is the calculation of integrated indicators “inputs” and “outputs” using the received canonical weights (rounded to the second decimal place) and their comparison.

High-technology industries have led the way in the globalization of international business in recent years. Success often depends on how well a firm transfers technology to another firm or market in a foreign country. ITT usually faces greater problems than in a domestic situation due to differing cultures, norms, laws, tax policies, etc.

Many of the important factors are ambiguous by nature and difficult to measure. For instance, the technology to be transferred and the target markets may be changing, estimating costs and prices can be difficult, and the competition may consist of only a small number of firms or governments. Several critical factors may be external to the firms involved, such as political, cultural, and economic conditions. It is important, under these conditions, for management to have a good understanding of the ITT process and the barriers and bonds that determine success.

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