



Technological forecasting as a prerequisite for successful country specialisation

Abstract. The article presents the results of the study showing how poor technological forecasting affects the determination of national economic development strategies. To accurately capture and neutralise negative effects of technological forecasting (TF), the author analyses it and reveals its complex multi-component and «foresighting» nature. The object of TF - the technological environment - is studied as a self-organising system which provides an optimal strategy for its controlled development. Such development should be based on «smart» diversification of scientific and technological potential, as well as on complex prognostic activity. Taking into account the need to support this strategy and the specifics of TF, the author identifies potential adverse effects of TF and proposes methodological recommendations for their neutralisation.

Keywords: Technological Forecasting; Foresight; National Economic Development Strategies; Risks of Innovative Development; «Smart» Diversification of Scientific and Technological Potential

JEL Classification: O32; O33; O38

Acknowledgement. The research was supported by the grant from the Russian Science Foundation, project No. 15-18-10013 «Socio-anthropological dimensions of convergent technologies».

DOI: <https://doi.org/10.21003/ea.V164-12>

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Технологічне прогнозування як умова успішної країнової спеціалізації

Анотація. У статті представлено дослідження недоліків технологічного прогнозування (ТП), які негативно впливають на визначення країнової спеціалізації, а також запропоновано методологічні рекомендації щодо їх нейтралізації. З метою точної фіксації негативних ефектів ТП було проведено аналіз цього явища та виявлено його комплексний, багатокomпонентний характер. На підставі аналізу з позицій систем об'єкта ТП, що самоорганізуються, а саме технологічного середовища, виділено оптимальну стратегію його регульованого розвитку, яка повинна спиратися на «розумну» диверсифікацію науково-технологічного потенціалу.

Ключові слова: технологічне прогнозування; форсайт; стратегія розвитку національної економіки; ризики інноваційного розвитку; «розумна» диверсифікація науково-технологічного потенціалу.

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Технологическое прогнозирование как условие успешной страновой специализации

Аннотация. В статье представлены результаты исследования недостатков технологического прогнозирования (ТП), негативно влияющих на определение страновой специализации; предложены методологические рекомендации по их нейтрализации. С целью точной фиксации негативных эффектов ТП проведен анализ данного явления. Выявлен его комплексный, многокомпонентный характер. На основании анализа с позиций теории самоорганизующихся систем объекта ТП - технологической среды - выделена оптимальная стратегия её регулируемого развития, которая должна опираться на «умную» диверсификацию научно-технологического потенциала.

Ключевые слова: технологическое прогнозирование; форсайт; стратегия развития национальной экономики; риски инновационного развития; «умная» диверсификация научно-технологического потенциала.

1. Introduction

Today economy at all levels (global, regional and national) is saturated with crisis phenomena. Such phenomena create opportunities for transformation of the existing system of international division of labour. Under the circumstances, extensive growth becomes an inefficient strategy of country development, whereas intensive growth, based on innovation, associates with various risks and thus requires an efficient system of technological forecasting (TF). The creation of such a system presupposes identification of weaknesses and possible negative effects of the contemporary TF and elaboration of methodological principles for their neutralisation.

2. Brief Literature Review

International specialisation and technological development. Works on the peculiarities of country/region specialisation, the ones, for example, written by M. Gryczka (2010) [8], J. Hardy (2007) [9], J. Simonen, R. Svento and A. Juutinen (2015) [17], differ in research perspectives, however all the authors mentioned above have common interest

in the innovation-based and hi-tech industries as engines of national economic development increasing competitiveness on the global market.

The strategy of specialisation. The question of specialisation for a country choosing innovative development has no unambiguous answer. The strategy of broad specialisation may be supported by those who appeal either to the benefits of association of complementary and neighbouring types of production and industrial sectors (Jacobs, 1969) [10], or to national security and national interests (Kokoshin, 2014) [11]. The creed, formulated in M. Porter's works, in contrast, points out the potential of a «unique competitive position» (Porter, 2005) [16, 413], and the results of N. Doi's empirical studies, for example, show that diversification of R&D economic activities is not quite productive (Doi, 1985) [7]. Recent years have seen the justification of the concept of «smart specialisation», in particular in (Simonen, Svento and Juutinen, 2015) [17]. According to this strategy, preferential development of several leading industries must be

supplemented by the development of several smaller and/or locally important industries.

Technological forecasting. Sophistication of scientific and technological development and a reduction in the technological cycle, associated with intense competition on the global markets, stimulate development of new methods and forms of TF, which are studied in different aspects (the United Nations Industrial Development Organisation (UNIDO, 2005) [19]; Dahl Andersen, Andersen, Park and Cagnin, 2014 [6]; Coates et al., 2001 [4]; the National Research Council of the National Academies (NRC, 2009). However, weaknesses of TF, as well as its possible negative effects on country specialisation and a possibility to minimise them, are still insufficiently researched. Furthermore, there is a problem of multiple definitions of TF (NRC, 2009; Coates et al., 2001), which puts into question the relevance of methodological principles proposed by different researchers.

3. The purpose of this paper is to identify negative effects of TF on the success of national development strategies and work out methodological requirements helping to neutralise or minimise such effects.

4. Methodology and Theoretical Foundations

The research is based on the author's terminological and methodological solutions, including the specification of different types of anticipatory activities such as predicting, forecasting, futurological researches, futures studies and foresight (Pirozhkova, 2015, 2016; Arshinov et al., 2015) [13; 14; 2]. As the drawbacks of certain activities can be identified only in relation to the tasks they help to carry out, the author used synergetics to determine the country specialisation strategy optimal in its technological environment.

5. Results

The research shows that the modern TF structure comprises cognitive, projective, reflective and socio-technological components. TF can thus be characterised as a complex future anticipation activity known as foresight (Arshinov, 2015) [2]. The definition introduced by G. Louie et al. (NRC, 2009, p. xvi), based on E. Jantsch and J. Martino, reflects a common understanding rather than the actual practice of TF. The analysis of several projects carried out in the past decades and qualified as TF (UNIDO, 2005; Dahl Andersen, Andersen, Park, & Cagnin, 2014; Coates et al., 2001) shows the irrelevance of this definition. The practice of TF includes not only scientific prediction, modelling and probabilistic descriptions, but also construction of perspectives, reflection on them, planning and socio-technological components. Unlike the umbrella-type definition by V. Coates et al. (Coates et al., 2001) [4, 11] - «anticipation of technological change», the definition proposed in the paper reveals the internal structure of such anticipation and therefore allows to accurately determine the sources of negative effects of TF.

The research shows complex TF to be useful for managing the problems of the development of a technological environment and determines the optimal strategy of specialisation most adequate to its system dynamics. Technological environments demonstrate the effects characteristic of self-developing systems, therefore system dynamics can be described by a system of indicators and a sum of constant relations between them only for a limited period of time, i.e. short and medium-term horizons. In the long term the system goes through periods of dynamic chaos, when the macro-level of hierarchical organisation of the technological environment restructures (Arshinov et al., 2015) [2].

Restructuring is a period of instability, when a system is determined by different factors, including wild cards - unlikely, but potentially extremely important events. So the choice of a development strategy requires a realistic view of the short- and medium-term conditions and, at the same time, the anticipation of factors like wild cards. It is also extremely important that during the periods of restructuring and instability we can influence the system, increasing its susceptibility to a certain wild card. In this way, we can make a desirable path of the system's evolution more probable, which is why projective and socio-technological components of TF are necessary.

When a country is involved in competitive struggle, the priorities of its innovative development should depend on wild cards, since they can provide important competitive advantages. Yet, working with wild cards is a venture process which cannot be reduced even to adaptive forecasting (Belyaeva, & Kozeva, 2016) [3], while social and economic sustainability requires to follow well-established trends, in other words, to use secure sources of development. The model of smart specialisation (SS) allows to overcome this contradiction. SS may combine intensive development of:

- 1) assured successful areas of scientific and technological progress;
- 2) areas of probable economic efficiency or areas associated with non-economic factors of stability, e.g. social, environmental, etc.;
- 3) areas opening great opportunities with slim or little-known probability.

Such diversification of scientific and technological potential, limited by country specifics (because TF needs a reflective component), is in the same time diversification of innovative development risks. Such diversification can also be called «smart».

Taking into account the specifics of dynamics of technological environment and the concept of «smart» diversification of scientific and technological potential as the most adequate strategy of innovative development, we find some imbalances related to modern TF and caused by the predominance of one of its components/methods over the others impacting the country's specialisation: 1) the dominant focus on medium-term regional and/or global trends, and disregard of potentially economically efficient and socially important areas; 2) development scenarios without complete fixation of productive conditions; 3) the narrow - disciplinary, institutional, sectoral - character of TF, such TF usually produces an inadequate picture of possible diversification of the scientific and technological potential; 4) the lack of reflection, including humanitarian assessment of forecasts and scenarios, consideration of cultural and ideological factors which impact the economic activity (Podgorny, 2011) [15]; 5) the predominance of the epistemic over the reflective and the projective components turns TF into an ill-controlled factor of the technological environment. The table 1 summarises the analysis of current TF practices in six selected countries makes it is clear that no national TF is free from shortcomings. In the case of strong economies (e.g. the USA), effects of TF's imbalances are minimum, however, developing and transitional economies (Brazil or Russia) are more sensitive to them. Despite the current relative prosperity, Japan and South Korea are in the risk group. Retention of their economic health needs further development of TF methods and organisational forms.

The following methodological requirements make it possible to neutralise or minimise the negative effects described above:

- 1) to combine identifying trends and wild cards with analysing of socially important areas of technological development;
- 2) to analyse promising areas of scientific and technological development in a wider context of resource, financial, human, etc. potential of the country;
- 3) to use system analysis, to link several sectoral foresights with each other and with the national one and to consider national technological potential in the regional and global context, therefore to use interdisciplinary and inter-institutional approaches;
- 4) to carry out humanitarian assessment and public discussion of scenarios and assumptions;
- 5) to explicate planning and projective components of TF as its special components (and stages).

Among the six national practices of TF analysed during the investigation the German TF is the one most in accord with the proposed requirements. At the same time, the German TF, indicating the importance of reflexive components and social context analysis in technological development, is fraught with danger of excessive attention to the current needs of society. This trend, associated with the

Tab. 1: Practice of technological forecasting (TF) in selected countries

Country, starting conditions	Projects, methodology	Virtue	Shortcomings	Results
Brazil - developing economy with great innovative potential and several competitive industries	National and sectoral Foresights since end of 1990s. Scenario and trends analysis revealing points of growth, communication «science-government-industry»	Explication of the projective component of TF, the emphasis on forming common vision	The lack of diversification of technological priorities, restricted participation, irregular character	Many industries developed, local progress; high-tech and medium-high-tech output - 38.6% of total manufactures output *, 69 th rank in GII-2016**, 81 st rank in GCI-2016-2017***
Japan - expanding economy with scientific and technological potential and limited resources	Science and Technology Delphi Surveys, 5-year periodicity since early 1970s, scenario analysis	Well-defined system of technological priorities, regularity	The predominance of the predictive component of TF, restricted participation, the lack of reflexivity	Efficient state policy in science and technology and corporate management (TF is called-for by ¾ companies [8]); high-tech and medium-high-tech output -51.8%, 16 th rank in GII-2016, 8 th rank in GCI-2016-2017
Republic of Korea - growth retardation, integration in the global economy	Technology Foresight since 1990s. Delphi, technology roadmaps, patent and bibliometric analysis	Regularity, allowance both intrinsic factors of technological development and social needs	Restricted participation, predominance of the predictive component of TF, especially linear predictions	Regular basic plans of technological development; high-tech and medium-high-tech output - 57.2 %, 11 th rank in GII-2016, 26 th rank in GCI-2016-2017
United States of America - rapid technological development replaced by technology-advanced diversified economy	Delphi since 1950s, lists of critical technologies (1980s, period of prosperity - 1990s). Delphi expert panels	Broad subject scope	Restricted participation and publicity, the lack of reflexivity	Federal target programs, orientation on high-tech industry; high-tech and medium-high-tech output - 43.3 % (at 2008), 4 th rank in GII-2016, 3 th rank in GCI-2016-2017
Germany - reunited country consisting of two parts with different levels of economic and social development	Delphi since 1990s; complex projects («Future») since 2000s. Expert panels, scenario and trends analysis, brainstorming	Meticulous trends analysis, interdisciplinary character, broad participation, reflexivity	Excessive attention to the current needs of society	Programs for state policy in science and technology, integration of the country, economic grows; high-tech and medium-high-tech output - 54.7 %, 10 th rank in GII-2016, 5 th rank in GCI-2016-2017
Russian Federation - transitional economy, resource-driven growth	Sectoral Foresights and foresighting by development institutions [1]. Technology roadmaps, Rapid Foresight	Rapid organisation of innovative nets	Emphasis on «popular» trends, the lack of projectivity and reflexivity, restricted participation	Local progress, the predominance of extractive industry; high-tech and medium-high-tech output - 26.3 %, 43 th rank in GII-2016 and GCI-2016-2017

Source: Compiled by the author using data from the following sources: *For all countries, except the USA, uses data from 2012 (Cornell University, INSEAD, & WIPO, 2016), **Global Innovation Index (Cornell University, INSEAD, & WIPO, 2016), *** Global Competitiveness Index (The World Economic Forum [WEF], 2016).

technologisation of the TF itself, is contrary to the interests of long-term innovative development.

6. Conclusions

The study shows that today's TF is a complex activity, responding to the goals of managing the development of technological environment, in particular to the goals of «smart» diversification of scientific and technological potential. «Smart»

diversification allows combining minimisation of risks with maintenance of high competitiveness on the global markets and socio-economic sustainability. Imbalances between different components of TF and within each of them give rise to negative effects for specialisation and should be eliminated by the implementation of methodological requirements suggested in the article.

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Received 26.01.2017